ALBERTUS MAGNUS

BOOK OF MINERALS

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PREFACE

WHEN Albertus Magnus wrote his *Book of Minerals* in the thirteenth century there was no science of mineralogy, and the fact that there is such a science today is partly due to him. The *Book of Minerals* continued to be read, and to influence the thinking of men who wrote about 'stones', at least until the time of Georgius Agricola in the sixteenth century. Today few mineralogists or geologists have even heard of it. I hope this translation may encourage some of them to explore this fascinating record of a science in the making. It shows us what had to be discarded or outgrown before a real science could come into being—the belief in astrological influences and the occult powers of stones, the inadequate 'chemistry' of the Peripatetics and the alchemists. It also shows us a first-class mind, trained in a bookish tradition, ignorant of elementary facts that we now take for granted, but keenly observant and highly rational, attempting to fit the confusing variety of nature into an orderly system of thought. Albert was indeed organizing a new science.

My study of the *Book of Minerals* has extended over a good many years, and I now express my gratitude for help from many sources. All who work in the field of the history of science must acknowledge a general indebtedness, not covered by mere bibliographic references, to the writings of Charles Haskins, Lynn Thorndike, and George Sarton. I feel a similar indebtedness to H. C. Scheeben's researches into the chronology of Albert's life.

I owe thanks, too, to those who have helped me to obtain materials for study: to those members of the staff of the Bryn Mawr College library who have helped me to locate and borrow, and to those other libraries that have lent, permitted me to consult, or supplied photographic copies of, rare books and manuscripts: the Boston Medical Library, the John Crerar Library in Chicago, the Houghton Library of Harvard University, the Library of the University of Pennsylvania, and the Library of the British Museum.

I am especially grateful to the Bodleian Library for a photograph of a manuscript showing the figures of chemical apparatus mentioned by Albert; and to the Kunsthistorisches Museum in Vienna for photographs of the 'Ptolemy' cameo.

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LIFE OF ALBERT

ALBERT was a famous man even in his own time but, as so often with famous men of the Middle Ages, contemporary biographers omitted much that we should like to know about him. Modern scholars have had to piece together the sometimes contradictory statements in medieval chronicles and histories of the Dominican Order, local traditions, surviving documents of business transacted in many different places, and casual references to times and places in Albert's own writings. The most comprehensive reconstruction is that of H. C. Scheeben[1], on which this sketch is chiefly based.

Nothing is known about Albert's parentage or childhood. The chonicles say that he was born of a family of the official class (*ex militaribus*), but there is no record of his father's name. The claim that he was the son of a Count of Bollstadt does not appear until the late fifteenth century and seems to be unfounded. He was known as Albert of Cologne and Albert of Teutonia, and various laudatory epithets were attached to his name, but *Albertus Magnus*, 'Albert the Great', became common only in accounts of him written by the later scholastics. The earliest documents bearing his signature and seal show that he then called himself Albert of Lauingen, a little town on the Danube about half-way between Ulm and Regensburg. Henry of Lauingen, who became prior of the Dominican house at Würzburg, is supposed to have been Albert's brother.

The year of his birth is unknown. Dates ranging from 1193 to 1206 or 1207 have been suggested, on the basis of conflicting statements as to his age when he died in 1280, or when he entered the Order of Preachers. The earlier date is rather more likely. Nor is anything known of his boyhood. An interest in natural history usually develops early, and some of the observations recorded in his scientific works, especially about animals, are certainly his own memories of a country life, but these cannot be dated with any accuracy.

Nevertheless, the earliest reliable date is given us by Albert himself, in describing as an eye-witness the earthquakes which in midwinter 1222–3

[1] Scheeben (1931) discusses and gives excerpts from important source materials. His later book (1955) contains some reinterpretations and a little new material, but is without any documentation.

caused widespread destruction in Lombardy (*Meteor.* III, ii, 9). What brought him to Italy and how long he remained there we do not know. Tradition mentions an uncle, whom he may have accompanied on some official mission. Or he may have been travelling by himself, for it was probably during this period of his youth that he visited mining districts in order to learn about metals, as he said in the *Book of Minerals* (III, i, 1). In the same work (II, iii, 1) he recalled a visit to Venice, when his companions asked him to explain a natural picture in a slab of marble—evidence that even as a young man he had a reputation for knowledge of such things. He was also in Padua (*Meteor.* III, ii, 12), where he is said to have been an Arts student, though his familiarity with medical writings seems to point to some medical education as well. At that time, indeed, the medical curriculum was the nearest approach to a 'scientific' training, and therefore might have had a special attraction for a man of Albert's tastes. He did not, so far as is known, take any degree.

Whatever his plans may have been, he abandoned them to join the Order of Preachers, founded by the Spanish monk Dominic in 1216. After Dominic's death in 1221 Jordan of Saxony, the second Master General of the Order, devoted much effort to recruiting young men from the universities. Histories of the Order say (and the story probably came from Albert himself) that Albert first became acquainted with the Dominicans in Padua and was deeply moved by Jordan's preaching, but that his decision to enter the Order was not made quickly or easily: his uncle opposed it and persuaded him to delay for a while, and he himself seems to have hesitated before so total a commitment. Several years may have passed while he continued his studies or his travels, for it was probably not until 1229 that he was received and 'clad in the habit'.

The preaching friars were generally trained for service in their own countries, where they were familiar with the language and local customs. Since Albert came from the German-speaking part of Europe he was assigned to the *Teutonia* province; and thus began his long association with Cologne. The Dominicans had been established at Cologne since 1221 and already had an important school, where for the next few years Albert devoted himself to theology and moral philosophy, the course of study leading to ordination as a priest.

Every Dominican house had its *lector*, who read and explained the texts that were studied; but it was customary for the more advanced students to help the others, and no doubt Albert's gift for teaching was discovered before he had finished his training. He was then given the duties of *lector* and sent to teach in other Dominican houses, going first, perhaps, to the newly founded one at Hildesheim (opened in 1234), then to that at Freiburg-im-Breisgau (opened in 1235 or 1236). Later, having proved himself, he taught in older and more important schools in Regensburg and Strassburg, and still later returned to Cologne.

In 1238 he may have revisited Italy as one of the representatives of the Teutonia province at the General Chapter meeting in Bologna. Jordan of Saxony had died in a shipwreck off the coast of Syria, and a new Master General was to be chosen. Tradition says that on the first ballot the votes were evenly divided between Albert of Cologne and Hugo of St. Cher. Perhaps this reflects a rivalry between the German and French provinces; if so, a compromise was reached on the second ballot, when Raymond of Pennafort, a Spaniard, was elected. (Raymond, however, served only two years and was succeeded by John of Wildeshausen.)

Albert remained a *lector* for some years after 1238. He may have taught at other schools beside those mentioned above, for he recorded that he was in Saxony when he saw the great comet that appeared in 1240 (*Meteor.* I, iii, 5); and he seems to have been in Cologne again for a time. About 1243 he was sent to the University of Paris, where the Dominicans had maintained a school for advanced studies since 1217. After taking the degree of Master of Theology (probably in 1245) he held a professorship there until 1248.

During this stay in Paris Albert, already learned in theology, turned to the broader aspects of philosophy, and was drawn into the scholastic movement centring on the revival of Aristotle[2], in which he was to be involved for many years. Greek philosophy and science were still in the process of being rediscovered, but already it was possible to read in Latin translations many works that were to become the foundations of later science—the medicine of Hippocrates and Galen, the geometry of Euclid, the astronomy of Ptolemy, and most of the Aristotelian *corpus*, as well as commentaries and original works on these subjects by Muslim writers. All this 'new' knowledge was exciting and disturbing—Aristotle perhaps most disturbing of all, with his marvellously complete and persuasive philosophical system, presenting novel ideas about the world of nature and doctrines quite at variance with the accepted teaching of the Church.

[2] See Appendix A for notes on Aristotle's writings and their transmission to Latin Christendom.

The possible dangers of conflict between intellectual curiosity and religious faith were recognized in 1210, and again in 1215, when the teaching of Aristotle's metaphysics and science was forbidden at the University of Paris. How far this ban was, or could be, enforced is uncertain. But in 1231 Pope Gregory IX again forbade the use of Aristotle's books until they had been 'examined and purged of all suspicion of error'. Thus by the time Albert came to Paris many scholars must have been reading Aristotle, and his ideas were becoming more familiar, if not yet systematically taught.

Within a few more years, however, certainly by 1254, many of Aristotle's works were required reading for a degree—a change due in part at least to Albert and his pupil, Thomas Aquinas, who advocated not censorship and suppression but study and interpretation, with a view to reconciling Aristotle's teachings with those of the Church. Albert began this task at the request of members of his own Order (*Phys.* I, i, 1), probably while he was still at Paris.

In 1248 the General Chapter, meeting in Paris, decided to establish a *studium generale*—a higher school, of university grade—in each of the four provinces of Lombardy, Provence, England, and Teutonia. Albert was appointed *lector*—a title in this case equivalent perhaps to Regent of Studies—at the school for the Teutonia province in Cologne. His return to Cologne must have more or less coincided with the beginning of the building of the present cathedral,[3] though the pious legend that he was its architect can be rejected. Plans for enlarging the old cathedral must have been made while he was still in Paris; at an early stage in the work fire broke out and totally destroyed the church and many of its treasures. But Albert must have been in the city when the debris was being cleared away and new foundations were being dug, and it was probably then that he saw a Roman pavement discovered deep below the surface of the ground (*De prop. elem.* I, ii, 3).

The school at Cologne was already an excellent one, but Albert seems to have broadened the curriculum, himself lecturing on the theology of

[3] Of all Europe's Gothic cathedrals, Cologne was longest in building. It was begun in 1248 and in 1322 the relics of the Three Kings of Cologne (*Min.* II, iii, 2) were placed in the completed choir. Thereafter work proceeded very slowly and ceased entirely at the time of the Reformation. In the eighteenth century the building stood as a picturesque 'ruin' in the midst of the city. Interest in completing it revived early in the nineteenth century. Work was resumed in 1842, and the finished building was opened in 1880, at a ceremony attended by Kaiser Wilhelm I and the princes of Germany.

the pseudo-Dionysus and the *Ethics* of Aristotle. Among his students, three may be especially mentioned here, although there is some uncertainty about the dates of their attendance at Albert's courses. One was Thomas of Cantimpré,[4] author of a well-known encyclopedia. Another was Ulrich of Strassburg, who became a lifelong friend of Albert. The third was Thomas Aquinas, the great theologian, who had entered the Order very young and had been much harassed by the opposition of his family in Italy; perhaps it was for this reason that he was sent to Germany for his training. One of the legends says that he was a silent youth, nicknamed 'the dumb ox' by his fellow students, but that Albert quickly recognized his quality and predicted that his voice would be heard in the world; and apparently it was at Albert's instigation that he was sent to Paris in 1252, where he became a famous professor.

But Albert was not entirely immersed in academic affairs. The year 1252 also saw the beginning of another task that went on for many years—that of composing the turbulent quarrels of the citizens of Cologne with their archbishops. Cologne, the most important centre of manufacture and trade in the Rhineland, had in the preceding century gradually won most of the rights of a free city, with the citizens themselves in control of such matters as coinage of money, customs duties, and other trade regulations. When Archbishop Conrad von Hochstaden, an autocratic nobleman, attempted to curtail these rights, bloody fighting took place before both sides agreed to accept arbitration. The agreement drawn up by Albert, and signed before him and the Papal Legate, Hugo of St. Cher, in April 1252, put an end to the strife for a time, but Albert's intervention was to be invoked again and again in the future.

In 1254 the Provincial Chapter, meeting in Worms, elected Albert Prior Provincial of Teutonia, an office he held until 1257. These were years of heavy responsibility and arduous travel, for it was the duty of the Prior Provincial to visit as many as possible of the Dominican houses under his charge. The Teutonia province then included all Catholic Europe north of the Alps and east of France, with the exception of Scandinavia and the British Isles—that is, Alsace, Lorraine, Luxemburg and the Low Countries, Germany, Austria, Switzerland, Bohemia, and parts of Poland, Lithuania, and Latvia. There were about forty Dominican houses in 1254, and several more were founded in the next few years.

The course of Albert's journeys is a matter of conjecture, though some

[4] See Appendix B, 13.

documents exist to show where he was at certain times. The Provincial Chapter generally met in late summer, and after leaving Worms in 1254 he seems to have returned to Cologne. In February 1255 he went to profess the first nuns at the Paradise Convent near Soest, and preached to them. He then went on into northern Teutonia, visiting Dominicans in Saxony and Brandenburg, perhaps going as far as Lübeck, or even Riga. The Provincial Chapter met that year in Regensburg, where Albert presided; after which he would presumably have made visits in south Germany and Austria. In January 1256 he was again in Cologne. He could have visited houses in Holland and Belgium in the spring, before going on to the General Chapter at Whitsun in Paris. He returned to Teutonia in the summer for the Provincial Chapter at Erfurt; but by the end of September he was at the Papal Curia at Anagni.

Travel in medieval times was slow and toilsome. Moreover, the Dominicans were vowed to poverty—mendicant friars who had no money, begged for food and lodging except when entertained in the houses of their Order, and were forbidden to use wagons or horses except in direst emergency. Albert's long journeys on foot are an amazing achievement: he covered hundreds of miles and must have been on the road almost continuously for weeks on end. He can have had little opportunity for study or writing, but many things that he saw or heard on the way he remembered and later put into his scientific books.

The reason for his journey to Italy was probably the trouble that had been brewing for some years over the right of the mendicant friars—the Franciscans and Dominicans—to teach at the University of Paris. In 1254 William of St. Amour had published a violent attack on them, and the matter had been discussed at the General Chapter in the spring of 1256. It is almost certain that Albert was then selected, as a distinguished member of one of the embattled Orders, and a former professor at Paris, to go and testify before the Commission of Cardinals that was to meet at Anagni in the autumn. The case was finished in October, when the Pope, Alexander IV, condemned William's book; but Albert remained with the Papal Curia, which moved in December to Rome, and in May 1257 to Viterbo. During this winter he lectured at the Curia on the Gospel of St. John and the Epistles of St. Paul, and collected material for his tract (not finished until much later) *On the Unity of the Intellect: against Averroes*. In May, when the General Chapter met at Florence, he obtained release from his office as Prior Provincial; and in the summer he set off, by way of Bologna, on the long journey back to Cologne.

There he resumed his duties as *lector* and his studies of Aristotle. In 1259 he attended the General Chapter at Valenciennes, serving on a committee that included also Thomas Aquinas and Peter of Tarantaise (later Pope Innocent V), to consider revisions of the curriculum in the Dominican schools.

In Cologne his services as negotiator and peacemaker were again in demand. He took part in another attempt to resolve the conflict between the citizens of Cologne and Archbishop Conrad von Hochstaden. A settlement was signed in June 1258; and, as an aftermath of this, negotiations over the liability of Cologne for damage done in Deutz during the fighting went on until 1260. There was also a trade dispute between Cologne and Utrecht, settled in 1259.

Meanwhile events in Regensburg on the Danube were about to give Albert's life a new direction. The citizens were having trouble with their bishop, Count Albert von Peitengau, who was more soldier than priest, constantly involved in war, and had been paying little attention to his diocese. In 1259, after an appeal to the Papal Curia, he was forced to resign. The Cathedral Chapter elected in his place their Provost, Henry of Lerchenfeld, who (perhaps prudently) declined the honour. The naming of a bishop then became a matter for the Curia, who chose Albert of Cologne.

This seemed to many a surprising choice, though it may have been suggested by Hugo of St. Cher, who was then at the Curia; and of course Albert was personally known to the Pope from his stay in Italy three years earlier. But Albert was now in a somewhat difficult position: the regulations of the Order forbade any Dominican to accept such office in the Church without the permission of his superiors; and when the Master General, Humbert of Romans, heard the news, he wrote to Albert begging him, for the good of the Order, to decline. The notification of his election and Humbert's letter of remonstrance must have reached Cologne at about the same time, near the beginning of February 1260. Albert seems to have taken some weeks to make up his mind, but in the end he accepted. In mid March he was consecrated as a bishop (where and by whom is not known) and set out for Regensburg. He arrived on March 29, spent the night at the Dominicans' house of St. Blaise, and next day went in procession to the cathedral to be enthroned. On the same day he began to look into the affairs of the diocese.

These were in a sorry way, and a reformer is seldom popular. No doubt he met with opposition and even ridicule: Regensburg hardly knew what to make of a bishop who walked the streets in the crude sandals of a begging friar. Surviving documents tell something of his activities during the next year. In August he consecrated an altar at Lerchenfeld, and in September he attended a conference of bishops at Landau. He struggled with debts and financial reforms, seeing that tithes were collected and properly used, devising means for the support of parish priests and a hospital.

When spring came he seems to have felt that he had done what he was sent to do, and that it was time to give the diocese back to a locally chosen bishop. In May he set out for Italy to present his resignation to the Pope in person. He arrived at Viterbo just about the time of Alexander IV's death (25 May 1261); nothing could be done until after the election of a new Pope. Urban IV was elected in August, but it was not until the following May (1262) that he confirmed the election of Leo, former dean of the Cathedral Chapter at Regensburg, as Albert's successor.

Finally freed of his office, Albert might have been expected to return to the Dominican Order, but he did not do so, probably because the new Pope had other plans for him. In fact, there is no evidence as to his whereabouts during most of the years 1261 and 1262. It has been conjectured that he returned for a while to Regensburg, or that he travelled to southern Italy or even to Greece. What is most likely, perhaps, is that he remained at the Curia, where Urban IV gathered a group of scholars and theologians including Thomas Aquinas, summoned from Paris in 1261, and no doubt others whom Albert had known in 1256–7. There he could devote himself again to writing, and it is not improbable that it was there that he finished his commentary on St. Luke and perhaps some of his commentaries on Aristotle.

At the beginning of 1263 Urban IV appointed Albert Preacher of the Crusade in Germany and Bohemia, giving him the powers of a Papal Nuncio, and providing him with letters commanding all bishops to assist his mission. Once again the prospect of long journeys lay before him, and Albert was growing older. These journeys are much better documented than those of 1254–6, because at many places along the way he consecrated altars or churches, granted indulgences, or settled local disputes. He is thought to have been in Orvieto when Hugo of St. Cher died there on March 19, and to have remained to celebrate Easter on April 1. But he must have left soon afterwards and travelled by way of the Brenner Pass, for on May 5 he was at Polling in Upper Bavaria. He can then be traced to Augsburg (May 10), Donauwörth (May 13), Würzburg (May 27), Frankfurt-am-Main (June 5), and back again to Würzburg (June 28). He reached Cologne about the end of July.

Once again there was trouble in Cologne. Archbishop Conrad von Hochstaden had died in September 1261; but the new archbishop, Engelbert von Falkenberg, was no more able to get on with the citizens than his predecessor had been. On 25 August 1263 Albert witnessed another agreement; but in November, after he had left Cologne, fighting broke out again, and Engelbert was taken prisoner. There was talk in December, and again in the following May (1264), of getting Albert to come back. But he did not come back, and a new settlement was attempted by the Bishops of Liège and Münster.

From Cologne Albert probably travelled through Holland and north Germany. At the end of October he was in Brandenburg, where he carried out a special mission: the local clergy, unable to agree on the choice of a bishop, had appealed to the Pope, who had sent Albert to deal with the case. After this he may have continued eastwards to the Saxon-Polish frontier, but by the end of the year he was at Adelhausen, near Freiburg-im-Breisgau. On 20 February 1264 he was in Speyer, and on March 18 in Regensburg. There are no records for the next few months, but it is likely that he was then carrying out his mission in southern Germany and Bohemia. In late summer he was in Mainz, where a document of 20 August 1264 is the latest one known bearing his signature as *praedicator crucis*.

It is strange that we have no information about the actual preaching of the crusade; but this is perhaps because it was not very successful. The Age of Crusades was nearly over and men's minds were turning to other interests. Albert's commission came to a sudden end with the death of the Pope and the next Pope did not renew it.

Urban IV died on October 2, but it may have been some weeks before the news reached Albert. When it did, he seems to have gone at once to Würzburg, for by December 4 he was engaged in mediating a dispute there. One of the witnesses to the agreement was Albert's brother Henry, Prior of the Dominicans; and it was perhaps because his brother was there that Albert remained in Würzburg (so far as we know) until May 1267. Numerous documents show that he took part in the settlement of local cases, but there is little to tell of his private life and occupations.

He lived with the Dominicans, but his status is not entirely clear. During his years in the papal service he had been released from the rule of the Order—that is, he owed obedience not to the Master General but directly to the Pope; and the Pope had granted him some property or revenues for his support, which he still retained and finally disposed of by will, in contravention of the vow of poverty. It may also be noted that he never again held any office in the Order, and was perhaps free to choose his place of residence. Yet in other respects he certainly returned to the Order and was identified with it for the rest of his life.

In the early summer of 1267 Albert left Würzburg, probably visited Regensburg, and then went to the Rhineland. In July he consecrated an altar in Burtscheid, near Aachen, and in August and September was in Cologne. Later in the autumn he arrived in Strassburg, which was to be the centre of his activities for the next few years. The Dominican school had grown in importance since Albert had taught there many years before, and was now second only to Cologne in the Teutonia province; and the *lector* was Ulrich of Strassburg, a former pupil of Albert's. Whether Albert himself resumed any teaching at this time is unknown; he may have lectured occasionally, but he was often away. Again there are records of churches consecrated and indulgences granted in many places not very far from Strassburg, as well as in Strassburg itself, where on 7 April 1269 he ordained a large group of clergy.

He undertook one more long journey at the command of the Pope, Clement IV, probably in the summer of 1268, to settle a dispute in Mecklenburg over property which had been given to the Knights of St. John in 1229 and was later claimed and seized by other nobles and the Abbot of Colbaz. Albert was now an old man, and efforts seem to have been made to save his strength. He was accompanied by two assistants, John of Freiburg (a young Dominican, probably a pupil of Ulrich's) and Albert of Havelburg. He was also permitted to use a vehicle; but the springless carts of those days could hardly mitigate the badness of the roads or shorten by very much the time spent on the way. This must have been an exhausting journey, and Albert may well have felt that it was in vain, for after his return the agreement he had arranged was broken, and he had to excommunicate the Abbot of Colbaz and his party, who were again trying to dispossess the Knights of St. John.

Another claim on his services came from John of Vercelli, now Master General of the Order, who wrote asking him to go to Paris and teach again at the university. It was unusual to recall a man to a post he had already held, but the mendicant friars were once more under attack, this time by Gerhard of Abbeville and Siger of Brabant, and the Master General no doubt wanted the Order's most distinguished teacher in Paris just then. Albert, however, excused himself, saying that he felt unequal to the work and he had no assistant; and he may have suggested the recall of Thomas Aquinas, who returned to Paris early in 1269. All this can be inferred from a letter of John of Vercelli, apparently written in 1270, in which, after mentioning the earlier call to Paris, he urged Albert to go to Cologne. This time an assistant was provided, probably Gottfried of Duisburg, who remained with him to the end.

The political situation in Cologne had been going from bad to worse. When the Papal Nuncio, Bernard of Castaneto, had tried to intervene and failed in 1268 he had excommunicated all parties to the quarrel, and the citizens had appealed to the Pope in vain. The fighting did not stop, though Engelbert was still a prisoner; and in the summer of 1269 the severity of the interdict was increased. Another appeal was sent to Rome; but Pope Clement IV died in 1269 and there was a delay of almost two years before his successor was elected. We may surmise that a message was sent through the Cologne Dominicans to the Master General, or to Albert himself, begging him to help as he had helped in the past.

The exact date of Albert's return to Cologne is uncertain—presumably about the end of the year 1270. Nor is it known just how he opened negotiations. But by spring Engelbert had been released, and on 16 April 1271 he signed a document declaring his complete reconciliation with his enemies, and agreeing to submit any future points of dispute to an arbitration commission headed by 'Brother Albert of the Order of Preachers, formerly Bishop of Regensburg'. Peace was at last restored, though the interdict of excommunication was not finally removed until after Engelbert's death and the election of his successor, Siegfried von Westerburg, in 1275.

For the remaining years of his life Albert lived with the Dominicans of Cologne. He contributed money for enlarging their church and is said to have laid the cornerstone of the choir in 1271, and to have given a large crucifix and some sacred relics. Very likely he still took an interest in the school, but he was no longer responsible for it, and he was busy finishing several theological works and revising earlier ones. His eyesight was beginning to trouble him,[5] but he had his helper, Gottfried of Duisburg, to read to him or write at his dictation.

It would be a mistake, however, to imagine that Albert had now 'retired' from active life. His name appears on many documents, not only in Cologne and near-by places, but as far away as Utrecht and Nijmegen in Holland. And he still kept in touch with larger affairs. Ulrich of Strassburg was elected Prior Provincial of Teutonia in 1272, and records of his term of office show that he several times consulted Albert and went to see him. It was probably on one of these visits to Cologne that Ulrich and John of Vercelli, Master General of the Order, met Rudolph of Hapsburg 'in the Church of the Friars'. Rudolph was crowned at Aachen on 24 October 1273, and in November spent some time in Cologne. He may have known Ulrich and Albert in Strassburg, and very probably he would have wished to enlist the support of these eminent Dominicans. If so, he evidently succeeded, for a letter of Ulrich's mentions him with enthusiasm, and tradition says that Albert spoke in his favour at the Council of Lyons.

The spring of 1274 was saddened for Albert by news of the death of Thomas Aquinas in March at Fossanova, on his way to the Council of Lyons. As to Albert's attendance at the Council, the evidence is conflicting. The earliest chronicles of his life do not mention it, and his name does not appear in the records of the assembly,[6] which opened on May 6. This however, might be explained by his late arrival, if he travelled with the German Dominicans who attended the General Chapter of the Order, also held in Lyons that year, and opening on May 13. The Council had many important matters to discuss and the election of Rudolph of Hapsburg was not taken up until June 6. On that occasion, at least according to a fifteenth-century account, Albert was present among the bishops, and spoke on the text 'Behold, I will send them a saviour and a defender, and he will deliver them'. If we may judge his sentiments from the text, Albert, like many of his contemporaries, saw in the Hapsburg prince the best hope of ending the long interregnum which, ever since the decline of the Hohenstauffens, had kept Germany in turmoil.

In August Albert was in Cologne and from there went to Fulda, on a

[5] Weisheipl, 1960, pp. 313–14, 354: *cecutientes pre senectute*, said by Albert of himself in 1271.

[6] Noted by Thorndike (1923, Vol. II, p. 526), who evidently does not think Albert went to Lyons at all; Scheeben believes he did, and spoke as reported.

commission from Pope Gregory X to look into the election of the Abbot of Fulda. In September 1276 he was in Antwerp, where he consecrated the Dominican church and attended the Provincial Chapter, at which Ulrich of Strassburg presided. This may have been his last meeting with Ulrich, who died in Paris a year or two later.

A legend of Thomas Aquinas relates that when, in 1277, some of his opinions were included in Bishop Tempier's condemnation of 219 theses ascribed to Siger of Brabant, Albert went to Paris and successfully defended them. This is extremely improbable. Albert was a remarkably vigorous old man—indeed he is not known to have suffered any illness during his whole life. But by 1277 he is said to have become very bent with age and to have begun to fail mentally.

Yet in January 1279, when he made his will, he described himself as 'of sound mind and body' (*sanus et incolumen*). The will is known to us in a copy made 'word for word' in 1408 by a Dominican, Narzissus Pfister, at Cologne. It is of interest because Albert appears to have feared that some question of its validity might arise, since the rules of the Order did not permit the friars to own or bequeath property. He therefore stated at the beginning that he had been exempted from this rule by the Pope, and wished to record his wishes while still able, so that no doubt be felt after his death. He left everything to the Order: his books to the library; his bishop's vestments to the sacristry; bequests in money to three Dominican nunneries; the rest of his property to be used for completing the choir of the Dominican church, to which he had already contributed. As executors he named the Prior Provincial, the Priors of Cologne and Würzburg (the latter his 'dear brother Henry'), Gottfried 'the physician', and Gottfried of Duisburg. The will was witnessed by the Prior of Cologne and two laymen, respected citizens of Cologne.

In February of that year he was still well enough to take part in the ceremony of translating the relics of St. Cordula to the Chapel of the Knights of St. John in Cologne; and in the summer he authenticated two more documents; so his decline seems to have been gradual. The end finally came on 15 November 1280. He died peacefully in his own cell, and was deeply mourned by the Dominicans, who buried him three days later in the choir of their own church, which he himself had helped to build. The funeral mass was attended by a sorrowing crowd of clergy and citizens of Cologne.

Albert's memory was honoured for five centuries in the Dominican church. Many people came to visit his grave and he was soon regarded locally as a saint. In 1483 his remains were transferred to a reliquary and placed upon an altar. But after the French Revolution, when Alsace was invaded, the Dominicans were expelled and their buildings put to secular uses. The church was torn down in 1804, and the cloister, where the friars had lived, after serving as a barracks during the Prussian occupation, was later demolished. Albert's bones had already been removed to the near-by church of St. Andrew, where in the nineteenth century they were kept in an ornate gilded shrine. During the Second World War this church was severely damaged in the bombing of Cologne. When it was being restored, the ancient crypt beneath the choir, long ago filled in, was re-excavated and made into a simple white-walled chapel, and in 1954 Albert's relics were placed there in a plain stone sarcophagus that rests beneath the high altar.

Even during his lifetime legends had begun to gather around Albert's name and this process was accelerated after his death. On the one hand, it was told of him—as of his contemporaries Michael Scot and Roger Bacon—that he had been a great magician skilled in the black arts; and books on magic, astrology, and alchemy were falsely attributed to him.[7] On the other hand, there were stories of a saint's miracles. A cult was already forming in the fourteenth century, and in 1484 Pope Innocent VIII gave permission to the Dominicans of Cologne to celebrate Albert's Feast each year on November 15. This permission, equivalent to beatification, was extended by later Popes, and in 1670, by a decree of Clement X, became world-wide. Albert was canonized in 1931, and in 1941 Pope Pius XII declared him the patron saint of scientists.

ALBERT'S SCIENTIFIC WRITINGS

Albert's works are so numerous and cover so wide a range of interests that we can only wonder how, even in a long life, he found time to write them all. The scientific treatises, taken all together, are but a small part of his complete works,[8] which include also commentaries on many books of the Bible and on texts used in the schools, and original theological treatises. For Albert himself there was no conflict between science and religion: his study of Aristotle's science was undertaken in order to under-

[7] Thorndike, 1923, Vol. II, pp. 549–55, 720–48. Waite, 1888, pp. 58–59.

[8] For example, the new Cologne edition of Albert's complete works, according to the *conspectus* issued in 1951, is to be in forty volumes, of which nine (Vols. IV–XII) will contain the 'natural history' treatises.

stand Aristotle's philosophy as a whole and to reconcile it with the Christian faith. He began his commentary on the *Physics* (I, i, 1) in these words:

Our intention in natural science is to satisfy, to the best of our ability, the Brothers of our Order, who have been asking us, for several years now, to compose for them the kind of book on *Physics* that should give them a complete natural science[9] and make them really competent to understand the books of Aristotle. Although we do not consider ourselves capable of this task, yet we cannot withstand the entreaties of the Brothers; and so at last we accept the task that we have often refused. Persuaded by their entreaties, we undertake it, first of all for the honour of Almighty God, the Fount of Wisdom and the Creator, Founder, and Ruler of nature; and also for the benefit of the Brothers, and of any others who read it with the desire of acquiring natural science.

Albert wrote commentaries on other works of Aristotle—on the logical works, the *Ethics*, *Politics*, and *Metaphysics*. But those on natural science form a special group, since Albert considered them as one closely related series, and listed them all together, rather elaborately classified in logical order, near the beginning of his *Physics* (I, i, 4). Here is his list:[10]

* Physics (*Physica*)
* The Heavens (*De caelo et mundo*)
The Nature of Places (*De natura locorum*)
Properties of the Elements (*De causis proprietatum elementorum*)
* Generation and Corruption (*De generatione et corruptione*)
* Meteorology (*Meteora*)
The Book of Minerals (*Mineralia*)
* The Soul (*De anima*)
* Life and Death (*De morte et vita*)
* Youth and Age (*De iuventute et senectute*)
Nourishment (*De nutrimento et nutribili*)
* Sleep and Waking (*De somno et vigilia*)
* The Senses (*De sensu et sensato*)
* Memory and Recollection (*De memoria et reminiscentia*)
Movement of Animals (*De motibus animalium*)
* Breath and Breathing (*De spiritu et respiratione*)
The Intellect (*De intellectu et intelligibili*)
* Plants (*De vegetabilibus*)
* Animals (*De animalibus*)

[9] *Physica* itself means 'nature' or 'natural science'; and Aristotle's *Physics* was considered to be the foundation for all the other sciences.

[10] These are listed in the order in which Albert places them. The Latin titles are those used in the *conspectus* (1951) of the new Cologne edition of Albert's complete works.

Those marked with an asterisk (*) are directly based on corresponding works in the Aristotelian *corpus*.[11] But we must remember that Albert never had a 'complete edition' of Aristotle. Various treatises or groups of treatises circulated in separate manuscripts: some were available in two or more different translations, and some were embedded in Arabic commentaries. Critical scholarship hardly existed, but an intelligent man like Albert could see that some of the works generally received as Aristotle's were not entirely satisfactory; and some that he had heard of could not be found.

The *Properties of the Elements* is now known to be a Muslim work; and Albert had to add a good deal to it to make it fit into his Aristotelian scheme. *Nourishment* and *The Intellect* probably correspond to the spurious *De alimentiis* and *De intelligentia* that appear in medieval lists of Aristotle's works;[12] and Albert acknowledged that he had not seen Aristotle's own books on these subjects but only writings by his followers (*De intellectu*, I, i, 1). He was in the same difficulty when he wrote the *Movement of Animals* (*De motibus animalium*); he later referred to this as if it were largely his own composition (*ea quae ex ingenio proprio diximus*), and wrote a new commentary, *De principiis motus processivi*, after he found a manuscript of Aristotle's *Movement of Animals* in Italy (*De prin. mot. proc.* I, i, 1). *The Nature of Places* and the *Book of Minerals* were put together by Albert himself, when he failed to find any Aristotelian treatises on geography and mineralogy.

In doing this he did not feel that he was taking unwarrantable liberties with his author; he did not think of himself as a scholar editing a text but as a teacher explaining new and difficult ideas. He justified this, too, in the Introduction to his *Physics* (I, i, 1):

Our method in this work will be to follow the sequence of Aristotle's thought, and to say in explanation and demonstration of it whatever may seem necessary; but without any quotation of the text. And also we shall put in digressions, so as to clarify difficulties as they arise or to add whatever may make the Philosopher's thought clearer to anyone. And we shall divide the whole work by chapter headings: where the heading simply gives the contents of the chapter, this means that the chapter is one of those in Aristotle's own books; but wherever the heading indicates that there is a digression (*digressio*), there we have added something in the way of supplement or demonstration. By such a procedure, we shall make our books correspond, in their numbering and

[11] See Appendix A.

[12] Wingate, 1931, pp. 23, 89.

titles, with those of Aristotle. And we shall make additions wherever books are incomplete, and wherever they have gaps in them, or are missing entirely—whether they were left unwritten by Aristotle or, if he did write them, they have not come down to us. But where this is done, the ensuing tractate will say so clearly.

Thus Albert's treatises are more original than the term 'commentary' might suggest. If there was a basic text, it was paraphrased and interwoven with his own contributions—sometimes exposition or refutation of the opinions of previous commentators, sometimes new illustrations, drawn from his own wide reading and experience, which reveal his lifelong interest in science and his quality as an observer. If there was no basic text, as for the *Book of Minerals*, the selection and arrangement of materials offered even more scope for the development of his own ideas. His aim was a complete account of all nature, and the titles of his treatises indicate the broad scope of the undertaking. But the individual treatises are not independent, they are all parts of one continuous and coherent 'natural history', and the reader is constantly reminded that points explained in the earlier books are necessary for understanding the later ones.

At the end of the *Animals* (which he expanded from nineteen to twenty-six books) Albert says that this is the end of the series on natural science. But he so often mentions astrology and alchemy that we may inquire whether or not he ever wrote anything on these subjects. Both lie outside the true 'Aristotelian' tradition (though the pseudo-Aristotelian *Properties of the Elements* contains some astrology), but they were an important part of medieval science.

Astrology was, of course, closely linked with astronomy; in fact the words *astrologia* and *astronomia* were used interchangeably by thirteenth-century writers. The two-fold character of the science of the stars is shown by the *Mirror of Astronomy*, or astrology (*Speculum astronomiae*). This was attributed to Albert as early as the fourteenth century, and has been printed in his collected works (Borgnet, Vol. X), although this attribution has been challenged.[13] The author, if he was not Albert, certainly held views very similar to Albert's. He recognized the two aspects of *astronomia* and listed books dealing with both: first, the science that observes and describes the movements of the heavenly bodies; and second, the application of this knowledge to predicting the future or invoking celestial influences for various purposes. In the latter science he carefully

[13] For discussion of this see Thorndike, 1923, Vol. II, pp. 577–92, 698–717.

distinguished licit from illicit practices; and this sort of distinction, together with some of his citations of authorities, we find also in Albert's discussion of astrological images (*Min.* II, iii).

Scientists of today who scorn astrology as mere superstition perhaps forget that at one time it included several subjects which have since become respectable fields for scientific research—weather and weather forecasting, the relation of climate to latitude, and the effects of climate on plants, animals, and men. But if all these things were influenced by 'the aspects of the heavens', medieval astrologers thought, the stars must surely affect men's lives in still other ways. Albert, for all his remarkable intelligence and his sturdy common sense, was, after all, a child of his time. He may well have written the *Mirror of Astronomy*. But other astrological works bearing his name are certainly spurious.

The same may be said of the alchemical treatises attributed to Albert, with the possible exception of the *Little Book on Alchemy* (*Libellus de alchimia*), also known as the *Straight Path* (*Semita recta*), which has been printed with his other works (Borgnet, Vol. XXXVII) and translated into English by Sister Virginia Heines (1958). It contains anachronistic references to Geber and Jean de Meung, but these may be later interpolations. The title *De alchimia* in a fourteenth-century list of Albert's writings has been taken to mean this work, but it may refer to a part of the *Book of Minerals*.[14] The *Little Book on Alchemy* is a practical 'laboratory manual', giving good advice to the novice, and describing the apparatus, materials, and procedures of the art; and it is quite free of the obscurity and mystification common in alchemical books.

Whether or not Albert wrote this, he had, according to his own statement (*Min.* III, i, 1), investigated alchemy. But he could have studied alchemical texts, talked with alchemists, and even visited their laboratories, without being an adept himself.[15] He certainly was much interested in alchemical theories, and, as the *Book of Minerals* makes clear, he realized that 'chemical' explanations were needed for many natural phenomena. But in my opinion his style and his expressed views on transmutations are unlike those of the author of the *Little Book on Alchemy*.

THE ARGUMENT OF THE *BOOK OF MINERALS*

The Aristotelian *corpus* contains almost nothing on mineralogy. The only discussion of the subject, some thirty lines at the end of *Meteor.*, III

[14] Paneth. 1929, 1930.

[15] Partington, 1937, pp. 12–13.

sets forth a theory that there are underground two 'exhalations': one of these, a 'dry smoke', produces earths and stones, the other, a 'watery vapour', produces metals. The passage ends with the remark that each of these kinds of mineral must be taken up separately and in detail; and this seems to point to some work no longer extant[16]. When Albert came to write the *Book of Minerals* he tried to find this missing work. He believed it existed, because he had heard of a *Lapidary* or *Book of Stones* by Aristotle,[17] but he could obtain only a few excerpts from it (*Min.* I, i, 1; II, iii, 6; III, i, 1). He was therefore forced to draw up his own plan for dealing with minerals. The result is of unusual interest, in that it shows us not only the contemporary state of mineralogy, but also Albert's idea of what a *science* of mineralogy should be.

The *Book of Minerals* is a typical scholastic treatise, and since this form of presentation is rather unfamiliar today, a brief summary of its argument may be useful.

Albert's model is, of course, Aristotle,[18] who says at the beginning of his *Physics* that data gained from direct observation of nature are of concrete particulars, but are often confused and difficult to understand. Science concerns itself with analysing the data, in order to arrive at general principles, to make things understandable by explaining their *causes*. For Albert, then, a *science* of mineralogy must be based on a discussion of the *causes* of minerals, that is, 'the four causes' distinguished by Aristotle as *material*, *efficient*, *formal*, and *final*.

First the *material cause*, the matter of which minerals are made: Albert's 'chemistry' is based on what is said of the *elements* (Fire, Air, Water, and Earth) in *The Heavens*, *Generation and Corruption*, and *Meteorology* (especially Book IV). And the *material cause* is the basis of his general classification of minerals into three groups—stones (Books I–II), metals (Books III–IV) and 'intermediates' (*media*, Book V). He treats stones first because they are 'simpler' than metals, being mixtures of Earth and Water; metals are made up of Sulphur and Quicksilver, which are themselves mixtures, Quicksilver containing Earth and Water, Sulphur something of all four elements. (The Sulphur-Quicksilver theory is not Aristotle's; Albert got it from Avicenna[19] and other alchemists.) The

16 Perhaps the reference is to a work of Theophrastus. See Appendix B, 1.

17 The *Lapidary of Aristotle*. See Appendix A, *Pseudo-Aristotelian Works*, 14.

18 See Appendix A for notes on the Aristotelian works that are relevant to the *Book of Minerals*.

19 See Appendix D, 9.

'intermediates' are neither stones nor metals, but have some characteristics of both.

Next, the *efficient cause*, the process by which minerals are made: here Albert adopts the two-exhalations theory of *Meteor.* III and extends it, for metallic ore deposits, by equating the 'dry smoke' with Sulphur and the 'most vapour' with Quicksilver. These exhalations, confined within the earth, are converted into minerals by the direct action of heat and cold; but heat and cold are merely the 'instruments' of the real *efficient cause* which is a 'mineralizing power' (this concept also came from Avicenna). Just how this power acts Albert can explain only through an analogy drawn from Aristotle's biology (especially *Generation of Animals*): the female supplies only the matter of which the embryo is made (*material cause*), and the male semen is the *efficient cause* of its development. For minerals, too, the process of development must be started somehow, and the impulse, according to Albert, is the 'influence' of the heavenly bodies, though this may be modified by the nature of the material and the place where the minerals are forming.

Then, the *formal cause*, that which makes a thing what it is: here the biological analogy is pushed still further, for Aristotle said that the male also contributes the *form* of the offspring, its *species* (e.g. the offspring of a dog is a dog and not any other kind of animal). In the same way, Albert argues, the *forms* of minerals are due to a 'formative power' that descends from the heavens through the influence of the stars—and this is what determines the particular kind of mineral that will be formed at any particular time and place. (The best-known example of this belief is the supposed formation of the seven metals under the influences of the seven planets.)

Last, the *final cause*, that for the sake of which a thing exists: this is hardly mentioned, presumably because Albert agrees with Aristotle that inanimate things like minerals can hardly be said to have an 'end' or 'purpose' of their own.

This whole account is un-Aristotelian in its emphasis on astrology. Yet to some extent it had its roots in Aristotle's cosmology, as described in the *Physics*, *The Heavens*, *Generation and Corruption*, and *Meteorology*: a spherical universe, with the earth at the centre, and as it were the *focus*, of all the motions, transmitted inwards from one etherial sphere to another, that cause all the changes in the atmosphere, sea, and land, in the life of plants and animals, and even in the growth of minerals underground. But in the course of centuries this scheme had been elaborated and fused with the notions of neo-Platonists and astrologers,[20] who assigned to each of the heavenly bodies more specific and more varied influences than Aristotle ever did. Albert believes in these 'powers', but he always maintains that they are subject to God's will.

Having thus dealt with the *essential* causes of stones (I, i) and metals (III, i), he next considers their 'accidental' properties, those features which, according to Aristotle (*Metaphysics*, VI, ii, 1026 a 33 ff.) are not really essential nor always present, but occur in some individuals and not in others. Again there are two parallel tractates: the one on stones (I, ii) deals with texture, colour, hardness, fissility or cleavage, density, structure, and fossils; the one on metals (III, ii) with fusibility, malleability, colour and lustre, taste and odour, and various chemical reactions. The systematic discussion of a list of physical and chemical properties seems to have been suggested by a similar list in *Meteor.* IV, and much of the material is drawn from that work and from *Generation and Corruption*; the account of colours, tastes, and odours, from the treatment of sense-perceptions in *The Soul* and *The Senses*. To all this Albert adds field observations of his own and, in the tractate on metals, information from alchemical sources.[21]

These two tractates (I, ii and III, ii) make vivid to us the difficulties that hindered the development of modern chemistry and mineralogy. The Peripatetic doctrine of elements and qualities was, in fact, quite inadequate for developing any sort of chemical classification of minerals. With metals, particularly, it is plain that if we regard fusibility, malleability, colour, etc., as 'accidentals' (because these can be altered by alloying, bronzing, annealing, etc.), we are left asking: But then what is it that is *essential*—the *real* difference between one metal and another? It was this uncertainty that fostered the hope of transmutation, which Albert does not entirely reject although he knows that many alchemists' claims are fraudulent (III, i, 9). On the strength of Aristotle's account of the transmutation of the elements in *Generation and Corruption* he accepts the theoretical possibility, and reasons that something of the kind must occur in nature, in the formation of ore minerals (III, ii, 6). But he seems to be doubtful whether the natural processes can be imitated successfully in the laboratories of the alchemists.

[20] See Appendix C for notes on astrological works.

[21] See Appendix D for notes on alchemical works.

Finally, in Books II, IV, and V, he carries out still further his plan for system and completeness, naming stones, metals, and 'intermediates', one by one, and describing each one, some of them in considerable detail. This kind of 'catalogue' is not found in Aristotle; but it was familiar in the popular medieval *herbals*, *bestiaries*, and *lapidaries*. The tradition goes back at least as far as Pliny and was still followed by the thirteenth-century encyclopedists.[22]

In the tractate on stones (II, ii) Albert incorporates an alphabetical lapidary, which is similar to, and probably partly based on, those of Arnold of Saxony, Thomas of Cantimpré, and the 'Dyascorides' cited by Bartholomew of England. Such unacknowledged use of others' works was not in those days regarded as plagiarism: Albert similarly incorporates a bestiary in his book on *Animals* and a herbal in his *Plants*. Compilations of this type seem to have been regarded as common property, at the free disposal of anyone who had occasion to write on topics animal, vegetable, or mineral.[23] Albert, in fact, was doing just about what anyone today might do in writing an elementary book on mineralogy—taking data from standard works familiar at the time.

The compilers of popular lapidaries transmitted some factual information; but their chief interest was the curative or magical powers of stones. Albert therefore prefaces his 'lapidary tractate' (II, ii) by another tractate (II, i) in which he endeavours to account for these wonderful powers. In order to understand his explanation, we must consider again the Aristotelian notion of *form*. To the mineralogist of today this term may suggest the 'crystal form' or 'habit' of a mineral; but to Aristotle, *form* was something more than shape or structure—it was the *essential being*, or identity of a thing; in living things, the 'life' or 'soul'. This is why Albert (I, i, 6) engages in what seems to us a needless argument, denying that a stone has a soul (*anima*) or is in any sense 'alive'. But even an inanimate thing has *form*, that which makes it distinctively what it is and able to do whatever it does (e.g. the *form* of an axe is what makes it able to cut). In this sense, then, the *forms* of stones account for whatever effects they produce. An excellent example is the 'power' of magnetism, essential to our identification or definition of the mineral magnetite. And medieval lapidaries ascribed many other 'powers', medical or magical, to other stones—

[22] See Appendix B for notes on lapidaries and the question of Albert's sources for *Min.* II, ii.

[23] Thorndike, 1923, Vol. I, pp. 777–8, Vol. II, p. 432.

powers that Albert considers to be inherent in their *forms* and imparted to them by the *formal cause*, the 'formative power' of the heavens.

This theme is further developed in a third tractate in this book (II, iii) on the *sigils*, images, or markings, found in certain stones. Albert intends (II, iii, 1) to distinguish between those made 'by nature' (picture agates, mineralized fossils, casts and moulds of shells, etc.) and those made 'by art' (antique cameos and intaglios); but subsequent chapters show that he often confuses 'natural' and 'artificial' figures, and knows little about gem-cutting. He recognizes the ancient practice of enhancing the powers of a stone by carving upon it some image or inscription, and gives his somewhat cautious approval by inserting here (II, iii, 5) another brief lapidary, of engraved gems bearing astrological figures.

The parallel book on metals (Book IV) is shorter and simpler than Book II, since less information was available about metals than about stones. The first two chapters describe sulphur and quicksilver, and the others take up all the other metals then known—lead, tin, silver, copper, gold, and iron (including steel). Since Aristotle had said little about metals, the material here is drawn partly from alchemical books and partly from Albert's own observations on visits to mines, smelters, or brass foundries.

Book V, on minerals intermediate between stones and metals, is a brief compilation, mostly from alchemical or medical sources: it includes salt, vitriol, alum, soda, etc.—the chief 'chemical reagents' of the alchemists' laboratories.

Taken as a whole, the *Book of Minerals* is an impressive attempt to organize a science of mineralogy. Despite its background of medieval thought, its many errors of fact or interpretation of fact, there is something here that we recognize: the introductory exposition of general principles (the origin, physical and chemical properties of minerals), followed by descriptions of individual minerals (appearance, mode and place of occurrence, uses, etc.). This general pattern is still to be seen in our own textbooks.

DATE OF COMPOSITION OF THE *BOOK OF MINERALS*

The *Book of Minerals* cannot be precisely dated. In fact the chronology of all Albert's Aristotelian commentaries, the writing of which must have been spread over many years, is a vexing problem for scholars.[24]

[24] Weisheipl, 1960, pp. 313–15, discusses this and gives references.

The Introduction to the *Physics* (I, i, 1, quoted above) indicates that that was the first work on natural science undertaken by Albert; and his list of the titles to be included (*Phys.*, I, i, 4) seems to represent his original plan for the whole series. But he did not write all the other works in that order: for example, at the beginning of *The Intellect* (*De intell.* I, i, 1) he says that the logical order is not necessarily the best order for teaching these subjects and therefore he will rearrange the following books. Then, too, there was the problem of sources: perhaps there were other works beside the *Movement of Animals* (*De principiis motus processivi*) that were written whenever he was able to obtain a text.

In the *Book of Minerals*, however, he refers to all of the six works that precede it in his original list, using the past tense, as if they were already completed, and mentions some of the others as future works. Evidence from such cross-references must be used with caution; sometimes Albert seems merely to be reminding the reader of what comes 'before' and 'after' in the course of study. But there are occasional slips, where one work is referred to in another, now in the past tense and again in the future, which lead me to suspect that Albert was working, at about the same time, on the four treatises which together make up his contribution to geography and geology—*The Nature of Places*, the *Properties of the Elements*, the *Meteorology*, and the *Book of Minerals*. This impression is strengthened by comparison of 'overlapping' ideas in the four works: the same points are explained and re-explained, sometimes in the same words, and comments or illustrations introduced in one place are repeated in another.

One of these treatises, *The Nature of Places*, contains the statement that it was written at Cologne (iii, 2: *Agripiam quae nunc Colonia vocatur, in qua istud volumen compilatum est*). A reasonable inference is that Albert embarked on his 'natural history' commentaries while he was still teaching at Paris, and continued them between 1248 when he returned to Cologne and 1254 when he became Prior Provincial. How many treatises would fall within this time-span is impossible to say.

Nor is internal evidence in the *Book of Minerals* itself very helpful. We know only that it was written after 1248, because Albert looks back to an incident that happened while he was a professor at Paris (II, iii, 1) and notes the recovery of Seville from the Moors (III, i, 4). There are many other passages certainly based on his own observations, but although Albert often tells us *where* he saw something interesting, he seldom tells us *when*; and an attempt to fit the localities into the known chronology of Albert's life reveals all too many possibilities.

Of particular interest, of course, are his reports on mining districts. We know that at some time or other he had travelled widely in order to learn about minerals (*Min.* III, i, 1: *Exul enim aliquando factus fui, longe vadens ad loca metallica, ut experiri possem naturas metallorum*). This statement is puzzling unless it is, as I am convinced, a recollection of his youth, before he joined the Order of Preachers. *Exul*—an exile, a homeless wanderer—seems a strange word for him to use of his condition as a Dominican; and even stranger is the assertion that his purpose was to learn about mining and metallurgy, if he refers to his journeys after he joined the Order. But some districts he may have visited, or revisited, later on. Goslar, for instance, which he mentions several times (*Min.* III, i, 10; III, ii, 4; V, 7), is not far from Hildesheim where he was *lector*, probably about 1234–5.

It is possible, then, that in writing the *Book of Minerals* Albert was drawing almost entirely on information acquired years earlier. Nevertheless, there are at least two observations—of the silver ores at Freiberg in Saxony (*Min.* III, i, 10 and IV, 5) and of the local impoverishment of a gold vein (*Min.* III, ii, 6)—which are so detailed that it is difficult (for a geologist at least) to believe that they were not made by a man who already had a definite theory in his mind, and took notes to use in a book already planned, if not under way. These notes, therefore, and perhaps the descriptions of alluvial gold (*Min.* IV, 7) and of the 'petrified bird's nest' at Lübeck (*Min.* I, i, 7), may date from Albert's journeys as Prior Provincial in 1254–6. The writing of the book might then belong to his stay at the Papal Curia in 1256–7. Perhaps, too, the Curia is the most likely place for his meeting with the men who told him about the Emperor Frederick's magnet (*Min.* II, ii, 11) and the occurrence of *smaragdus* in Greece (*Min.* II, ii, 17).

Another line of evidence also suggests that the *Book of Minerals* was not written before 1256–7 at the earliest: this has to do with Albert's sources. Since his original plan (*Phys.* I, i, 4) required a book on mineralogy, he undoubtedly began to collect and arrange material for this while he was still working on the preceding treatises. His method of selection is illustrated by his use of the chapters by Avicenna found in some manuscripts as an appendix to the *Meteorology*.[25] Albert put a few sentences

[25] See Appendix D, 9.

from Avicenna (on 'thunderstones') into his own version of the *Meteorology* (III, iii, 20); he quoted the chapter on mountains in his *Properties of the Elements* (II, ii, 5); and reserved the rest for the *Book of Minerals*.

But the source that he considered the most important of all—Aristotle's own 'Book of Stones'[26]—he was unable to obtain; and, for a time at least, I believe, he was unwilling to proceed without it. Meanwhile his search led him to other lapidaries, probably to those of Arnold of Saxony and Thomas of Cantimpré,[27] and to their sources, including a manuscript attributed to 'Diascorides' (also quoted by Bartholomew of England). These he probably obtained in Cologne or Paris or somewhere else in northern Europe. Bits of these, too, seem to have found their way into the treatises he was then writing: for example, in *The Nature of Places* (i, 5), which was written at Cologne, the illustration of a magnet that attracts iron at one corner and repels it at another (cf. *Min.* II, iii, 6); or, in the discussion of the rainbow (*Meteor.* III, iv, 8; 19) the mention of a quartz crystal used as a prism (cf. *Min.* II, ii, 8, *Iris*). These compilations also contained a few excerpts from the *Lapidary of Aristotle*, but Albert wanted a complete copy. His statement that he had sought for it persistently in many parts of the world (*Min.* III, i, 1) implies inquires made during his travels, perhaps over a fairly long period of time. He did, as we know, find another Aristotle manuscript, the *Movement of Animals*, in Campania, probably during his stay in Italy in 1256–7. But he did not find the *Lapidary of Aristotle*.

Additional light may be thrown on this problem by a short anonymous manuscript described by Paneth[28]. It is written in a north Italian hand of the early fourteenth century and entitled *Metals and Alchemy* (*De metallis et alchymia*). The contents agree almost exactly with some sections of the *Book of Minerals*: a chapter on transmutation (III, i, 9) and parts of the descriptions of the metals (IV, 1–8). Several questions arise here: Is this an unacknowledged source used by Albert, or is it his own composition? And is it an abbreviation of the *Book of Minerals*, or a first draft that Albert later elaborated? Its style is like Albert's, and it refers, as he does, to the *Meteorology* in the past tense and to the *Animals* in the future, thus indicating its place in a series of Aristotelian works. It does not read like an abbreviation: complete sentences follow each other, sometimes word for

[26] See Appendix A, *Pseudo-Aristotelian Works* 14, and Appendix B, 8.

[27] For these encyclopedists and the relation of their works to the *Book of Minerals*, see Appendix B.

[28] Paneth, 1929, 1930; Sudhoff, 1929.

word, as in the *Book of Minerals*, with little attempt at condensation or paraphrasing. And it is easy to see how Albert could have expanded it, by adding whole sentences or longer passages, into the version of the *Book of Minerals*.

Paneth's conclusions were that this is a copy of a genuine work of Albert, which he wrote in Italy, possibly at Bologna; that it circulated independently before the *Book of Minerals* was completed, or 'published', in the sense of becoming well known; and that it is the *De alchimia* mentioned in early lists of Albert's writings.

This is a tempting hypothesis. Many a teacher works up a new subject one topic at a time, and a short paper, intended to be complete in itself, is later incorporated in a book. Moreover, this method of composition would explain many of the difficulties in dating Albert's works. If Paneth is correct in thinking that this first draft was written in Italy, it might be dated 1256–7. But in that case it is odd that it contains none of the field observations which Albert later put into these very chapters, and which would presumably have been fresh in his mind if they were made during his journeys of the preceding two years. But of course the original of the Paneth copy was not necessarily written in Italy, and might have been much earlier, though not before the inception of the series of Aristotelian commentaries. Or a first draft written in Italy might have been reworked after 1257.

It is true that by 1258, when Albert was again in Cologne, he was turning his attention to biology; in that year he conducted a *disputatio*, answering questions about Aristotle's books on *Animals*,[29] and this was recorded and preserved by Conrad of Austria (presumably a fellow Dominican, although nothing more is known of him). But this does not prove that the *Book of Minerals* was finished by that time. Indeed, I suspect that Albert laid aside his notes on minerals, and perhaps a first draft, and wrote some of the biological treatises before he returned to it. Evidence of this is not conclusive, but merely suggestive: for example, in the *Book of Minerals* (I, i, 6) he cites *The Soul* (II, i, 3), and apparently quotes his own *digressio* on the difference between *form* in a mineral and *orm* as the *soul* (*anima*) in a living thing; and the chapter on the colours of minerals (*Min.* I, ii, 2) is more intelligible in the light of a long *digressio* in

[29] *Quaestiones de animalibus*, printed for the first time in the Cologne edition of Albert's works, Vol. XII. In addition, Thorndike (1923, Vol. II, p. 524), reports a manuscript of *Sleep and Waking* dated 1258.

The Senses (ii, 2), which also contains references to gypsum and chalk and a recipe for *lac virginis* (cf. *Min.* II, iii, 2 and V, 4). There are numerous parallels between the *Book of Minerals* and the *Animals*: for instance, on 'salamander's down' (*Min.* II, ii, 1; *Animals*, XXV, 47); on 'toadstones' (*Min.* II, ii, 2 and 12; *Animals*, XXVI, 8); on the nesting habits of eagles and cranes (*Min.* II, ii, 5; *Animals*, VII, i, 6 and XXIII, 9); on pearls (*Min.* II, ii, 11; *Animals*, XXIV, 74). None of these examples really proves which passage was written first, but taken all together they at least show that Albert had not stopped thinking about minerals while he was writing about animals, and suggest that he was still making notes for the *Book of Minerals*.

If the work on minerals was thus interrupted, the most probable reason for the delay is that Albert had not yet given up hope of getting a copy of the *Lapidary of Aristotle*. It may have been only after he had exhausted the possibilities of Italy, which he visited again in 1261–3, that he abandoned the search and finished the *Book of Minerals*.

On the whole, 1261–3 seems to me the most likely date for the completion of the book. If, however, some of the field observations were made during the journeys of 1263–4, the writing or final revision of the work must have been done still later—perhaps at Würzburg, after his preaching of the crusade was over. The text we now have shows some evidence of revision: in the first book (I, ii, 6–8), Chapter 6 closes with a formula appropriate to the end of the whole book, and Chapters 7 and 8 look like an afterthought, adding a few points not included earlier.

One attempt to date the *Book of Minerals* rests on the fact that it is not cited by Vincent of Beauvais[30], although he cites several of Albert's other works—*The Soul*, *The Senses*, *Sleep and Waking*, and *Animals*. Therefore, it is argued, the *Book of Minerals* cannot have been available before 1250, the supposed date of completion of Vincent's encyclopedia. Thorndike[31], however, has questioned this dating of Vincent's work. Be this as it may, it is, I think, quite probable that the biological works that Vincent cited were finished before the *Book of Minerals*.

The opinions of 'Albert of Cologne' on minerals are quoted at some length in the *Summa philosophiae*,[32] formerly ascribed to Robert Grosseteste, who died in 1253; but the *Summa* is now believed to be the work of a follower of Grosseteste, and to have been written between 1265 and

[30] See Appendix B, 14.
[31] Thorndike, 1923, Vol. II, pp. 459–61.
[32] Grosseteste, ed. Baur, 1912, Vol. 9, pp. 625–43.

1275.[33] The citations show that the *Book of Minerals* was recognized as authoritative before Albert's death, but do not establish a 'date of publication'.

To sum up: the *Book of Minerals* was certainly written after 1248. I believe it was begun at Cologne before 1254, then delayed while Albert searched in vain for the *Lapidary of Aristotle*, and finished in Italy either in 1256–7 or more probably in 1261–2, though revisions may have been made even later. This dating is not very satisfactory, but it is perhaps the best we can do for a work that seems to have given Albert a good deal of trouble.

TEXT AND TRANSLATION

The Albertus Magnus Institute of Cologne, which in 1951 began the publication of a new edition of Albert's complete works, has not yet produced a text of the *Book of Minerals*. I have therefore used the text of Borgnet (*Opera omnia*, Paris, 1890–9, Vol. V: *Mineralium libri V*), which differs little from that of Jammy (Lyon, 1651, Vol. II, Part iv). I have also used two earlier printed editions: *De mineralibus*, Johannes et Gregorius de Gregoriis, Venice, 1495; and *Liber mineralium*, ed. Jacob Köbel, Oppenheim, 1518. In a few places, indicated in the footnotes, I have preferred the readings of the latter to those of Borgnet, but I have not attempted to collate the texts throughout. Nor have I felt myself competent to undertake a critical examination of the many extant manuscripts, a number of which have been listed by Thorndike.[34]

The work has been known by various titles in addition to those given above: *Mineralia, Lapidarius, Liber de mineralibus et lapidibus, De mineralibus et rebus metallicis*. I have chosen *Book of Minerals* as simple, and adequately descriptive of its contents.

In translating, my first concern has been to make Albert's thought intelligible to readers of today. Albert was a clear thinker; but he was a prolix writer and his style is monotonous, even allowing for the natural difference in pace between medieval Latin and modern English. I have broken up his longer sentences and have repunctuated and reparagraphed, in order to produce a more 'readable' English version. But I have not

[33] McKeon, 1948, pp. 7–13.

[34] Thorndike, 1923, Vol. II, p. 524, footnote 3.

intentionally altered the meaning except where Borgnet's text seems to me to be wrong. Square brackets indicate such changes, or the addition of a few explanatory words where they seem to be needed; Borgnet's readings and, in some cases, additional comments, will be found in the footnotes.

BOOK OF
MINERALS

BOOK I. MINERALS

Tractate i. Stones in General

Tractate ii. The Accidental Properties of Stones

BOOK II. PRECIOUS STONES

BOOK III. METALS IN GENERAL

BOOK IV. THE METALS INDIVIDUALLY

BOOK V. MINERALS THAT SEEM TO BE INTERMEDIATE BETWEEN STONES AND METALS

BOOK I
MINERALS

TRACTATE i
STONES IN GENERAL

CHAPTER 1: THE PLAN OF THE BOOK, AND THE DIVISIONS, METHOD, AND ORDER OF THINGS TO BE DISCUSSED

This chapter is a general introduction, stating Albert's intention—to fill a gap in the existing series of books on natural science, coming after Meteorology *and before the biological works—and outlining his plan for the whole treatise. The authorities mentioned are cited again in later books as writers of lapidaries or alchemical works (see Appendixes B and D).*

MIXING and hardening, and likewise solidification and liquefaction, and all the other ways in which things are acted upon, have already been discussed in the book on *Meteorology*.[1] Among natural things the first in which such effects appear are the stones and metals, and intermediates between these, like *marchasita* and alum and other things of that kind. And since these are the first compounds naturally formed from the elements, inasmuch as they come before the combinations[2] that are alive, they are the next subject to be discussed after the *Meteorology*: for they seem to contain little except a simple mixture of elements. We have not seen Aristotle's books about these [minerals], but only some excerpts from them; and what Avicenna says about [minerals] in the third chapter of the first book which he wrote about them is not sufficient.

First, then, we shall investigate stones, and afterwards metals, and finally substances intermediate between these; for in fact the production of stones is simpler and more obvious than that of metals. Many things come to mind which ought to be said about the nature of stones in general,

[1] *Meteor.* IV, which has been called the 'chemical treatise'.

[2] *complexionata.* Albert (*Phys.* II, ii, 1) defines the terms used here: minerals are *commixta*, simple 'mixtures' of elements. Plants are *complexionata*, 'combinations' of humours. Animals are *composita*, organisms 'composed' or built up of tissues and organs. But his usage is not always strictly consistent with the definitions.

and these we shall put first. And then of course we shall discuss particular stones, such of them as have names. But we shall make our discussion of these brief, since the causes of many of the things that must be mentioned have already been determined in the *Meteorology*.

In treating of stones in general, we shall investigate their material and the immediate cause that makes them, and the place where they are produced; and then, the way in which they are mixed, and the cause of the variety of their colours and of the other accidental properties found in them—such as greater and lesser hardness, fissility and non-fissility, porosity and compactness, heaviness and lightness, and so on; for stones seem to have no small variety, not only in the specific nature and number, but even in the general character, of such properties.

There are indeed some men of the highest authority in philosophy who have treated of some kinds of stones, although not of all. Among these are Hermes, [Evax],[3] King of the Arabs, and Diascorides, Aaron, and Joseph; but they have treated only of precious stones, not stones in general. Even less satisfactory is the account given by Pliny in his *Natural History*: for he does not offer an intelligent explanation of the causes common to all stones. But we do not need to introduce the opinions of all these men, because knowledge of this subject is not so occult that we have to extract it from among the errors of many authorities. The nature and constitution of stones will be sufficiently well understood when we understand the material that is peculiar to them, the immediate cause that produces them, their forms, and their accidental peculiarities, according to the method of inquiry outlined in the fourth book of the *Meteorology*.[4]

We do not intend here to show how any one of these may be transmuted into another; or how, by the remedy of that medicine the alchemists call the *elixir*, their diseases may be cured, or their occult properties made manifest, or conversely their manifest properties be removed. But instead we shall show how they are mixed from the elements, and how each one is constituted in its own specific form. Therefore we do not trouble to investigate the difference between stone and spirit or soul, or between body or substance and accidental properties. These are what the alchemists investigate, calling 'stone' everything that does not evaporate

[3] *Cuates* (or *euates* in texts of 1495, 1518) is an error for *Evax*, later cited several times, once as 'Evax King of the Arabs' (II, ii, 1, *Agathes*).

[4] *Meteor.* IV, 8, 385 a 12 ff. gives a classification of physical properties which served Albert as a model in discussing the 'accidental' properties of stones (I, ii) and metals (III, ii).

in the fire; and this they call 'body' and 'substance'. But what does evaporate in the fire—like sulphur and quicksilver, which impart various colours to the so-called 'stones'—they call 'spirit' and 'soul' and 'accidentals'. But it is the task of another science[5] to investigate these things which depend so much on occult theories and practices.

We shall continue here the method we have used elsewhere, subdividing the whole work into books, and the books again into tractates, and these finally into many chapters.

For when dealing with many particulars we must first understand their natures from the evidences and effects [observed], and proceed from these to their causes and compositions; for the evidences and effects are more obvious to us. But in [dealing with] the nature of universals, which we have mentioned in all the preceding books, we had to proceed in the opposite way, [reasoning] from the cause to the effects and powers and evidences; for in such matters, general and confused phenomena are more obvious, at least so far as we are concerned, as has been shown in the first book of the *Physics*.[6]

The place of the present book in the series of books on natural science has been adequately indicated at the end of our book on *Meteorology*,[7] where we spoke of the order in which these subjects should be discussed: for the stones and metals are more *homeomerous*[8] than plants, which have a variety of parts—root, leaf, flower, and fruit; and *homeomerous* things naturally come before *anhomeomerous* things. Therefore the treatise on stones and the other minerals should come before those on living bodies.

CHAPTER 2: THE MATERIAL OF STONES

Here Albert begins his discussion of the causes *of stones, taking first the* material cause, *that is, the* matter *of which they are made. His 'chemistry' is that of Aristotle's* The Heavens, Generation and Corruption, *and* Meteorology

[5] 'another science' is alchemy, to which Albert does in fact devote some attention, especially in Book III, i.

[6] This paragraph is based on Aristotle's statements about scientific reasoning in *Phys.* I, 1, 184 a 10 ff.

[7] *Meteor.* IV, 12, 390 b 20. Albert's version (*Meteor.* IV, iv, 8) is more specific, saying that as there are three kinds of things in nature—minerals, plants, and animals—so the study of them is similarly divided into three parts, which are to be taken up in that order, in separate works.

[8] The *homeomerous* or 'uniform' substances are defined in *Meteor.* IV, 10, 388 a 13, and in *Parts of Animals*, II, 1, 646 a 13–25. See Appendix A, 4 and 9.

(*Appendix A, 2, 3, 4*), *but its application to stones is based on Avicenna's* De congelatione et conglutinatione lapidum (*Appendix D, 9*). *The formation of stones from Earth* (*gravel, sand, or dust*) *requires a 'gluing together'* (conglutinatio) *of the dry particles by moisture. Thus any stone, however hard and apparently dry, must contain some of this cementing Water: otherwise it would simply fall apart.*

To begin, then, with our treatment of the nature of stones: we say in general that the material of all stone is either some form of Earth or some form of Water. For one or the other of these elements predominates in stones; and even in stones in which some form of Water seems to predominate, something of Earth is also important. Evidence of this is that nearly all kinds of stones sink in water: and so they must be rich in the material of Earth, as we have said in the science of *The Heavens*.[1] For if the lighter[2] elements were predominant in them, undoubtedly they would float on water. Now no kind of stone floats, unless it is spongy, or burnt and made spongy by burning, like pumice and the stone spewed out by hot springs and the fire of a volcano; and even of these, if they are reduced to powder, the powder sinks in water. Furthermore, if in transparent stones there were not something earthy mixed with the Water and imposing a boundary[3] on the moisture, they would not sink in water, as rock crystal and beryl do; for ice and the other things that are entirely or chiefly made up of Water do not sink. And likewise, all stones that are produced in the kidneys and bladders of animals are made of a viscous, gross, and earthy moisture; and therefore something of the sort must be the material of stones.

In speaking in particular of those stones which are made of Earth, it is perfectly clear that in these Earth is not the only material, for this would not cohere into solid stone. For we say that the cause of coherence and mixing is moisture, which is so subtle that it makes every part of the

[1] *The Heavens*, IV, 4, 311 a 15: heaviness and lightness are explained by the doctrine of 'natural places' and 'natural motions'. The natural place of Earth is at the centre of the world and its natural motion is downwards towards the centre. Therefore Earth, or anything composed mostly of Earth, will sink through all other elements; or, conversely, anything that does so sink must be composed mostly of Earth.

[2] *superiora*, literally 'upper', since Fire and Air have their natural places above Water and Earth.

[3] *Gen. and Corr.* II, 2, 329 b 31 distinguishes between solid and liquid: a solid is *terminatum*, 'determined by its own boundary', but a liquid (or anything that is very moist) has no such 'boundary' of its own, but takes the shape of its container. Cf. I, i, 3, note 8.

Earth flow into every other part; and this is the cause of the thorough mixing of the parts of the material. And in that case, if this moisture were not soaked all through the earthy parts, holding them fast, but evaporated when the stone solidified, then there would be left only loose, earthy dust. Thus there must be something viscous and sticky, so that its parts join with the earthy parts like the links of a chain.[4] Then the earthy dryness holds fast to the moisture, and the watery moisture existing within the dryness gives it coherence.

Avicenna testifies to this when he says that pure Earth does not become stone,[5] since on account of its dryness Earth does not produce coherence, but rather a tendency to break into little pieces; for the dryness predominating in it prevents it from sticking together. The same philosopher explains that sometimes clay is dried out and becomes something intermediate between stone and clay, and then after a while it becomes stone. And again he says that the clay most suitable for transmuting into stone is unctuous, and the reason why that kind does not break into little pieces or crumble into dust is that its moisture is not easily separable from it.

Evidence of this is that in the stones themselves there frequently remain layers of Earth; it is hard dry Earth, and if it is compressed or pounded it becomes dust. And the cause of this simply that its moisture, which was not unctuous or viscous enough, evaporated when the stone solidified; and so the Earth was left hard and easily broken, because of the solidifying power of the surrounding stone. And there is still another evidence of this: for when stones are produced not in one continuous mass, but like timbers,[6] one above another, the earth in the intervening layers is not firmly united, but breaks into pieces, if subjected to pressure or a blow, and yet it is hard. And the cause of this we have stated above.

And that it is the viscous and unctuous moisture which gives coherence to the material of stone is indicated by the fact that the animals called shellfish[7] are very commonly produced with their shells in stones. These

[4] *Meteor.* IV, 9, 387 a 12 uses the analogy of a chain to explain the consistency of viscous things: they do not fall apart into drops (like a liquid) nor into grains (like a friable solid).

[5] *Terra pura lapis non fit* is the beginning of Avicenna's *De congelatione*; the next few sentences are also quoted or paraphrased from this.

[6] *asser*, a pole or beam: the outcrop, on a cliff or quarry face, of alternating strata of sandstone and shale is aptly compared to timber-work with the interstices filled with clay.

[7] *testudo*, in classical Latin, is a tortoise; but Albert uses it for any kind of shell; cf. *Animals*, XXIV, 32, where *testudines* are snail shells.

are extremely common in the stones found [at Paris],[8] in which there are many small holes shaped like the shells which some people call moonshells.[9] For the cause of this is the moisture which has evaporated there; and being confined by the surrounding material, it rolled itself up, hardening first on the outside and coiling inwards, and received vital spirit, as we have said in the fourth book of the *Meteorology*.[10]

This then is the common material of those stones which are not transparent or nearly so. But there are many different kinds, as will appear in the following chapters.

CHAPTER 3: THE GREATER OR LESSER TRANSPARENCY OF STONES

Continuing his account of the material cause, *Albert now passes from stones made of Earth (by Avicenna's process of* conglutinatio) *to stones made of Water, by the process of* congelatio, *the changing of liquid to solid. The theory offers a convincing explanation for glass and minerals like quartz, in which one of the most striking characteristics of Water, its transparency, seems to persist; but their solid state is evidence of a content of Earth. This is further discussed in I, i, 9.*

OF stones that are transparent to a greater or lesser degree, like those called gems, it can be said in general that their common material is not pure Water. For these stones are a sort of glass produced by the operations of nature; and therefore they are of a more subtle mixture and a clearer transparency than glass made artificially. For although art may imitate nature[1] nevertheless it cannot reach the full perfection of nature. And evidence of what we have said—namely that Water acted upon by dryness, either hot or cold, is the common material of these [transparent] stones—is that glass[2] is made from a moisture of this sort, which is melted

[8] *parvis:* evidently an error for *Parisiis.* Cf. Albert's *Properties of the Elements* (II, ii, 5) for another mention of these fossil moulds or impressions of shells *in lapidibus Parisiensibus.* The Paris Basin is made up of Cretaceous and Tertiary sediments, many of them richly fossiliferous.

[9] *lunares:* perhaps the species of *Natica* still called 'moonshells'; perhaps less specific, since there was a general belief that some marine animals were directly affected by the moon (cf. Albert, *Animals*, XXIV, 32).

[10] *Meteor.* IV, 1, 379 b 7: spontaneous generation in putrefying material; but a closer parallel, relating to shellfish, is *Generation of Animals*, III, 11, 762 a 19.

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[1] 'Art imitates Nature'—Aristotle, *Phys.* II, 2, 194 a 22 and elsewhere.

[2] Glassmaking is described in detail by

out of various ashes, either of lead or flint or iron or anything else, by the strongest fire. That this moisture is Water is shown by the fact that it is solidified by cold and is melted and liquefied by intense dry heat.[3] But that the moisture has been acted upon by earthy, burnt dryness is proved by the fact that it is melted only out of ashes, by the most intense roasting, as we have said. In the art of glassmaking which depends upon alchemy this is clearly shown: for the more subtle vapour in earth or stone is sometimes confined by the surrounding material and, being compressed upon itself, it becomes moist, as happens in clay pots containing some moisture when they are shut up and heated [in a kiln].[4] And when this moist humour is thus intensely acted upon by dryness, and the force of dryness [works] within it, it grows firm and solidifies into stone. But it is not the means by which stones are produced, but rather the common material in them, which is to be discussed here. Whether their solidification is the effect of heat or of cold will be shown later.

But that Water is the sort of material of [which] stones of this kind [are made] is shown by the fact that in some places, where there is a strong power capable of producing stones,[5] water descending drop by drop as rain, or flowing in some other way, grows together into stone,[6] for it is acted upon as it descends first of all by earthy dryness, according to the nature and operation of the place; and so it becomes material suitable for stone. And this is shown by the great transparency of such stones. Now since the transparency of Air and Fire is not indestructible, the transparency [in this case] must necessarily be that of Water; and therefore the material peculiar to these stones will be of the nature of Water.

As to what some of the ancients say, in pointing out the material of

Theophilus (Book II, Chs. 1–5, Hendrie, 1847), who gives directions for combining two parts of beechwood ashes with one part of clean river sand. He does not say anything about lime, though this must have been present. Lead is mentioned in other medieval recipes, and also various metals or metallic oxides used for colouring (Hendrie, op. cit., notes, pp. 163–77). Cf. I, ii, 2, note 12.

[3] *Meteor.* IV, 6, 383 a 1: Water and watery things freeze by cold and melt by heat; therefore things that behave in a similar way, such as glass and metals, are assumed to be made of Water.

[4] The context in the passage that Albert is paraphrasing (*Meteor.* IV, 6, 383 a 24) shows that the pottery is being fired: if not thoroughly dried out beforehand, the clay steams and softens and becomes distorted in the kiln.

[5] *virtus lapidum generativa*, the mineralizing or petrifying power invoked by Avicenna (*De congelatione*, Holmyard and Mandeville, 1927, p. 46).

[6] Avicenna, loc. cit., thus describes the formation of dripstones in caves or mineral springs, assuming that the water itself hardens into stone.

stones—that there settles out of running water something that stays at the bottom, and this becomes stone[7]—this I do not accept; because what settles out of water is an earthy substance, and therefore often the stones produced from it have as their material not Water which has been acted upon by the power of Earth, but rather Earth which has been acted upon by the power of Water. Evidence of this is that such stones are usually not transparent, although they have definite shapes;[8] and they are said to be without any fissility, having rather a tendency to break into little pieces; and the common people call them flints (*silices*). Especially strong evidence of what has been said is offered by rock crystal and beryl, which have, as it were, taken on completely the form of frozen Water; and Aristotle[9] said of these that they are made of Water by the complete removal of heat.

But just as we have said that the material of the stones mentioned in the preceding chapter is not simple Earth, but [Earth] acted upon by unctuous, viscous moisture; so it must be understood, of these stones [in this chapter], that simple watery moisture cannot be the [only] material of transparent stones. For as we have shown elsewhere, such moisture [i.e. simple Water] does not grow firm by boiling,[10] nor solidify by dry heat, nor harden [permanently] by any cold. Therefore it must necessarily be mixed with a little very subtle Earth; and in addition it must be very strongly acted upon by earthy dryness, so that the power of this [dryness] may, as it were, take a firm hold on all parts of the moisture, although without yet transmuting the substance of such moisture into Earth. For in every transmutation of the elements such an effect precedes the transmutation of the substance, because the power of the transmuting element takes hold completely, and the parts of the element that is being transmuted assume the shape of the other before the substance is transmuted; and if these are then mixed into anything made of elements, that [substance] will have the material of one element and the powers of the other.

[7] Avicenna again, loc. cit.

[8] *terminati*. Albert means river pebbles, not realizing that their shapes are due to wear and tear while being transported by water; he believes that they are formed *in situ* (cf. I, ii, 1).

[9] *Meteor.* IV, 10, 388 b 17. The passage really refers to *ice* (Greek *krustallos*). Confusion later arose from the use of the same word (Latin *crystallus*) for clear, colourless quartz, 'rock crystal', and similar minerals. Albert himself did not misunderstand the passage in the *Meteorology*, but he found this statement in other lapidaries, handed down from Pliny (*Nat. Hist.* XXXVII, 9, 23).

[10] *elixatio*, a technical term in alchemy for 'boiling dry'—either evaporation to dryness, or thickening and solidifying to something like porridge. *Meteor.* IV, 6, 383 a 13 says that pure water does not 'thicken' in this way when boiled.

And this, the greatest skill of the alchemists, Hermes[11] teaches in his *Secret of Secrets*, saying metaphorically: the stone 'gently, with great skill, ascends from earth to heaven, and again descends from heaven to earth. Its nurse is the earth, and the wind carried it in its belly.' For intending to teach the operations of alchemy he says it 'ascends to Heaven' when by roasting and calcination it takes on the properties of Fire: for alchemists mean by *calcination*[12] the reduction of material to powder by burning and roasting. And the material 'again descends from heaven to earth' when it takes on the properties of Earth by *inhumation*,[13] for inhumation revives and nourishes what was previously killed by calcination. And when he says that 'the wind carries it in its belly' he means the *levigation*[14] of the material, raising it to the properties of Air. And [the reason] why he says that the wind carries the material in its belly is that, when the material is placed in an *alembic*[15]—which is a vessel made like those in which rose-water is prepared—then, by evaporation it is rendered subtle and is raised towards the properties of Air: and that is why he says, 'the wind carries it in its belly'. And there distils and issues from the mouth of the alembic a watery or oily liquor with all the powers of the elements.

It is only by toil and with many mistakes that art accomplishes this; but nature [does it] without difficulty or toil. And this is because the powers existing in the material of stones and metals, when subjected to these operations, are influenced by the powers of the heavens, which are sure and effective. And these powers are the operations of intelligences[16] which do not make mistakes—unless by some accident, for instance because of the uneven qualities of the material. But in the art of alchemy there is nothing of this, but only the miserable assistance of skill and fire.

All this shows that whether Earth or Water be called the material of stones, it certainly must be strongly acted upon by the qualities of other elements.

Let this, then, be our account of the common material of stones.

[11] From the *Emerald Table* (Steele and Singer, 1928, p. 48; see Appendix D, 7).

[12] *calcinatio*, technical term for burning to a *calx*. The prototype was quicklime, but *calx* was also applied to other earthy products obtained from metals in alchemical operations.

[13] *inhumatio*, lit. 'burial'; alchemical term explained in III, i, 10, note 23.

[14] *levigatio*, lit. 'making light'; still another alchemical term, for distillation or sublimation.

[15] *alembic* (from Arabic), originally the still-head, fitted over the top of another vessel and provided with a beak in which the vapour condensed. Rose 'essence' seems to have been one of the first products made by distillation on a large scale. For notes on alcohol see III, i, 2.

[16] Movers of the celestial spheres: see I, i, 8.

CHAPTER 4: THE PRODUCTIVE OR EFFICIENT CAUSE OF STONES, ACCORDING TO THE DIFFERENT OPINIONS OF PHILOSOPHERS

This chapter begins the discussion of the efficient cause*—the agent or process by which stones are formed. Here Albert follows a method often used by Aristotle, first reviewing and criticizing the theories of others before giving his own, the 'correct opinion' of I, i, 5.*

The question of 'soul' (anima) *may seem irrelevant, but it leads up to the later question of* form. *In* animate *beings Aristotle regarded the form as 'soul', the principle of life, which functions at different levels of organization in men, animals, and plants (Appendix A, 5). In this scheme minerals would occupy a place below plants, being without soul in this sense; yet they are, in some sense, more than simple matter, since they have form. This distinction is further discussed in I, i, 6.*

ALMOST all who have spoken about stones say that the efficient cause of stones is a *mineralizing power*. But it does not seem adequate to assign this power as the efficient cause of stones, since it acts in common not only upon stones but also upon all metals. For these [authorities] do not indicate by any specific distinction what sort of thing they mean by a 'mineralizing power'. Nor is anything more found out from Avicenna, than that by this 'mineralizing power' stones are produced from Earth and Water.

Hermes, too, in the book that he wrote on *The [Universal] Power*,[1] seems to say that the productive cause of stones is a certain power, which, he says, is one in all things, but on account of the variety of things it produces, it is called by different names. He gives as an example the light of the Sun which alone produces all things; but when it is divided, no longer acting through a single power in the things acted upon, it produces various effects. He chose to assign this power first of all to Mars,[2] as its source; but it varies greatly in proportion to the effects of the light from other stars and of the material that receives it, as we have said; and hence different kinds of stones and metals are produced in different places.

This statement is entirely contrary to nature, since here we are not

[1] *de minerali virtute*; but (ed. 1518) *de universali virtute* is more likely correct, since the latter title is cited again in II, i, 2. For Hermes, see Appendix C, 3.

[2] *Mars* would seem to be a mistake for the *Sun*, which is given this pre-eminent power in the citation of Hermes, apparently from this same book, in II, i, 2.

looking for first causes which are responsible for action and movement, and which are perhaps the stars and their powers and positions: for this is the proper task of another science. But we are looking for immediate, efficient causes, existing in the material and transmuting it. And if what Hermes says were correct, then, once we knew the cause producing stones, we should know the efficient cause of everything that can be produced. For we know that the motion and power of the heavenly bodies, the rising and setting and rays of the stars, are causes different [from other natural causes]. Furthermore, these are acting causes in a different sense (*aequivoce*), since they have nothing in common with the materials of the things that can be produced. But, in accordance with the proper methods of natural science, we are looking for causes appropriate to their effects, and especially for the material and whatever transmutes it, in the same [material] sense (*univoce*).

Therefore Empedocles,[3] long after Hermes, declared that stones are produced by burning heat, taking his assertion from the old story told of Pyrrha and Deucalion,[4] in which stones are called the 'bones of the Great Mother'. For bones, according to Empedocles,[5] are chiefly composed of fiery parts.

But this is completely false, since we know—and it will be shown later—that some stones are produced by cold. For as we have already said in the book on *Meteorology*,[6] things of which the principal material is Water harden by cold. Moreover, the statement of Empedocles is not satisfactory, because we shall soon show, in the second book on *The Soul*,[7] that there is a hot, burning element in ashes, but it does not consume [things and convert them] into any particular form except when influenced

[3] Empedocles (fifth century B.C.) is supposed to have originated the doctrine of four elements. Seneca (*Quaestiones naturales*, III, 24) quotes his opinion that there is fire beneath the earth; and Albert (*Meteor.* IV, ii, 1) tells the story of his death in the crater of Mt. Etna.

[4] Ovid, *Metamorphoses*, I, 363–415: Deucalion and his wife Pyrrha, sole survivors of the Flood, consulted an oracle and were told to go forth 'casting the bones of the Great Mother behind them'. It was Pyrrha who rightly interpreted this to mean the stones of the earth. Pyrrha's stones became women and Deucalion's men, and so the land was re-peopled.

[5] Aristotle (*The Soul*, I, 5, 410 a 5) quotes a few lines from Empedocles, saying that bones were created of 'two parts out of eight of gleaming Nestis (Water) and four of Hephaistos (Fire)'.

[6] See I, i, 3, note 3.

[7] *The Soul*, II, 4, 416 a 10. Albert's version (*The Soul*, II, ii, 4) states it thus: 'For there is operative in food not the specific form of Fire but that of the living body and the power of the soul, as we have said; and therefore things are not changed into the specific form of Fire, but of flesh and bone, which are the specific forms of the organs of the soul.'

by some other power which guides it towards some specific form; just as the heat of digestion, influenced by the soul, converts what it transmutes into the specific form of flesh and sinew and bone and similar parts of the living body.

Democritus[8] and some others say that things made of elements have souls, and that these [souls] are the cause of the production of stones; and therefore he says that there is a soul in a stone, just as there is in any other seed for producing anything; and this moves the heat within the interior of the material in the production of a stone, just as the hammer is moved by the workman in the production of an axe or saw.

But we have shown elsewhere that this [statement] cannot stand: for the soul is first discovered not in animals which have senses, but in plants; for stones have no function corresponding to a soul, since they do not use food, or [have any] senses, or [even] life, as shown by any vital activity. And to say that there is a soul in stones simply in order to account for their production is unsatisfactory: for their production is not like the reproduction of living plants, and of animals which have senses. For all these we see reproducing their own species from their own seeds; and a stone does not do this at all. We never see stones reproduced from stones;[9] but we see each stone produced by some cause that is present in the place where it is produced; because a stone seems to have no reproductive power at all.

And some of those in our own time who are practitioners of alchemy seem to say that all stones are produced entirely by accident, and there is no other special cause of their production. For they say that fiery heat wherever it may be found, by roasting suitable material, turns it into stone, just as such material is turned into brick (*lapis coctus*) by baking in the fire. They say that these stones have no real principle that produces them except the material in them; and furthermore, stones have no specific form, although certain passive properties of the material, such as hardness, take the place of form, as has been shown in the book on *Meteorology*.[10] Solidification and its effects are due to the kind of material

[8] Democritus, the atomist philosopher, was known to Albert through Aristotle, who, however, does not attribute to him this statement (unless it is a misquotation of *The Soul*, I, 2, 405 a 8 ff.). But there were also alchemical works under the name Democritus, and Albert may be thinking of some statement in one of these about 'souls' or 'spirits' (volatile constituents) in minerals. See Appendix D, 5.

[9] But see II, ii, 14, *Peranites*, a stone that reproduces.

[10] *Meteor.* IV, 8, 384 b 24 ff. classifies substances according to their 'passive qualities'—hardness, fusibility, ductility, etc. See topics treated in I, ii and III, ii.

and its passive properties, and are not substantial forms. And these [men] draw persuasive arguments from the operations of the alchemists, which all seem to be accomplished by roasting heat; and [they argue that] stones and metals are made by something that acts in the same way; and hence it is not necessary to have any special efficient cause in nature, since nothing in nature is developed into its specific substantial form if it lacks or is deficient in [the properties of] that specific form.

But the consequence of these [arguments] is intolerable error—namely that every stone would be of the same species as every other stone, but they [would] differ to a greater or lesser degree in their specific, material properties, for all stones have solidification, and its effect, hardness, instead of specific form. But that this is false is shown by the various powers and actions[11] of various stones, which are entirely the consequence of the various specific forms of the stones. Moreover, stones would have to belong to the same species as metals, which also, being produced in the same way, have solidification and hardness instead of specific forms. Furthermore, if there were no efficient cause of stones except drying heat then all stones would be dissolved by moist cold, as we have demonstrated in the fourth book of the *Meteorology*;[12] and we do not see this happen.

These, then, are the erroneous opinions stated by the ancients about the productive cause of stones.

CHAPTER 5: THE EFFICIENT CAUSE OF STONES, ACCORDING TO THE CORRECT OPINION; AND ITS PARTICULAR INSTRUMENTS

Albert now attempts to formulate his own, the 'correct', theory about the mineralizing power. *He makes use of a biological analogy found in some alchemical books—that minerals 'grow' from 'seeds' in the earth. But his treatment of it is directly based on Aristotle's statements in the* Generation of Animals *(see Appendix A, 10): in the production of offspring the female supplies* matter *and the male supplies* form, *as the artisan forms his materials by means of his tools. In the formation of minerals the 'tools' are heat and cold, designated in the*

[11] These 'powers' of stones are treated in Book II.

[12] *Meteor.* IV, 6, 383 b 15: moist cold and dry heat are 'contraries', so whatever is formed by one must be destroyed by the other.

Meteorology *(see Appendix A, 4) as* active *qualities, working on the* passive *qualities of matter, moisture and dryness. Discussion of the relation of* efficient *and* formal causes *is resumed in I, i, 8–9.*

NOW, drawing the correct conclusion from all this, we say that in very truth the productive cause is a mineralizing power which is active in forming stones. For the mineralizing power is a certain power, common to the production of both stones and metals, and of things intermediate between them. And we say in addition that if this is active in forming stones, it becomes a special [power for producing] stones. And because we have no special name for this power, we are obliged to explain by analogies what it is.

Let us say, then, that just as in an animal's seed, which is a residue from its food, there comes from the seminal vessels a force capable of forming an animal, which [actually] forms and produces an animal, and is in the seed in the same way that an artisan is in the artifact that he makes by his art; so in material suitable for stones there is a power that forms and produces stones, and develops the form of this stone or that. This can be seen still more distinctly in the gums that ooze out of trees; for we see that these are moisture that has been intensely acted upon by earthy dryness; and so they are solidified by cold. But when they remain in the tree and do not ooze out, a force in the tree converts them into wood and leaves and fruit. In exactly the same way it happens that, when dry material that has been acted upon by unctuous moisture, or moist material that has been acted upon by earthy dryness, is made suitable for stones, there is produced in this, too, by the power of the stars and the place, as will be shown below, a power capable of forming stone—just like the productive power in the seed from the testicles, when it has been drawn into the seminal vessels; and each separate material [has] its own peculiar power, according to its own specific form. And this is what Plato[1] said—that the heavenly powers which act upon things in nature are poured into matter according to its merits.

And just as we have shown in the books on *Physics*,[2] every formative power which makes anything into a specific form has its own particular instrument by which it acts and produces its work: so this power, too,

[1] Chalcidius's commentary on Plato's *Timaeus* (295–6) says that *form* is good and *matter* is evil, and the intentions of Providence are thwarted by the perversity of matter.

[2] In Aristotle's *Physics* (see Appendix A, 1), all change is regarded as motion, and all motion requires a mover.

existing in the particular material of stones, has two instruments according to different natural conditions.

One of these is heat, which is active in drawing out moisture and digesting the material and bringing about its solidification into the form of stone, in Earth that has been acted upon by unctuous moisture. And this heat is controlled in its operations by a formative power, just as the heat which digests and transmutes the seed of an animal is controlled by the formative power in the seed. For otherwise, undoubtedly, if the heat were excessive it would burn the material to ashes; or if it were insufficient it would leave the material undigested and unfit for the form of a stone.

The other instrument is in watery moist material that has been acted upon by earthy dryness; and this [instrument] is cold, which is not so active in congealing moisture [in stones] as it is in metals, but which is active in expelling moisture: for this produces the most intense hardening and solidification. And since it completely expels moisture, so that only enough remains in the material to hold it together, such stones can by no means be liquefied by dry heat. And this is what Aristotle[3] says—that crystal is produced from Water by complete removal of heat.

Evidence of this is that the operations of alchemy fail in liquefying stones, except by adding some other moist material.[4] It is clear why the operations of the alchemists are even more difficult and unsuccessful in making stones than in making metals: it is because they do not impart to the material any formative power. Instead of a formative power they have only their uncertain art; and as an instrument, only burning heat, and this is very uncertain in its operation. But what is called the formative power, imparted by the heavens to the place and the material, is certain both as to material and instrument; and the instrument is accurately proportioned to the material; and therefore nature is most certain in its operations.

There is one other thing to be noted about this instrument—namely, that cold, although by no means effective in producing life in living things, nevertheless [is effective] in producing stones; because stones are not far removed from the elements, and in the material [of stones] the elements are only slightly transmuted; and therefore the qualities of the elements in them remain very little altered.

[3] See I, i, 3, note 9.

[4] That is, a flux that lowers the melting-point.

CHAPTER 6: THE SUBSTANTIAL FORM OF STONES

In preparing for the discussion of the formal cause, *Albert raises the question whether or not the terms* forma *and* species (*'specific form'*) *can really apply to stones. This is no idle question, for on the answer to it turns the whole possibility of* classifying *stones, as plants or animals are classified, for scientific study. Albert argues that, just as the* form *of an* animate *being is its* soul (anima), *its life, manifested in its actions, so a mineral, though* inanimate, *also has an identity, a* form, *manifested in its magnetic, chemical, medical, or magical 'actions' (see Book II); and that there are different* species *of minerals, just as there are different* species *of plants and animals.*

It seems madness to have any doubts concerning the substantial forms of stones; for sight assures [us] that they are all solidified and their material is fixed according to a definite, specific form. For if the arrangement of the elements were only such as occurs in the successive transmutations of one element into another, or into something else—as, for example, in clouds, rain, and snow—then certainly [stones] would not long remain as they are, but after a while would be dissolved again into elements; and we see that the nature of stones is just the opposite of this. Moreover, we find in stones powers which are not those of any element at all—such as counteracting poison, driving away abscesses, attracting or repelling iron; and, as we shall show later, it is the common opinion of all wise men that this power is the consequence of the specific form of this or that stone. From this it is firmly established that stones do have specific forms.

These forms are not souls, as some of the ancients thought; for, as we shall show in the book on *The Soul*;[1] and, as has already appeared in the

[1] *The Soul*, II, 1, 412 a 20 defines *soul* as 'the form of a natural body which potentially has life'. Aristotle admits that an inanimate thing —e.g. an axe—also has *form*: deprived of this, an axe is no longer an axe; but this form is not a soul, because an axe does not have the capacity for life. Albert, in his own version of this, adds a *digressio* making the point even more specific in regard to minerals (*The Soul*, II, i, 3):

In what has gone before, in the first book on this science, we have said that the natural forms are universally of two kinds. There is one kind which is more closely connected with the nature of the natural body, in which the form is no higher than the body and its powers.... It has only one function, as has been shown at the beginning of the second book on *Physics*. We have already dealt with all mixed bodies having this kind of form in the science of stones and minerals. But there is another kind of form which is more closely related to the universal First Cause that acts upon all forms. This is an incorporeal essence, moving and perfecting the body. It impresses itself upon the whole nature of the body, so that in the natural order it is higher than all corporeal forms. This is called the soul. And since it draws its power of acting not from the body but from the First Cause, to which it is related, it has not merely one function but many—whatever function is proper and essential to it.

beginning of the *Physics*,[2] the soul has [not][3] one function only, but many, which it performs by its own power and not by chance; but the nature of stone has only one function, and what it performs is performed by necessity, which is not so with the soul. Furthermore, the first function of the soul is life; but no characteristics of life are found in stones. For if a stone used food, it would necessarily have pores or channels by which food would sink into it; and that this is not so is shown by the hardness and compactness of many stones, which prevent them from being divided and opened up for the intake of food. Furthermore, if [a stone] used food, it would necessarily have a part for drawing in the food in the first place, like the roots of plants or the mouth of animals; and we see nothing like this in stones. Nor is it correct to say that the soul of a stone is weighed down by earthiness, so that it cannot exercise [the powers of] life and sense, as many natural scientists (*physiologi*) have claimed. For according to this belief, nature would fail in something which was necessary,[4] in not giving a stone the organs by which it might carry on its necessary functions. Stones, therefore, have no souls; but they do have substantial forms, imparted by the powers of heaven and by the particular mixture of their elements.

These forms are mostly without names,[5] but nevertheless it is the differences among them that provide a basis for the different names of stones, which are called tufa, pumice, flints, marble, *sapphirus*, *smaragdus*, and the like. But when we do not know these [names], we have no proper definitions of stones, except as, in a roundabout way of speaking, we take their accidental properties and appearances in place of definitions. But we know these properties because they are variations of a body subject to movement and simple transmutation[6]—a mixture, because stone is one of the mixed bodies. Now mixed bodies are divided into [two groups]—

[2] The reference should probably be to the second book of the *Physics*, cited in this connection in Albert's own version of *The Soul* (note 1 above), where Aristotle discusses the relation of matter and form (*Phys.* II, 1, 193 b 4).

[3] *non* has been supplied, as required by the sense. Cf. parallel passage from Albert's *The Soul* (note 1 above).

[4] Aristotle often says that 'Nature does what is best', or 'Nature does nothing in vain', etc. Perhaps the citation most relevant here is *Parts of Animals*, III, 1, 661 b 29: Nature gives organs for defence and attack to animals that have a use for them.

[5] *innominata*: lack of a consistent nomenclature has always been a difficulty in mineralogy. But in the present context there is probably the additional thought that the *form* is also the 'formula', definition, or name. Cf. *Meteor.* IV, 12, 389 b 28; *Metaphys.* VII, 12, 1037 b 8 ff.

[6] This is Albert's definition (in his *Phys.* I, i, 4) of 'inorganic' or 'inanimate' compounds.

simple mixtures and combinations; and we know that stones belong to the former and not the latter group.

Summarizing all that has been said, then, we say that a stone is not a combination, but a simple mixture, solidified into its own form by a mineralizing power. And from this, it further appears that stone is of a more *homeomerous*[7] nature than living things are, although it, too, is essentially made up of different elements. For this reason the science of stones should be taken up before the science of combinations. And there are many forms of stones, as [for instance] the group[8] of marbles [includes] porphyry, alabaster, and so on. And the same is true in other groups of stones, but there is no use in listing them here since their forms will be made clear later, from their accidental properties and hardness. For these accidents are peculiar to each one. And once these are known, their nature is sufficiently plain.

But we need not look for a final cause, since in physical things the form is the final cause;[9] and so, since we think we know each thing once we know its essential and particular causes,[10] we now understand completely the things which all stones have in common.

But in fact since the place of their production is also fundamental, as has been shown previously, we must, in addition to what has been mentioned, know [something] of the place where stones are produced; because place is a sort of efficient cause, since the formative power of stones is first imparted to it.

CHAPTER 7: A REVIEW OF THE PLACES WHERE STONES ARE PRODUCED

Place *in Aristotle's* Physics *(IV, 1, 208 a 27 ff.) has a somewhat technical meaning: the space or room occupied by a body—the interior surface of whatever encloses it, as the wine-jar encloses the wine. This meaning is less obvious here than in the corresponding chapter on the formation of metals (III, i, 10), but it is in Albert's mind. A suitable* place *for the formation of stones, then, is not a general geographic locality, but the immediate environment, regarded as the*

[7] See I, i, 1, note 8.

[8] *genus*: this suggests that stones, like plants and animals, could be considered as *species*, grouped into *genera*. But no such classification is carried out in later chapters.

[9] *finis*: the 'end' or *final cause* is not discussed here because in inanimate things it is not distinguishable from the *formal cause*. Cf. *Meteor.* IV, 12, 390 a 5.

[10] Aristotle, *Phys.* I, 1, 184 a 12–15.

receptacle or mould that determines the form of the stone. Thus this discussion of place *follows logically upon that of* form *in the preceding chapter.*

The emphasis on place, *moreover, is due to the fact that here and elsewhere (I, i, 8; I, ii, 7) Albert takes it for granted that all stones originated where we now find them. Although Avicenna had mentioned the possibility of transportation and deposition, Albert rejected this. (See I, i, 3.)*

LET us therefore call to mind the places where stones are always, or frequently, produced, and let us investigate the power of places and the differences among them.

Now we see that many stones are found on the banks of perennial streams; and from this we know that the banks of certain waters are places that produce stones. But such banks differ [in this respect] because some bring forth stones more quickly and some more slowly. In certain places on the banks of the river called Gion [Oxus][1] stones are produced in the space of thirty-three years, as Avicenna and some other philosophers testify. But not all water is active in producing stones on its banks; because the water of swamps, where the earth has been dissolved, dissolves stones instead of producing them; just as we see that, in some regions, although there are watery places there, nevertheless very few stones are produced.[2]

Moreover, we shall frequently find that mountains are stony; from which we know that another place that produces stones is in mountainous regions. Yet sometimes we find mountains[3] without stones. But these are frequently not large nor associated with other mountains, but are found alone, so that perhaps there is one all by itself, or at most two or three. For wherever many mountains are grouped together they are found to be stony; and there are sometimes many stony mountains on the solid surface of a flat plain, although this cannot happen everywhere. And those are places that are active in producing stones.

Furthermore, stones are very frequently produced in waters;[4] and this

[1] *Glon*, for *Gion* (Arabic, *Jaihun*) in Avicenna (Holmyard and Mandeville, 1927, p. 45). But medieval writers knew little about the Oxus, and commonly took the *Gion* or *Hion* to be the Nile, as did Albert himself in *The Nature of Places* (iii, 4).

[2] Probably this refers to the Low Countries of the Rhine Delta, where stones are lacking because the streams have too low a gradient and too slow a velocity to transport anything except fine silt and clay.

[3] *montes* is used by Albert not only for mountains but also for hills and even for such small features as sand dunes (*Properties of the Elements*, II, ii, 5). See also I, i, 8, note 8.

[4] Some streams and springs, in limestone regions, deposit crusts of calcareous material along their channels. The scientific problem,

could not be said, if waters were not also a place that produces stones. Evidence of this is that there are some waters from which stones are produced when they overflow the banks that confine them, but if they flow anywhere else, stones are not produced from them. It has been observed that there are certain places in the region of the Pyrenees where rain water is converted into stone, but if it flows somewhere else it remains [merely] water and is not transmuted. In the same way, wood which lies in some waters and seas is converted into stone, but still retains the shape of wood. Sometimes, too, plants native to those waters and seas are so close to stone in their nature that if they are somewhat dried out in air they assume the form of stones. Evidence of this is the stone called coral,[5] which undoubtedly is produced from wood and plants. For once, in our own time, in the Danish [Baltic] Sea near the city of Lübeck, there was found a great branch of a tree on which there was a bird's nest[6] with magpies in it; and the nestlings in the nest had been converted into stone which was slightly reddish. This could have happened only if the tree [had been] uprooted by winds and waves at the time when the nest was in it; and the birds fell into the water and afterwards, by the power of the place where they were lying, were entirely converted into stone.

There is also a spring in Gothia [Gotland in Sweden?], of which reliable reports say that everything that is immersed in it is converted into stone. And so the Emperor Frederick[7] sent there a glove with a mark on it, to test the truth of the story; and when the glove had been half-way immersed in the spring for a few days, half of the leather [up as far as] the mark was converted into stone, and the other half remained leather. It is truly reported by trustworthy people that the drops which are spattered over the banks of this spring by the violence of its fall are converted into stones of the size of drops;[8] and yet the water as it runs out is not converted into stone, but keeps running continually.

for Albert, was why some streams form such deposits and some do not: the water itself is clear and does not seem different from any other water, so there must be something peculiar about the *place* that produces stone in this way.

[5] Pliny (*Nat. Hist.* XXXII, *11*, 21–24) said that coral is a plant, soft while it is in the sea, but hardening into stone on exposure to the air; and this opinion persisted all through the Middle Ages. See II, ii, 3, *Corallus*.

[6] This was probably just a bird's nest that had been placed in a calcareous spring until it was coated with calcite.

[7] Emperor Frederick II, Ruler of the Holy Roman Empire from 1220 to 1250, was a patron of science and learning, and eagerly collected information from all parts of the world (Haskins, 1924, Chs. XII–XIV).

[8] A pisolitic deposit, made up of calcareous spherules about the size of peas, not uncommon around mineral springs.

We also see with our own eyes that rock crystals are produced in very high mountains [covered] with perpetual snow;[9] and again this cannot happen except for a mineral power that is in those places.

From all this is seems impossible to report anything certain about the [kind of] place that produces stones. For [stones occur] not in one element only, but in several,[10] and not in one *clime*[11] only, but in all. And, even more remarkably, they are produced in the bodies of animals[12] and in the clouds.[13] It seems very difficult to reduce [whatever is in] all these places to one common material; but nevertheless, this must necessarily be so, since we have no doubt that one particular kind of mixed body always results from one particular kind of cause. For all things produced must have a certain place of production, and away from this they are destroyed and dispersed.

CHAPTER 8: THE REASON WHY SOME PLACES PRODUCE STONES AND SOME DO NOT

Albert now sums up his views on the causes *of minerals. And he also begins to lay emphasis on the 'vapour' theory of the* Meteorology *(III, 6, 378 a 13 ff.).* Vapour, *of course, has not the meaning today attached to the term in physical chemistry. It is necessarily vague—something material but invisible, like the* spirit *produced by distillation, something very subtle and potent, like odours or tastes or poisonous fumes. The* Meteorology *(see Appendix A, 4) refers to earthquakes and volcanoes as evidence of underground vapours; and Albert assumes that vapours are present everywhere, but produce different effects under different physical conditions.*

If we wish, then, to investigate this power, which is one and the same in all these places, let us recall to mind what has been determined in the preceding books on natural science—namely, that the stars by the amount

[9] See I, i, 8, note 8.

[10] Stones are formed not only in Earth, but also in Water, in Fire (volcanic lava), and even in Air (meteorites, see note 13 below).

[11] *clima*, used by ancient geographers not in the sense of 'climate' but of a belt of latitude See II, iii, 4, note 3.

[12] Perhaps kidney or bladder stones. But medieval mineralogy recognized a number of other stones supposed to originate in animals: see in II, ii: 1, *Alecterius;* 2, *Borax;* 4, *Draconites;* 11, *Margarita;* 12, *Nusae;* 15, *Quandros;* 16, *Ramai.*

[13] Avicenna (*De congelatione*, Holmyard and Mandeville, 1927, pp. 47–48) describes meteorites; Albert cites this passage in his *Meteora* (III, iii, 18, 20). See also II, ii, 3, *Ceraurum.*

of their light, and by their positions and motions, move and regulate the world through [influencing] the material and the place of everything that can be produced or destroyed. The power thus determined by the stars is poured down into the place where each individual thing is produced, in the way that has been explained in *The Nature of Places*.[1] For this is the power that brings forth and produces the elements and everything composed of elements.

The power of a place, then, is a combination of three [powers]. One of these is the power of the Mover that moves the sphere.[2] The second is the power of the sphere that is moved, with all its parts, and the figures that result from the varying positions of the parts with respect to each other as they move more rapidly or more slowly. The third is the power of the elements—that is, hot, cold, moist, dry, or a mixture of these. Now the first of these powers is like the controlling form which shapes everything that is produced, as the power of an art is related to the material of the artifact. And the second is like the operation of the hand. And the third is like the operation of the instrument which is moved by the hand and directed towards the end conceived by the artisan. And therefore Aristotle[3] said that every work of nature is a work of Intelligence: for the place receives these powers just as the womb receives the power that is active in forming the embryo. Therefore this power, directed towards the production of stones, is in the earthy or watery materials which are common to all places where stones are produced. For just as the life-giving power is poured down from the stars into animals produced by putrefaction, so the stone-forming power is poured down into the material of stones, in the manner already explained.

So wherever unctuous Earth is mixed by means of vapour concentrated in it, or wherever the forces of Earth attack the nature of Water, intensely influencing it and converting it to dryness—there, for a certainty, is a place where stones are produced. And therefore earths which have a

[1] Albert, *The Nature of Places*, i, 4–5: the power that gives form to the elements descends from heaven, but its effects are modified by conditions on earth—by the angle at which the rays from stars and planets strike the surface in different latitudes, and by the arrangement or responsiveness of the matter itself in different places.

[2] The concentric spheres supposed to carry the heavenly bodies.

[3] This saying is not found in Aristotle's works, although the sense is compatible with *Phys.* II, 8, 199 a 3: Nature does nothing without a purpose; VIII, 1, 252 a 12: Nature is orderly; *The Heavens*, II, 11, 291 b 13: Nature does nothing in vain; and other passages. Probably the phrase was coined by a commentator. Once, at least, Albert attributed it to Averroes (*Problematadeterminata XLIII*: Weisheipl, 1960, p. 348).

solid surface from which such vapour cannot escape produce many stones. But in earth that is soft like ashes and is more likely to taint water than to impart its own properties to it, stones cannot be produced.

This is the reason why many stones are produced on the banks of perennial streams;[4] for such banks are very solid, and so retain the rising vapours. And these banks are also filled with vapours, because the heat produced by the reflection of light on the water is driven off towards the banks by the coldness of the water,[5] and becoming entangled with the sticky parts of earth, bakes and hardens the mixture of Earth and Water. For the same reason, the bottoms of such rivers become full of stones; for the heat in the earth along the banks penetrates under the water; and since the water everywhere fills up the pores by which the vapour might escape, it mingles with the mixture and at the same time bakes it into stones. And this is the reason why such places are active in producing stones.

And there are some waters that flow through materials of very strong mineralizing powers, and as they flow they are saturated with those minerals; and so the waters and whatever is immersed in them are converted into stone, more or less quickly depending on the increasing or decreasing strength of the power that is active in making and forming stones. The reason why water that is divided into drops along the banks, as it flows out of a spring, is more quickly converted into stone than water that simply flows along from a spring or river or sea, is that the [mineralizing] power more quickly overcomes a small amount [of material] that is divided than a large amount that is undivided. This is the same with every transforming power—for every power transforms a small [quantity] more quickly than a large [one].[6] But the same water flowing in some other place is not converted into stone; and this is because when it is away from a mineralizing place it evaporates and is destroyed, just as everything else is destroyed away from the place where it is produced.

That water does in fact absorb and become saturated with such a power is proved by other accidental properties of water, such as a taste of sulphur or orpiment, or of bitterness; for water does not acquire these

[4] Again Albert tries to explain alluvial gravels, which he believes to be formed *in situ*.

[5] Heat and cold, being contraries, exert a mutual repulsion. See also the statement in II, ii, 3, *Crystallus*.

[6] *Gen. and Corr.* I, 10, 328 a 34: things readily divisible into small parts combine most readily; *Meteor.* IV, 1, 379 b 2: a small quantity is more rapidly attacked by decay than a large one.

tastes except from the places through which it passes. In the same way, it happens that the mineralizing vapour, along with stony material in the form of vapour, is extracted by the water, and the water is completely tainted by this vaporous spirit; and the mineralizing vapour, if able to overcome the water, converts it into stone.

Even more rapidly it converts earthy things such as wood, plants, and the bodies of animals, etc.[7] For these, if immersed in Water, are attacked by such a mineralizing power and changed into something of an earthy nature, suitable material for stones, which is [then] dried out and solidified and developed into the specific form of stone by the mineralizing power dissolved as vapour in the Water.

In very high mountains there is perpetual and extreme cold—the reason for this has been explained in the book on *Meteorology*.[8] And this cold, by expelling moisture, attacks the Water from the snows, and induces in it the properties of dryness—for this is the nature of extreme cold—and then, out of that dryness, solidifies the ice into rock crystal or some other transparent stone.

And thus it is easy to understand places that produce stones, and the similarities and differences among them.

CHAPTER 9: HOW THE POWER OF THE PLACE ACTS UPON THE NATURE OF STONES

This rather prolix account of the way Water changes into Earth is based on Aristotle's account of the transmutations of the elements in Generation and

[7] This explanation of fossils is from Avicenna (*De congelatione*, Holmyard and Mandeville, 1927, p. 46).

[8] *Meteor.* I, 9–12 (346 b 16–349 a 12) deals with phenomena in the sphere of Air—rain, hail, snow, dew, etc. The atmosphere has three layers: the lowest is warmed by reflection of the sun's rays from the surface of the earth; higher up, it is cooler, so that clouds can form; and at the top the Air is again warm and dry, merging into the Fire above. In Albert's version of this (*Meteor.* II, i, 12) he introduced a threefold classification of mountains, as related to these three layers: For some are *mountains* (*montes*), and others are *high mountains* (*alti montes*), and still others are *extremely high mountains* (*supremi montes alti*). *Mountains* rise above the general level of the earth's circumference, but do not extend beyond the first layer of Air, where the sun's rays have power. But *high mountains* rise into the next layer of Air, which is cold; and so they have perpetual snow. And by compression of the snows, crystal and beryl are produced in their depths, and other stones of this sort, from which heat has been removed by natural means. *Extremely high mountains* rise above the latter, and extend beyond the second layer of Air, and project far up into the third, into Air which is dried out by a heat that does not burn, but dries out the moisture of the Air; and on the summits of these neither hoar frost nor dew is produced.

Corruption (*see Appendix A, 3*). *Any element can be transmuted into any other element by a change in its* qualities; *but Albert attempts to analyse the change into stages, in order to explain the different degrees of transparency in different minerals.*

Transparency *is discussed in terms of Aristotle's theory of light* (The Soul, *II, 7, 418 b 3 ff.*): light *is a sort of* activity *going on in a medium of transparency; and transparency is a property especially of the upper spheres of the heavens* (Ether), *though it is shared to some extent by Fire, Air, Water, and even some solids. We cannot see transparency, as such, but recognize it as it is made visible by the activity—light. The theory is extended to account for the colours of minerals in I, ii, 2.*

THERE remains one more thing [necessary] for understanding everything that has been said. This is that we should determine how the power of one thing attacks the substance of another and transforms it into itself. Now this can be understood from what we have said about the transmutations of the elements into each other. For when Earth converts Water into [Earth], first of all the powers of Earth enter into the substance [of Water] and alter it and, as it were, master it and hold it fast; and then the Water begins to grow firm and be limited by a boundary,[1] although as yet it does not lose its transparency; and then finally it is destroyed and passes into Earth, and takes on the qualities of Earth, opacity and dryness. It is the same with the other elements when they are transmuted into each other. And it is just the same, too, with the powers of mixed substances, as is shown by the juice of plants and the food of animals. For in these the powers of living things first of all alter, and then, as it were, attack the material and hold it fast, and afterwards convert it into the part of the body that is being nourished. And it is just exactly the same with the stone-forming power when it penetrates anywhere, whether in Water or in Earth: first of all it alters the material it touches, and then masters and holds it fast, and after so holding and overcoming it, converts it into stone.

This action generally occurs in three ways, although really the number of ways is infinite. One of these [ways] is that the power attacking the material alters it only as to the active and passive qualities[2] by which the action takes place; and this is a weak power. The second way is that it alters not only the qualities of the material but also the secondary effects of these qualities, which are hardness and softness; [but still] in such a way

[1] *stare et terminare*, that is, change from liquid to solid; see I, i, 2, note 3.

[2] Heat and cold are *active*, moisture and dryness *passive*, qualities.

that the transparency or opacity of the material is not removed; and this is a stronger power, and in this way transparent stones are produced. The third way is that it attacks the material completely, not only the secondary effects but also the consequences of these; and thus alters the qualities, and the hardness and softness, and even the colour that belongs to the material. And in this way there are sometimes produced from Water stones that are not transparent, or not completely so, like chalcedony and the kind called 'toadstone', and some others.[3] In all these ways there are many degrees which will be mentioned later, when we deal with precious stones.

An example of this is that sometimes the earthy force, which acts upon moisture by compelling cold and dryness, acts upon Water in such a way that there remains in it some power of such cold and dryness; and then things that are washed in such Water are intensely dried out and cooled. The alchemists try very hard to make waters of this kind, which have the qualities of different elements—not actually but as a [potential] power—so as to use them in drying out and solidifying what they wish to transmute; and for that reason they have books compiled about the *Seven* [*Twelve*?] *Waters*.[4]

Sometimes, too, an earthy force attacks Water in such a way that cold expels its moisture, and dryness causes it to take on the shape of a solid, although the transparency of the Water remains unchanged. For the clearness of Water does not depend upon how much it contains of the qualities of cold or moisture, or both, but upon how much it has in common with the substance of heaven [Ether]. And therefore [transparency] inheres in Water even more than the active and passive qualities do by their nature; for [transparency] is more common among the elements[5] than any one of the active or passive qualities is. And when the cold and dryness of Earth act in this way, they necessarily induce in Water their secondary effects, hardness and solidity; and then a trans-

[3] See II, ii, 3, *Chalcedonius*; 2, *Borax*; 12, *Nusae*.

[4] 'seven waters' perhaps should be 'twelve waters', a scribe having written VII for XII. Sarton (1927, II–2, pp. 889–90) mentions several treatises of this kind—*Liber de aquis qui dicitur XII aquarum*, and *Liber XII aquarum alkimie*, etc. One of them, *Tractatus mirabilis aquarum*, is ascribed to Peter of Spain (Pope John XXI), and includes *aqua vite* and *aqua ardens* (alcohol). The waters that harden things are probably solutions of alum or other sulphates. (See also II, iii, 2, notes 5–6.)

[5] That is, transparency occurs in elements that have *different* active and passive qualities: Fire (hot—dry), Air (hot—moist), Water (moist—cold), even in minerals that contain Earth (cold—dry).

parent stone is formed. But sometimes Earth overcomes Water still further, changing its substance into the opacity and nature of Earth; and then an opaque stone is formed from Water, perhaps very black, like certain little stones that are found in abundance on the banks of rivers; but these are sometimes produced from earthy material, as we shall show later. And what we have said about Earth must be understood to apply as well to the qualities of all the other elements.

It should also be added that the power of the elements is the *material cause*, and the power of the heavens is the *efficient cause*, and the power of the Mover is the *formal cause*; and the result of all these is the power that is poured into the material of stones and the place where they are formed, as has been adequately stated in earlier chapters.

Let this, then, be enough explanation of the causes by which we may understand the production of stones in general.

TRACTATE ii
THE ACCIDENTAL PROPERTIES OF STONES

CHAPTER 1: PROPERTIES OCCURRING SPONTANEOUSLY IN STONES: [GOOD AND BAD MIXTURES]

This tractate deals with accidental *properties, things which occur spontaneously* (quae per se accident), *and which are due to chance or individual circumstances; that is, inessential differences that do not affect the substantial* form—*stone is* essentially *stone, although individual specimens may differ in size, shape, colour, hardness, etc.* Meteor. *IV, 8–9 (385 a 11–388 a 9) lists and discusses eighteen such 'passive' properties (Albert,* Meteora *IV, iii, 2–19), and the relevant explanations are applied here to stones and in III, ii to metals.*

Good and bad mixtures *in the Borgnet edition stands as part of the title of the following chapter. I have transferred it to this one, where it obviously belongs, since differences in the 'mixing' account for the textures and fabrics of rocks. Again it may be noted that Albert does not recognize sedimentary rocks as made up of fragments transported, worn, and deposited by water or ice, but considers the pebbles or sand grains to have been formed* in situ *by a process analogous to cooking. The difference between a conglomerate and a fine-grained rock is, so to speak, like the difference between lumpy and smooth porridge—a matter of thorough mixing and just enough heat. Raw materials that are too dry mix poorly and form lumps; moister materials blend into an even paste, producing a fine, uniform texture.*

Now we must speak of the properties that occur spontaneously in stones. For there are many accidents which happen in the very beginning to all stones in general. And first among these is the mixing of the material. Let us say that if the material is intensely dry, then it will be incapable of being well mixed. Furthermore, the place may be either porous and not solid, or else solid. If it is not porous but solid, there is produced one [mass of] gravelly stone; when it is handled it yields little bits of gravel, differing according to the amount of dryness and heat that solidified it; for sometimes perhaps it can be rubbed into [loose] gravel, when such heat has dried it out. But if the place is very porous so that heat penetrates all through it, baking the unctuous Earth, then the heat divides the material into small [bits] and bakes it into a very fine gravel. And if the material was very viscous, then it is divided and reduced to little pebbles of different sizes, which are extremely hard and differ in colour because of differences in the material.

But stones that show good, flat surfaces when they are cut, from which only the finest dust rubs off, are made of material that is very well mixed. First the moisture affected it, causing every part of the dry [material] to flow into every other part; and later the moisture was attacked and dried out; and therefore such stone is well mixed. For what is subtle and moist is capable of being well mixed, since it is active in penetrating the parts and even the smallest particles, as has been said in the second book on *Generation and Corruption*.[1] But above all, those stones are well mixed which have been mixed by means of vapours; and they take the best polish of all and become brilliant. This is because the substance of vapour approaches the subtlety and moisture of Air; and these two [Water and Earth] are more subtle and penetrate each other more thoroughly in the form of Air than in [their own] form of Water or Earth. These are the causes of compactness and firm coherence, and of their opposites. And whatever things have their material well mixed—unless heat bakes out the moisture and dries it up—are most firmly coherent and strongly compacted.

Evidence of this is [found] in those operations of art which imitate nature. For brickmakers first mix with earth something to make the parts hold together, such as horse-dung or something of that sort; and when the material has been made sticky they try to mix it very thoroughly. And the better they are mixed, the flatter and firmer the stones are. And potters do the same, adding to their material not just any kind of earth at all, but the tenacious kind called *glis*,[2] when they want to shape things of clay; and they mix it thoroughly before they shape it. Then they let the moisture remain in it for a time, and then draw out the excess in the sunshine; and finally the vessels are solidified by digestion in the fire, which is called *optesis*.[3]

Therefore Nature, too, must use this method in mixing stones. Thus

[1] *Gen. and Corr.* I, 10, 328 a 34: the smaller the particles, the more easily they will mix, etc. This is at the end of the first, not in the second, book of *Generation and Corruption*. Albert may have been quoting from memory. Vapours, of course, are even more 'subtle' or finely divided than liquids.

[2] *glis*: not a classical Latin word, although Pliny (*Nat. Hist.* XVII, 4, 46) uses *glisomarga* for a fatty marl.

[3] *optesis* is a technical word, defined in *Meteor.* IV, 3, 381 a 23 as roasting by dry heat, baking.

Earth is first penetrated by moisture, either as liquid or as vapour,[4] and then the excess moisture is separated from it; and after a long time the [remaining] moisture is incorporated into it and holds it together, and cannot be driven off by baking heat; and then the material, by such baking, is converted into stone. And if sometimes there is found some Earth not completely stuck together, along with the stones, we know that such material was [not][5] completely acted upon and so remains undigested.

But stones made from Water that has been acted upon by earthy dryness and cold are very well compacted and look smooth as if polished; for Water is numbered among [the causes of] smoothness,[6] and every part of it flows into every other part; and thus cohering together it solidifies and hardens into stone.

Let this, then, be our account of the way stones are mixed.

CHAPTER 2: THE CAUSE OF DIFFERENT COLOURS IN PRECIOUS STONES

Borgnet prints the title for this chapter as De his quae bene et male commixta sunt, et de causa diversitatis colorum in lapidibus pretiosis. *I have omitted the first part of this, since, as already noted, it belongs to the preceding chapter. Albert's theory of colour is based on Aristotle's* The Senses; *but he here seems to cite a long* digressio *in his own version of that work.*

Colours, according to Aristotle, result from the mixture of transparency (light) and opacity (darkness), or white and black; as, for instance, the light of the sun looks red when seen through dark smoke (The Senses, *3, 440 a 11*). *Albert elaborates this (perhaps with the help of Arabic commentators like Avicenna, whom he cites in* The Senses, *ii, 2*), *attempting to account for all possible colours. A simple mixture of white and black gives a series of greys. But if light or whiteness is partly obscured by a smoky 'earthy' vapour, the resulting colours are reddish—bright red if the vapour is thin, dark red or purple if it is thick. If the vapour is predominantly 'watery', with only a very little, finely divided 'earthiness', the colour is blue. Vapours with other proportions of 'earthiness'*

[4] *aut corporali aut spirituali:* water has some 'body', vapour is 'spirit' (cf. I, ii, 6, note 1).

[5] The sense requires a *non* omitted in the text.

[6] Aristotle does not explain *smoothness* in *Generation and Corruption*, but Averroes in his Commentary on that work (Fobes, 1956, pp. 105–6) quotes Alexander (of Aphrodisias) to the effect that rough is caused by dryness and smooth by moisture on the surface. He adds that 'this is why stones formed in water are dry (hard) and yet smooth'.

and 'wateriness' produce other colours, between red and blue, which Albert sometimes calls yellows and sometimes greens. This theory is the basis of the present chapter, though there are some discrepancies which may be due to corruption of the text and to the inexactness of colour-words, in both Latin and English.

A special note is needed on Albert's usual word for 'blue', blavus *(cf. German* blau), *which has been printed as* flavus, *'golden yellow'. I have silently corrected this throughout the translation.*

More information about the precious stones mentioned here will be found in the alphabetical lapidary, II, ii.

HOW a decision is reached about the colours of stones must be learned from the book on *The Senses*; of that science we shall tell later, at a convenient time; and what we assume here will be demonstrated there. Thus it is assumed here that everything that is transparent, in any kind of body whatsoever, is caused by many transparent parts which enter into the constitution of the transparent body. And furthermore, white is caused by many transparent parts distributed in something else;[1] and black, by opaque parts predominating over the transparent parts in the same body. Intermediate [colours] are caused by a combination of these in three ways,[2] as will be [told][3] in the science of *The Senses*.

Let us say, therefore, that all transparent stones are caused by a large amount of the material of Air and Water which is hardened and compacted by the attack of earthy material; and if the transparency is not of any particular colour, but remains [like] the transparency of Air or Water, then this is evidence that extreme cold alone has attacked the material. And this is like the transparency of rock crystal and beryl and *adamas* and the stone called *iris*. But they show differences in their transparency and watery nature. For rock crystal seems to have not the material of Water alone, but a wateriness approaching airiness, and hence it is very transparent, almost perfectly clear. But beryl approaches nearer to Water; for when it is [turned about] big drops of water, as it were, are

[1] Cf. Albert's description of the whiteness of snow (*Meteor.* II, i, 19): 'For snow must necessarily be white, since it is itself composed of parts of transparent material with clotted Air dispersed among them. All such parts take in some light between them, and so they are white; but nevertheless they limit the sight [that is, are not perfectly transparent], as is seen when rock crystal or glass or any other transparent material is powdered.'

[2] Albert, in *The Senses*, ii, 2, says that 'white passes into black in three ways': (1) through a series of greys; (2) from pale to dark red and purple; (3) from pale to dark green and blue-green.

[3] *radetur*, but (ed. 1495, 1518) *tradetur* seems to be correct.

seen [moving inside it].[4] *Adamas*, however, has its wateriness further advanced towards earthy dryness, and therefore it is darker, and extremely hard, so that it scratches all metals except the hardest steel—for in steel the wateriness and earthiness are thoroughly dried out. And thus it happens that the stone *adamas*, when it has sharp corners, divides and cuts all iron, and penetrates every metal so as to divide it. But *iris* is made of Water which is, as it were, just turning into dew, hardening partly from vapour and partly from dewdrops melting away; and therefore, if placed in sunlight, it paints the colours of the rainbow on the opposite wall. These similar stones are made of similar materials.

Along the banks of rivers there are frequently found stones that are dark-coloured and transparent to a great or lesser degree; their colour is caused simply by transparency either combined, or mixed more or less completely, with dark earthiness. Since it is easy, from what has been said already, to understand the cause of these colours, I say no more about them.

A black colour in stones is most frequently caused by burnt earthy [material]; and therefore black stones are frequently very hard, and capable only of being polished but not cut. For this colour is caused merely by lack of transparency in the mixture, as will appear when the science of colours is discussed [in *The Senses*].

The intermediate colours are reds, greens, and blues,[5] and different shades of these. And, as will be said in the book on *The Senses*, there will be red when a luminous transparency is covered by a thin burning smoke. This colour is found in certain stones which are called 'water jacinths' and in the three kinds of carbuncles; and therefore Aristotle[6] says that these are all hot by nature. But there are different shades of red: for if there is a great transparency, and the smoke that covers it is very thin and bright, the colour is that [of the stone] called *palatius* or *palatium*.[7] And if there is a great transparency and the smoke is, as it were, fiery, burning, and thick, then the colour is that of the true carbuncle; and thus [a carbuncle] that

[4] The text seems to be corrupt here: *cum solvitur quasi aquae guttae magnae manere videntur*, 'when it is dissolved, big drops of water, as it were, are seen to remain'; but beryl is not easily 'dissolved', and two very probable scribal errors could have produced this from *cum volvitur quasi aquae guttae magnae movere videntur*, which I have adopted as agreeing with the description of beryl, in II, ii, 2.

[5] *Meteor.* III, 2, 371 b 34 ff. describes the rainbow as showing only three colours—red, green, and blue. Yellow is treated as a mere transition between red and green.

[6] *The Lapidary of Aristotle* (see Appendices A, 14 and B, 8).

[7] *Balagius*, II, ii, 2.

has attained its true specific form shines in the dark like a firefly, especially when clear, limpid water is poured over it. But if the transparency is slightly less clear, and the smoke floating over it slightly darker, the colour will be that [of the stone] called *granatus* because it is the colour of pomegranate seeds. And all three of these Aristotle calls carbuncles, and he says that the noblest and hardest among them is the *granatus*, although this is considered less valuable by jewellers and artisans.

But the stone called by some people 'water jacinth' has a colour composed of the limpid transparency of Water and not of Air; and covering this it has a watery steaming smoke, such as there is in a cloud in the sky and[8] in the dawn.

In the same way we shall discover the colours of transparent stones which are blue. For if a stone is made of a very clear transparent substance, and has, mixed into this, a very subtle, thoroughly burnt, earthy material, then the colour will be that of the clearest *saphirus*; and there will be different shades of colour, depending on whether the transparency combined with the subtle, thoroughly burnt, earthy material was clearer or darker. For a clear, pure blue is undoubtedly caused by a great deal of transparency, because the sight penetrates it—for neither light nor anything luminous offers any hindrance to the sight. But if, along with such burnt, earthy vapour, the watery transparency is slightly less clear, then the result is the colour of the jacinth (*hyacinthus*), which is considerably less clear than the colour of the noble *saphirus*. But a brilliant sky-blue colour[9] is caused by a bright transparency that is thinly covered by a little steamy watery vapour.

[There is also] the green[10] [of the stone] called *topasion*. And in some stones veins of shining gold are found, as in *chrysoprasus* and *chrysolitus*; the colour of those veins is produced by the same cause. And there are many transparent stones that are green, such as *smaragdus*, and *chrysolitus*, and the stone called *prama*,[11] although there are different shades of green

[8] *et non in aurora*. If Albert is still talking about red stones, *non* must be misplaced and should be omitted. But 'water jacinth' (II, ii, 8, *Hyacinthus*) is said to have a very pale 'watery' colour, either pink or blue. So this sentence may be a transition to the discussion of blue stones.

[9] *coeruleus*, a paler and more brilliant blue than *blavus*.

[10] *et hic est colour viridis* is separated from the preceding only by a comma in the printed texts. I believe, however, that this should begin a new sentence and a new topic, since the stones that follow are all green, yellow-green, or 'golden'.

[11] *prama* is perhaps the same as *prassius* (II, ii, 14); or it may be what is today called *plasma* (bright green chalcedony).

in them. But the colours of all these are produced by one and the same cause: from a transparent wateriness [mixed] with strongly burnt earthiness; and, depending on whether it is clearer or less clear, the greenness will be clearer or less clear. Evidence of this is seen in glass that is made from a mixture of lead;[12] for this is very green; and the more often and more strongly it is fired, the purer it becomes. For by repeated firing the transparency is purified and rendered subtle, and the clear brightness of Fire is imposed on the nature of Water; and so it becomes clear.

But the intermediate colour which is somewhat brownish or bluish, such as that of the stone called *corneola*,[13] is caused by a transparency that is limited and covered over by a thick, smoky wateriness and at the same time by a burning earthiness. And these are nearly all the colours found in precious stones.

Next is [the colour of] *onychinus*—a brilliant snowy white, which is said to be the colour of the stone called *orphanus*. For onyx or *onychinus* is composed of a substance of two colours, and is sometimes found with more than two colours; but usually it is composed of two colours, one of them floating on the other. The lower [layer] is flesh-coloured, which is [made] of earthy, smoky material mixed as vapour. And the upper [layer] is pale-coloured, slightly greyish; and this is caused by the victory of the transparent over the opaque parts in the mixture, in such a way that the opaque altered the white. [Onyx] is [formed] from such a substance, when watery material, mixed with subtle earthiness, evaporates a little and, as it does so, solidifies into stone. There are also found some kinds of *onychinus* having lines of bright red and white; and the causes of these colours are not difficult to discover from what has already been said.

But a brilliant snow-white is undoubtedly caused by the fact that it is itself composed of a transparent body, so to speak, solidified; for the powder of anything transparent is always found to be extremely white; and when the powder coheres together the result is a shining white body,

[12] Lead oxide imparts a pale yellow tinge to glass, but medieval glassmakers generally used copper to obtain green or blue colours. For example, a recipe from Heraclius (Merrifield, I, p. 216):

VIII. *How glass is made of lead and how it is coloured.* Take good and shining lead, and put it into a new jar, and burn it in the fire until it is reduced to powder. Then take it away from the fire to cool. Afterwards take sand and mix with that powder, but so that two parts may be of lead and the third of sand, and put it into an earthen vase. Then do as before directed for making glass, and put that earthen vase into the furnace, and keep stirring it until it is converted into glass. But if you wish to make it appear green, take brass filings and put as much as you think proper into the lead glass.

[13] Common chalcedony, by the description. But *corneola* was also confused with the red variety, carnelian: see II, ii, 3, *Corneleus*.

like a pearl.[14] This depends on the reflection of light from the surfaces of smooth parts; and therefore the stone is said to shine a little in the dark, like a firefly. For in the daytime the light incorporated with the translucency in the stone is hidden because the daylight [is stronger]; but at night it shines out; and therefore in the daytime this stone appears white, as a firefly does. The complete explanation for all these things will be given in the science of *The Senses*.[15]

But there is also found a stone having a great many colours, and for this reason it is called *panthera*; all its colours are caused by the different substances of which its parts are composed. The same explanation holds, more or less completely, so far as the dyeing of bodies is concerned.[16]

Such, then, are the many different statements made about the science of the colours found in precious stones.[17]

Amethyst comes next after *rubinus* in its dark transparency; and chalcedony comes after beryl, being somewhat transparent in its substance, but full of clay and dregs—somewhat as lead is an imitation of silver.

CHAPTER 3: THE CAUSE OF THE COLOURS IN STONES WHICH ARE [NOT] TRANSPARENT, NOT LIMITED IN SIZE, AND NOT PRECIOUS

The title of this chapter is printed as: De causa colorum in lapidibus perspicuis non terminatis et non pretiosis. *There is certainly an error here, the omission of* non *before* perspicuis, *for Albert now deals with stones that are* not *transparent, as he has already dealt with transparent stones in the preceding chapter. A similar omission of* non *occurs in the first sentence of this chapter.*

The phrase non terminatis *is difficult to translate:* terminatus *means 'limited by a boundary', 'having a definite shape'. I have rendered* non terminatis

[14] See II, ii, 11, *Margarita*. Albert does not mention phosphorescence again there, but similar statements are made about other stones: II, ii, 3, *Carbunculus, Chrysopagion;* 19, *Virites*.

[15] Aristotle, *The Senses*, 2, 437 b 6. Albert, *The Senses*, i, 12, goes into more detail: things that shine in the dark have in themselves a sort of transparency—either throughout their bodies, like the gem *carbunculus*, or just on the surface, like fish, fireflies, rotting wood, etc. But the light is faint and cannot be seen in daylight.

[16] *Dyeing* seems hardly relevant here, unless Albert has in mind the artificial colouring of stones. Perhaps this is a gloss that has crept into the text.

[17] This sentence is the usual formula for the end of a chapter. What follows appears to be displaced; or it may be an interpolation.

here as 'not limited in size', because what Albert is really talking about, and lacks a term for, is rock*—bedrock, as opposed to 'stones' in the sense of pebbles or precious stones, which are small, and are 'limited' in that they 'have a shape'. It is curious that Albert nowhere uses the useful word* saxum *for 'solid rock'. The distinction is made by Pliny* (Nat. Hist. *XXXVI*, 49, *169*) *in describing material (probably serpentine) that occurs 'as loose boulders, not as bedrock';* lapis non saxum. *And Isidore of Seville* (Etym. *XVI*, 3, *1*) *gives definitions: 'Stones* (lapis) *are movable and scattered about. Rocks* (saxa) *are firmly embedded and are quarried out of mountains.' Albert's long title, then, really means: 'An explanation of the colours of rocks.'*

It is also somewhat surprising that Albert says that very few rocks are red. Geologists today would call many rocks red, including some formations in regions that Albert must have visited. But perhaps he called them 'brown', and words for 'brown' and 'grey' are poorly differentiated in Latin.

Most of these rocks are mentioned again in the following chapter. The nomenclature is that of Vitruvius, Pliny, and Isidore, to whom I have given some references, although Albert does not appear to be quoting them directly.

STONES are found which are [made] of a substance that is [not] transparent and not limited in size; they are of a great many different colours and are—to make a generalized statement—of four kinds, namely flint, tufa, freestone, and marble.[1] In all these kinds there are found many colours, namely black, grey, slightly greenish, and white. Apart from the marbles, hardly any large stone is red, but small red [bits] are found,[2] especially in some marbles. And the explanation of all these colours is the same as that stated in the preceding [chapter]. But in some marbles it happens that pieces broken out of them sparkle slightly, as if mixed with metal;[3] and this happens because their substance contains something transparent mixed with it, and when this is condensed, its surface gleams or sparkles. And this is one of the reasons why marbles are more noble than other stones.

[1] *silex* is flint, massive quartzite or other siliceous rock, or indeed any very *hard* rock. *Tofus* includes both calcareous tufa and volcanic tuff or scoria. *Quadrum* is just stone in rectangular blocks; Vitruvius speaks of *quadrata saxa* or *quadrati lapides*, 'squared stone' or 'cut stone', but I believe Albert means what is popularly called 'freestone'—any rock that breaks naturally, or can easily be worked, into more or less rectangular slabs. *Marmor*, like 'marble' in popular usage today, means any stone capable of taking a high polish. It includes not only what geologists call marble—crystalline carbonate rocks—but also serpentine, alabaster, granite, porphyry, etc.

[2] Probably red feldspars in a porphyry or granite.

[3] Flakes of mica, with a silvery, coppery, or bronzy lustre.

Black in such stones is caused by [something] sooty and earthy solidified in the mixture. But white is caused by very subtle Earth mixed with a great deal of Water; for this, when boiled down, becomes white, like the Earth in cheese and milk.[4] Grey is caused by opaque Earth which has slightly altered the white, as it began to solidify from subtle Earth and a great deal of Water. Green, in all kinds [of stones] is caused by a great deal of Water which was mixed with vapours condensing at the same time and thus solidified. There is also a kind of dripstone[5] having several or all of these mixtures in [different] parts, because of the many [different kinds of] materials brought together in one place. But tufas are commonly either of an earthy colour or else white like pumice. For this kind of stone is produced from Earth mixed with foaming Water, and so, when it has been solidified by the digestive heat called *optesis*,[6] it is found to be spongy and light. And pumice[7] is made from a great deal of Water whose foam has been intensely acted upon by Earth mixed with it; and so it is white, because of the whiteness of such foam. But among marbles, the white [kind] called alabaster is undoubtedly composed of a great deal of transparent [material] which has been altered and intensely acted upon by subtle Earth; and the result is a most noble, sparkling colour in it. But that called porphyry marble[8] has a dark flesh-colour with small white spots; and we have already stated the cause of such a colour. Flints, however, are mostly of a greyish colour; and the cause of this has been sufficiently indicated.

Let this statement, then, be sufficient about the colours of stones.

[4] *Meteor.* IV, 7, 384 a 21: boiling down and coagulation of milk is interpreted as the separation of its earthy from its watery part.

[5] *guttae*, '*drops*'. *Meteor.* IV, 10, 388 b 25 calls them 'tears' and refers to stalactites in caves.

[6] *optesis:* see I, ii, 1, note 3.

[7] *pumex*, vesicular glassy lava; but probably includes also very light, porous calcareous tufa or siliceous sinter. Vitruvius (*On Architecture*, II, *6*) speaks of *spongia sive pumex* and discusses its origin. Pliny (*Nat. Hist.* XXXVI, *42*, 154–6) lists many of its properties, some of which are repeated by Isidore (*Etym.* XVI, *3*, 7).

[8] *porphyricum marmor:* an igneous rock with white spots (phenocrysts) in a dark red background (groundmass). Pliny (*Nat. Hist.* XXXVI, *11*, 57) says it is an Egyptian rock; Isidore (*Etym.* XVI, *5*, 5) adds that the name comes from the Greek word for purple or dark red.

CHAPTER 4: THE CAUSE OF THE DIFFERENCES IN HARDNESS IN STONES

Hard and soft are defined by Aristotle (Gen. and Corr. *II, 2, 330 a 8) in terms of dry and moist, resistant or unresistant to pressure.*

The accounts of the various stones are somewhat reminiscent of Vitruvius (On Architecture, *II,* 7, *1–3) on the hardness of building stones, and (II,* 8, *2–3) on the failure of walls. But Albert is not really quoting from Vitruvius, nor from Pliny or Isidore, who repeat many of the same statements. Probably Albert, since he lived in the great age of cathedral building, acquired some of this information directly, by watching workmen and talking to them, either at Cologne or during his travels. He recorded one such incident at Venice (II, iii, 1).*

WE shall speak next about the differences in hardness, in which stones are found to differ greatly. All kinds of precious stones are so hard that the file removes nothing from them, and if struck forcibly against each other or against hardened steel, they emit fire. On the other hand, nearly all kinds of tufa are found to have so little hardness that they can be cut with an ordinary tool. And certain white stones which the common people call chalk,[1] and some which are even softer and whiter, are found to have less hardness than any other kind of stone.[2] All kinds of flint[3] are very hard; and after these come the marbles, according to their kinds. Freestone,[4] however, is of intermediate hardness among stones, and yet some variation in hardness is found in this, too. But it commonly happens that the harder stones, if exposed to the air for a long time in cold weather, are later, in the sunshine, broken into many pieces. On the other hand, some which are less hard—unless they are poorly mixed, like quicklime solidified by baking heat (*optesis*)—the longer they are exposed to the air[5] in buildings, the better and harder they become and they are not broken by cold.

[1] *creta*, includes a number of white, soft, almost earthy materials. Pliny (*Nat. Hist.* XXXV, *57*, 195–9) mentions varieties like fuller's earth and polishing powders. Isidore (*Etym.* XVI, *1*, 6) abbreviates Pliny, adding (as usual) the origin of the name—from the island of Crete.

[2] *in generatione lapidum*, but texts 1495, 1518, *in genere lapidum*.

[3] *silex* is always a hard stone. Vitruvius (*On Architecture*, II, 5, 1) says it can be burnt for lime, so some *silex* must have been hard limestone. But other kinds were probably lavas, since Pliny (*Nat. Hist.* XXXVI, *49*, 168) says 'the fire does not harm them', a statement that could not apply to limestone.

[4] *quadrum* would include a variety of sandstones and limestones, having a considerable range of hardness and durability. Some building stones of this type weather very badly, splitting along bedding planes if improperly laid.

[5] Hardening in the air after quarrying is characteristic of many rather soft limestones, like those of northern France.

It is [the task] of natural science to assign causes for these accidental properties, based on the material and efficient causes, in the manner described elsewhere. Let us say, therefore, that the general cause of hardness is dryness. For since what is hard has a natural tendency to resist anything that touches it, and what is soft does not have this tendency, the cause can only be dryness, which stands firm and does not yield to anything else. Dryness is caused by two things in the nature of stones, as has already appeared: for either heat has dried the moisture out of earthy material, leaving it hard; or else very cold dryness has intensely attacked transparent moisture and in converting it to its own properties [of cold and dryness] has expelled the moisture, and by intensely compressing the material has hardened and highly compacted it. [This is the case] in transparent stones, and so they are very hard, and when struck emit fire; and they resist the file and must be polished, as it were, by grinding and rubbing.

But in the other stones made of the material of Earth, the cause of greater hardness is nothing but greater dryness, which is due to greater or lesser heat, acting as the efficient cause, and moisture, which is separable from the material with greater or lesser ease, acting as the material cause. For if the moisture is very unctuous it coheres easily; but if it is entirely watery, it evaporates easily. And therefore stones like chalk, or those softer than chalk, [which are] very white and leave a white streak on whatever they touch, have surely been mixed with a moisture highly susceptible to evaporation, and have been burnt by a heat exceeding [that which merely causes] solidification, and have already begun to be calcined.

Therefore they are not durable in walls. For because their dryness has been calcined they are always rough on the surface, which tends to separate from the grip of the cement, so that the stone as a whole is not held fast by the cement; and so these stones fall out of walls, and after a while a wall made of them becomes like an earth wall. But flints are very hard because their moisture is not separable from the material and is thoroughly dried out and hardened by intense earthy dryness. And so they do not hold the cement well, because their pores are contracted and do not absorb it. And this is why stonemasons rarely use them in construction, and say that these stones ruin walls. Marbles are also very well mixed and intensely baked; and therefore they are hard and suitable for walls. But freestones are best of all for buildings; and when they are intensely hard they have a great deal of dryness and [only] a little moisture holding them together. And when [the moisture] is hardened by cold, it leaves the outside and retreats to the inside; and such moisture is not well incorporated with the parts of the stone and therefore it is easily transferred inwards or outwards; and so, after it has been forced into motion by cold, it is later dried out by exposure to the heat of the sun, and then the stone breaks into separate pieces. On the other hand, stones which are slightly moist, with the moisture firmly incorporated in their composition, are intensely dried out in the air; and therefore in buildings they become harder and better with the passage of a long time. In tufas the cause of their softness is moisture, which is neither completely removed nor very well mixed with the Earth; and therefore tufa is soft; and if exposed to fire, it is not baked hard like brick but is transformed into earthy ash.

These, then, are the statements made about the hardness of stones; and from these, other differences, too, can easily be understood.

CHAPTER 5: FISSILITY AND NON-FISSILITY IN STONES

Fissility (dolabilitas) *is the tendency of some rocks to break into thin slabs, either along bedding planes in sediments, or along planes developed by metamorphism in slates and schists. Albert does not seem to include here the cleavage of crystals, although he later mentions the fact that mica and gypsum can be split into thin pieces (II, ii, 17,* Specularis). *Rocks that are not fissile are* comminuibiles—*tending to break into little bits—brittle, friable, or crumbly.*

The explanation, based on the role of 'pores', is taken from Meteor. *IV, 9, 386 a 9–17; 386 b 26–387 a 3.*

On this [same basis], the cause of fissility and non-fissility can be explained. For stones that are extremely hard are not fissile but have a tendency to break into little pieces; and since they do not have their pores arranged in rows they do not split straight. For just as in wood the knottiness depends upon variations in the flow of the [sap][1] by which the body of the wood is produced, so [the same thing] in stones depends upon variations in their mixture, and disorder in their materials; and that knottiness causes the

[1] *sicci,* evidently an error for *succi:* cf. Albert's work on *Plants* (I, ii, 1) for discussion of the role of sap or juice (*succus*) in forming the grain and knots in wood.

stone to break irregularly and not straight. Nevertheless the hardest and driest stones, whether they are knotty or not, have a tendency to break into little pieces rather than to be fissile; for compaction or baking heat (*optesis*) has compacted and distorted the pores in them so that their capacity for splitting and parting has been removed. But stones that have not been excessively compacted or hardened are fissile and can be cut straight; though, to be sure, they cannot be cut like wood, but rather by chipping away a little at a time, meanwhile leaving the rest of the stone untouched. This, then, is what fissility and non-fissility are.

And the very procedures of the stonemasons' art show this: for stonemasons cleave fissile stones straight, parallel to the whole surface;[2] but non-fissile stones, which tend to break into little pieces, they do not cleave parallel to the whole surface; but it is enough if the projections of the surface, which is not flat but rough, are in line. This is what the stonemasons of Lesbos are said to do; because in the island of Lesbos the only stones are those that tend to break into little pieces.

CHAPTER 6: THE CAUSE OF THE POROSITY AND COMPACTNESS OF STONES, AND THEIR HEAVINESS AND LIGHTNESS

Although the principle of specific gravity *is said to have been formulated by Archimedes (d. 212* B.C.*), and was certainly known to the Arabs, Albert here adheres faithfully to Aristotle's doctrine of natural motions and natural places, as stated in* The Heavens *(IV, 1, 307 b 28 ff.). Air has a natural tendency to move upwards (levity,* levitas*), since its natural place is above Water. In a porous rock this tendency of the Air in it can counteract the opposite tendency of the Earth in it to move downwards (gravity,* gravitas*) to its natural place, which is below Water.*

IN this way, too, the causes of the porosity of stones, and of their compactness, are determined. For there are found some stones of such great porosity that they float on water, like the stones that a volcano casts out, and pumices; and some are found that are very compact, like precious stones and marbles; and some are found that are, as it were, intermediate between these. And indeed the cause of porosity is simply that the moisture has not been completely mixed with the Earth, but stayed in separate

[2] That is, along a regular cleavage like that of slates.

parts of it, just as in a clay vessel, even after it has been dried out by firing, there remain little holes. And thus the stone becomes porous. And because of the Air enclosed in these little holes, it floats on Water. But compactness is caused especially by moisture that penetrates everywhere throughout the material of the stone, causing every part of it to flow into every other part. And so the stone becomes compact. Now the moisture is either liquid and watery or vaporous and airy;[1] and since what is airy is more subtle than what is watery, stones are of more compact substance if they are mixed from vapours rather than from another substance, either watery or earthy.

It is superfluous here to go into the cause of heaviness or lightness, since this has been adequately dealt with in the book on *The Heavens* where it has been shown why lighter stones sink in water while heavier [pieces of] wood float on water.[2]

These, then, are the statements made about stones in general.[3]

CHAPTER 7: THE CAUSE OF THE GREAT NUMBERS OF LITTLE STONES ALONG SHORES, AND THE ROWS OF BRICKS THAT ARE SOMETIMES FOUND ON SHORES AS IF THEY HAD BEEN ARTIFICIALLY PUT THERE

This chapter offers Albert's own speculations about certain phenomena that have puzzled him. The first seems to be a firmly cemented river gravel or conglomerate. The second is probably an outcrop of a hard bed of sandstone or quartzite, or of a sill or dike of igneous rock, so regularly jointed as to have the appearance of masonry (though of course old Roman and Celtic walls do exist in some places in northern Europe, and Albert may have seen one of these). Believing firmly in the Aristotelian saying 'Art imitates Nature', Albert offers his explanations in terms of the technological operations of burning and slaking lime, and of making bricks.

BESIDES everything that has already been said, it happens that sometimes along the banks of rivers and seas there are found enormous numbers of

[1] *corporale et aqueum, aut spirituale aut* (for *et*) *aereum*. Cf. I, ii, 1, note 4.

[2] This apparent paradox illustrates the confusion between *weight* and *density*. Today we should say that a (small) stone may be lighter (weigh less) in air than a (large) piece of wood; but in water the stone, having a greater density (or specific gravity) than the wood, sinks, while the wood floats.

[3] This sentence seems to be the closing formula not merely of this chapter, but of Book I as a whole. Perhaps the following two chapters were added later.

little stones, bound together, as it were, by a very strong cement, as if they had been taken from some wall. And on this account some people think that there were once works of the ancients there, which have been destroyed by the water. And what is even more wonderful [is that] along the whole length of the shore there is found sometimes a row of bricks, as if they had been artificially put there. But nevertheless this does not seem to be artificial, because it is very thin, not at all like any wall, but just one brick next to another, with no more bricks above or below.

Now I say that the cause of the first of these two things—namely that little stones are found stuck together as if by cement—is that at first those different kinds of flints were hardened, and there was in that place material something like quicklime burnt by baking heat, and when this was later mixed with water, it heated the stones again,[1] and stuck them together. And that cement is extremely hard: for every time earthy dryness is baked by dry heat it is calcined, and by repeated baking it becomes excessively hard and, as it were, incapable of being consumed by fire. And this is proved in artificial operations, when [old] pottery is crushed and calcined, and again mixed with moist clay to make pots that are solidified by firing and thus rendered extremely hard and incapable of being consumed by fire. And for this reason artisans demand vessels made in this way when they are casting metals.[2]

Nor is there any reason, either, why it should be said that bricks are made only artificially and not naturally. For if tenacious clay is mixed in the earth and afterwards baked by the heat enclosed there, a better brick is made in the earth, naturally, than is made artificially. And this can occur most of all along the shores of seas and the banks of rivers, because those places are mixed with moisture, and they are warmed by the rays of the sun, and they are solid enough to keep in the heat so that it may not evaporate. And it is only in such places that effects of this kind are found. For there would be no reason for artificially putting one brick next to another in a row, just along one straight line, without building any more.

[1] Quicklime is made by heating limestone, and then is 'heated again', as heat is evolved when it is slaked with water.

[2] Crucibles made in this way are recommended for refining gold (IV, 7).

CHAPTER 8: CERTAIN STONES THAT HAVE THE FIGURES OF ANIMALS INSIDE AND OUTSIDE

Organic fossils were one of the enigmas of nature in the Middle Ages, but Albert here follows Avicenna in acknowledging that they are really what they appear to be—that is, the remains of actual plants and animals that lived in former times. The relevant passage in Avicenna (De congelatione, *Holmyard and Mandeville, 1927, pp. 46–47) reads:*

In the same way also certain plants and animals are turned into stone by a certain mineralizing, petrifying power; and this happens in stony places, or they are suddenly disintegrated [into their constituent elements] by a certain power that issues from the earth at the time of an earthquake and converts to stone whatever it encounters at that time. And this transmutation of the bodies of animals and plants is just as short a step as the transmutation of waters. Yet it is impossible that any organism should be turned into a single element; rather, the elements are changed into each other successively, and so pass into the dominant element. And thus what falls into salterns becomes salt, and what falls into fire becomes fire, some things more quickly and some more slowly; and this depends on the potency of the active qualities [heat and cold] and on the state of the passive qualities [moist and dry].

It seems wonderful to everyone that sometimes stones are found that have figures of animals inside and outside. For outside they have an outline, and when they are broken open, the shapes of the internal organs are found inside. And Avicenna says that the cause of this is that animals, just as they are, are sometimes changed into stones, and especially [salty] stones.[1] For he says that just as Earth and Water are material for stones, so animals, too, are material for stones. And in places where a petrifying force is exhaling, they change into their elements and are attacked by the properties of the qualities [hot, cold, moist, dry] which are present in those places, and the elements in the bodies of such animals are changed into the dominant element, namely Earth mixed with Water; and then the mineralizing power converts [the mixture] into stone, and the parts of the body retain their shape, inside and outside, just as they were before. There are also stones of this sort that are [salty][2] and frequently not hard; for it must be a strong power which thus transmutes the bodies of animals,

[1] *lapides falsos*, 'false stones'. This might mean 'stones that look like stones but really are not (because they are petrified animals)'. But the correct reading is probably *lapides salsos*, 'salt stones', which becomes intelligible in the light of the passage from Avicenna on which this chapter is based (see above).

[2] *falsi*, again for *salsi*.

and it slightly burns the Earth in the moisture, and so produces a taste of salt.[3]

A story that confirms this is that of the Gorgon, who is said to have converted into stone those who looked upon her. A strong mineralizing power was called 'the Gorgon', and exposing the bodily humours to the petrifying power was called 'looking upon the Gorgon'.[4]

These, then, are all the statements that seem necessary about stones in general.

[3] *Meteor.* II, 3, 359 b 11: Earth that is burnt takes on a salty or acrid taste. Evidently this notion arose from the use of wood ashes for lye, but it was extended to explain the salt of the sea. See V, 2 for more about salt.

[4] Ovid (*Metamorphoses*, IV, 741–52) tells how the Gorgon's head, laid on seaweed and twigs, changed them into stones, which the nymphs scattered in the sea: this was the origin of coral.

BOOK II
PRECIOUS STONES

TRACTATE i
THE CAUSE OF THE POWERS OF STONES

CHAPTER 1: THE CAUSE OF THE POWERS OF PRECIOUS STONES, WITH A REFUTATION OF THOSE WHO SAY THAT THERE ARE NO POWERS IN STONES

The title of this tractate, as printed by Borgnet, is: De causis virtutis lapidum, et descriptionibus eorum, et sigillis quae inveniuntur in quibusdam depicta. *This, however, is really a subtitle for the whole of Book II, which deals with: The causes of the power of stones (Tractate i); descriptions of individual stones (Tractate ii); and sigils in stones (Tractate iii).*

This first chapter is a defence of the belief, prevalent in the Middle Ages, that stones possess extraordinary powers, medical or magical. But Albert denies that such powers indicate that stones have souls, or share in some divine essence. He attributes their effects to form *rather than* matter, *and this view is further developed in II, i, 4.*

In considering precious stones we shall not discuss the cause of their colour, nor their capacity to be acted upon, nor their hardness, nor anything else of that sort; since in the preceding book all these things have been covered sufficiently for our present purpose. But there are three [topics] which must be investigated as well as possible, namely the cause of their power, and descriptions of them individually, and the *sigils* that are found marked on some of them. When these three things have been dealt with, we do not seek to know any more, in terms of natural science (*physice*), about the nature of stones.

The cause of the power of stones is very obscure and many natural scientists (*physiologi*) seem to have held very different opinions about it. Many indeed seem to doubt whether there are in stones any of the powers which are regarded as belonging to them, such as curing abscesses, expelling poison, reconciling the hearts of men, bringing victory, and the like; and they assert that there is nothing in a composite substance except [what is due to] its constituents and the way they are combined. But such action as is said to be inherent in stones is not caused by their constituents. These are responsible only for such properties as heat and moisture, hardness, and capacity to be acted upon, and the like, which have been determined in the preceding [book]. And moreover, they say, the powers attributed to stones ought rather to belong to living things, since these are nobler than stones. This is the kind of reasoning used by those who do not admit that stones have any powers.

But the opposite is proved most convincingly by experience: since we see that the magnet attracts iron and the *adamas* restricts that power in the magnet.[1] Furthermore, it is proved by experience that some *saphirus* cures abscesses,[2] and we have seen one of these with our own eyes. This is a widespread belief; and it is impossible that there should not be some truth at least in what is a matter of common report.

But there have been some who, even though they assign special powers to stones, attribute these to a *soul* in the stone. These are certain of the Pythagoreans; for they say that this [power] belongs to soul alone, and not to any single material; but it extends from one [thing] to another by a sort of vital activity—just as man extends his intelligence to intelligible things and his imagination to imaginable things. And thus they say that the soul of one man, or of some other animal, can go out and enter into another, fascinating it and hindering its actions; and therefore they warn [one] to be careful in all actions, so as to turn aside the fascination of the eye.[3] So, too, certain augurs say that undertakings may be hindered or helped by the sight and sound of certain birds or other beasts. Therefore they assign souls to stones and extend them to the natures attributed to stones.

The school of the Pythagoreans—of which in many respects

[1] See II, ii, 1, *Adamas;* 11, *Magnes.*

[2] See II, ii, 17, *Saphirus.*

[3] This passage is very similar to one in Albert's *Animals* (XXII, i, 5), where he says that man is the link between God and matter. Some men, by the power of the mind, have been able to control matter and work miracles, or to exercise 'fascination' over others 'though the sight or another sense'. But the souls of men who yield to bestial passions are reborn as beasts. He gives as his authorities 'Hermes writing to Asclepius', and Plato. In *The Sacred Book of Hermes Trismegistus addressed to Asclepius*, I, 6a (Scott, 1924, Vol. I, pp. 294–7) Hermes discourses on the divine soul of man; in III, 23b–24a (Scott, pp. 338–41) on man-made statues of the gods that work miracles; in II, 12a (Scott, pp. 308–9) on the transmigration of souls. Plato's *Timaeus* (42 C; Chalcidius's Commentary, 193 ff.) also mentions transmigration. But none of these mentions 'fascination' or 'the Evil Eye'.

Democritus[4] was a follower, since he said that stones have souls—held as dogma that all things are full of gods[5] as later Orpheus[6] sang in his poetry; for he said that the gods are divine powers diffused in things; and that even God is nothing but the formative power diffused in all things. And therefore he said that in stones there is a divine part which he called the soul of stones, extending to things roundabout, on which it acts. But this is the height of absurdity. As to fascination, whether this is true or not belongs to [the art of] magic. And then, too, it is madness to say that God is diffused in things, in such a way that He is united and mixed with them like some essential property: for if He were thus mixed with things, He would be capable of being produced in certain things, and would pass from non-being to being, and from potentiality to actuality; and all this is impossible to reconcile with [the idea of] God. It is true that anything whatsoever may have within it something divine, or similar to the divine, by means of which it seeks and pursues divine being; and this has been shown elsewhere.[7] But that stones do not have any souls has been shown in the book preceding this.

Therefore, leaving aside these and similar [statements] as too ridiculous, let us say that there are no two opinions about it: stones do have powers of wonderful effect and these powers reside not in their constituents but in the way they are combined, for a reason that we shall explain later. Nor is it true that living beings [only] ought rather to have these powers. For throughout all nature it is as if a thing which is occupied with the higher powers is withdrawn and cut off from the lower [ones]. Evidence of this is that intelligent beings, such as men, are not so keenly aware of changes in the elements as brutes are—for instance, birds judge the different hours and seasons better than men do. And man himself, when he is occupied with meditation, does not exert his sight and hearing, so that he does not perceive what is before his eyes.[8] Thus in the whole of nature it is as if

[4] See I, i, 4, note 8.

[5] Aristotle, *The Soul* (I, 5, 411 a 8) attributes this statement to Thales. But probably Albert is merely alluding to the Platonic-Pythagorean 'World Soul'.

[6] I have here disregarded a full stop which in Borgnet's text stands before *Orpheus*. Orpheus is certainly intended as the author of the poetry—that is, the Greek *Lithica* (see Appendix B, 5: *Damigeron*). But Aristotle also mentions Orpheus, as saying that the soul is in the wind and enters into animals with their breath (*The Soul*, I, 5, 410 b 28).

[7] Aristotle, *The Heavens*, II, 12, 292 b 5 ff.: the ultimate end of all action is to attain 'the best', but this is not equally possible for all. The lower animals and plants have only a limited sphere of action: they strive for 'the better' but cannot attain to 'the best'.

[8] Aristotle, *The Senses*, 7, 447 a 15. Albert, *The Senses*, iii, 3 adds 'and thus we do not notice our friends when we meet in the

living beings, when they are occupied with the higher powers of the soul, do not exert the lower, less noble powers that inanimate compounds exert.

For there is nothing in all nature that does not have its own specific action, as scammony purges yellow bile, and the like. This is proved in [the use of] medical simples, and in the science of *Incantations and Ligatures*,[9] where it is shown that parts of many different animals, bound round the neck or on the hip or on some other part of the human body, produce wonderful effects. The same [is true] with herbs, roots, and woods. But even human flesh and—what seems even less likely—the dry residues[10] of a human body, and wolves' dung, are wonderfully effective against poison or other deadly illnesses. Hence it is known that stones, too, undoubtedly are effective—all, or nearly all, stones, although the effects of many of them are unknown. And therefore John of Damascus[11] says that there is nothing that does not have its own action, due to its own substance. For it would be ridiculous if we were to say that the primary qualities [hot, cold, moist, dry] have strong effects and yet the substantial forms which are set as their natural limits, as being divine and best, have no effect at all; although, to be sure, they [play] neither an active nor a passive [role][12] in the transmutation of the material, yet they are able to effect such action as is exactly suited to anything made by nature according to what is divine and best.

CHAPTER 2: THE OPINIONS OF FOUR PHILOSOPHERS ABOUT THE CAUSE OF THE POWERS OF STONES

Here again Albert follows the Aristotelian plan of first giving the opinions of several authorities, which are to be refuted later.

street, when our minds are occupied with something else'.

[9] *Incantations and Ligatures* by Costa ben Luca (see Appendix C, 5). In it Galen is cited on wolves' dung, which is most efficacious if worn suspended by a thread made of wool from a sheep killed by wolves; and Aaron, for elephant's dung as a contraceptive. Other valuable ingredients for charms are the teeth of a mad dog, the hair of a totally black dog, feet of hares and tortoises, cobwebs, seeds and roots of various plants, as well as certain stones (see also II, iii, 6).

[10] 'Residues' include not only excrements but also such growths as hair and nails, clippings of which have long played a part in magic.

[11] John of Damascus (eighth-century theologian of the Eastern Church), *Exposition of the Orthodox Faith* (Salmond, Vol. I, p. 28): 'For there is not a single animal or plant in which the Creator has not implanted some form of energy capable of being used to satisfy men's needs.'

[12] That is, *form* is different from *matter*, and the properties designated as active (hot, cold) and passive (moist, dry) belong not to the *from* but to the *matter* of any substance.

The discussion of colours, attributed to Hermes, may be regarded as a supplement to that in I, ii, 2. The precious stones mentioned are described in the alphabetical lapidary, II, ii.

FOR a long time philosophers have been inquiring into the cause of these powers that are infused into stones; and it would be a waste of time to review all their different opinions. Let us therefore touch upon four which are probable, and afterwards declare our own conclusion, and then support it by reasoning.

Some have said that such powers in stones are due to their constituent elements. To this the objection may be raised that the elements do not act except through the primary qualities [hot, cold, moist, dry], and the actions of stones cannot be reduced to these primary qualities. The reply [that is made to this] is that the elements have certain actions in themselves and certain others when they are in a mixed [body]; because in a mixed [body] an elementary quality is moved and acts as an instrument; and then it is able to effect many things which it could not do by itself. And therefore, just as the alteration of food, when it is taken up and reduced to flesh, is not ascribed to any power except digestive heat, which we know is the heat of Fire that brings together things of the same kind and separates things of different kinds, as is said in the second book of the *Meteorology*;[1] so they say that whatever is in [a body] made of elements is to be attributed only to the power of the elements; for [a body] made of elements does not act except by the mediating power of the elements in it.

This, then, is the opinion of some ancient philosophers, which Alexander,[2] the Greek Peripatetic, seems to defend. For he attributes all things whatsoever, whether living or not, to the elements. He even says that the intellect is the consequence of certain combinations of elements. For the elements themselves when combined, he says, are wonderfully and highly effective. And the power which in a mixed [body] rules and directs the elemental qualities is, according to him, merely the consequence of their being combined; and this, he asserts, is wonderful. He offers proof from the operations of alchemy, in which there are only a few simple

[1] This seems to be a mistake for *Gen. and Corr.* II, 2, 329 b 27. But Albert may be merely quoting himself, since he uses this same phrase about heat or Fire repeatedly in his own version of the *Meteorology* (e.g. II, iii, 20 in the account of mineral waters).

[2] Alexander of Aphrodisias (*fl. c.* A.D. 200), a famous Greek commentator on Aristotle. Albert seems to be citing this account of Alexander's theory from Averroes's Commentary on *The Soul* (Crawford, 1953, pp. 393–8).

substances present, but when they are combined, they produce remarkable effects.

But this opinion was not acceptable to Plato,[3] who says that all lower things are activated by higher Ideas, which are separate and of wonderful potency. It is these [Ideas] that produce whatever is produced, according to his assertion. He says, too, that things which have a greater likeness to the separate [Ideas], and in which the separate [Ideas] are less deeply submerged in matter, have a wonderfully powerful action, like that of the separate Idea. And the separate Ideas, he says, act by transmuting and altering the material of things that are capable of being produced and destroyed. Therefore in things in which the Idea is less deeply submerged in matter, once it has been incorporated in them, it does not cease to perform wonders. And this, he says, is the case in precious stones and many other natural things.

We learn the proof of this opinion not only from Plato but also from Platonists like Apuleius[4] and some others, who say that even after the death of mortal things, that which is immortal in them does not cease to perform wonders. They also say that if these actions were attributed to the elements as some [Peripatetics][5] have said, or to the combination of elements, then, since the combination is unique, a stone would have only one action. But we see [that it may have] many. Furthermore, whether an elementary quality acts by itself or in combination, these elementary qualities do not act except by transmuting the material which they affect. But precious stones do not seem to act by making any such transmutation of substance; and therefore their action seems to be that of some separate principle or other. This, then, is the opinion of the Platonists.

But Hermes[6] and some of his followers, and many of the Indians, writing a great deal on *The Universal Power*, said that the powers of all things below originate in the stars and constellations of the heavens; and that all these powers are poured down into all things below by the circle called *Alaur*, which is, they said, the first circle of the constellations. These

[3] Plato's Theory of Ideas was often outlined and criticized by Aristotle, but Albert seems here to be giving a general summary of neo-Platonic views.

[4] Apuleius (see Appendix C, 1), in his *De deo Socratis*, speaks of souls which after death do not enter another body, but become ghosts—*Manes* or *Lemures;* and Augustine quoted this in *The City of God* (IX, 11).

[5] *Pythagorici:* but this does not agree with the views attributed to the Pythagoreans above (II, i, 1); it seems to be an error for *Peripatetici*, referring again to the views of Alexander.

[6] See Appendix C, 3 for notes on Hermes's book, *The Universal Power.*

powers descend into natural things in a manner that is either noble or ignoble: noble when the materials receiving these powers are more like things above in their brightness and transparency; ignoble, when the materials are confused and foul, so that the heavenly power is, as it were, oppressed. Therefore they say that this is the reason why precious stones, more than anything else, have wonderful powers—because, that is, they are in substance more like things above in their brightness and transparency. On this account, some of them say that precious stones are stars composed of elements.

For in the upper [spheres], they say, there are, as it were, four colours, which are also the colours most frequently found in precious stones. One of these is the colour of the starless sphere, which is called sapphire by everyone; and this colour is pre-eminently that of the *saphirus* from which it is named. But some other stones have a lesser share in it. The second colour is that of most stars, which is called bright, shining white; and this is the colour of *adamas*, beryl, and many other stones. The third is called fiery and flashing; this is in the Sun and Mars and certain other [stars]; and this is pre-eminently [the colour of] the carbuncle, and, after this, of *palachius* or *palatius*, and of *granatus*, and of some others. And therefore they say that the carbuncle is the noblest, having the powers of all other stones; because it receives a power similar to that of the Sun, which is more noble than all other heavenly powers—and it is his universal power that gives brightness and power to all heavenly [things]. The fourth colour is a dark [cloudiness],[7] found in certain stars as well as in some of the mansions of the Moon;[8] and this is found in stones containing dark clouds, such as chalcedony, amethyst, and sometimes in *smaragdus*, and some others. From these and similar statements these philosophers have drawn their opinions.

But Avicenna[9] and some others who follow him said that in all nature monstrous things sometimes appear, because of the *imagination* of the movers [of the heavenly spheres] above. For this philosopher contends that the intelligences that move the spheres cannot in any way direct one

[7] *rubeus obscurus*, 'dark red'; but more likely the reading should be *nubes obscurus*, 'a dark cloud', as in the following clause.

[8] The *mansions of the Moon* are the divisions of the Zodiac circle corresponding to the positions of the moon, night by night, in its monthly circuit.

[9] Avicenna thought of the celestial movers as 'intelligences' or 'angels', separate from God. Albert repeatedly rejected this opinion, since he believed that all the spheres were moved by the 'First Mover', which is God Himself.

motion or another except by seizing upon particular [things]; and this seizure, he says, is called 'imagination' in a figurative sense (*aequivoce*), after the 'image' that is [formed] in the sensitive soul of living things. But in practice, he says, everything that is created is already existent in the thoughts of the movers of the starry spheres. Furthermore, he adds, all the material in things that can be produced obeys the mover, just as our bodies obey our souls. We, too, have our own feelings, so that when we think of some form or other our bodies are stirred with delight, or horror, or aversion. In the same way, then, he says, frequently the souls of the heavenly bodies think of various things, and then matter is moved in obedience to that [thought], and this is how the things produced receive the various powers that we ascribe to their constitution. [And this applies] most of all [to] stones, in which the primary mixture is more easily affected by this sort of 'imagination' than in other things which have greater variety because of a soul infused into them. This, then, is what Avicenna and his followers have said, as may be gathered from some of his statements written about magic and alchemy.

CHAPTER 3: REFUTATION OF THESE OPINIONS

In refuting the opinions of the previous chapter Albert refers repeatedly to various works of Aristotle, but only in a general way. Albert uses the same method of exposition in his version of The Heavens (*I, iii, 4,* digressio)*: 'But because perhaps it would be difficult and tedious for anyone to search in the* Physics *and many places in the* Metaphysics (First Philosophy), *we shall summarize the proof briefly here, without proving every point, but indicating where the proofs are given.'*

THE statements of Alexander the Peripatetic do not fit the case, because we know that, although any heat at all, either by itself or in a mixture, acts in various ways, yet these are consistent with its general [property of] bringing together things of the same kind and [separating] things of different kinds. And we say that the same [is true] of cold, moisture, and dryness. But the actions of stones are neither in a general nor in a specific way consistent with the actions of the simple qualities, but seem to be much more monstrous and wonderful. Furthermore, it is wrong to say that nothing guides and shapes the qualities of the elements except their mixture and constitution. For [if that were true] their specific forms would be nothing except their constitutions; and this has been shown to be untrue, as we shall also show in our books on *The Soul* and *First Philosophy*.[1] [It is] because the powers of stones are not due merely to their constitution or their elements that magicians prefer precious stones to anything else for use in rings or other images which have a wonderful effect. For this and like reasons Alexander's statement is shown to be untrue.

And what Plato says about Ideas has been proved unsatisfactory by many [writers], and we shall take up the arguments elsewhere,[2] for the theory of Ideas demands more inquiry than the subject now before us. But here it may be assumed that Ideas do not confer form on things that are produced, nor is there anything immortal in mortal and destructible things, since when these are destroyed nothing that was in them is left; and mixed bodies are not dissolved into elements and Ideas, but only into their constituent elements. But even if Ideas were supposed to be of this character, they would be useless; for they would not bear any relation to the material, nor be in contact with it, nor transmute it. For all such [effects] seem to be in the material itself and not separate from it. These and similar [considerations] disprove Plato's statement.

Of all the ancients, Hermes gives the most probable reason for the powers of stones, since we know for a fact that all the powers of things below come from above. For [the stars] above, by their substance and light, position, motion, and configuration pour down into things below all the noble powers they possess. Nevertheless this statement is not enough for natural science, although perhaps it may be sufficient for astrology and magic. For natural science discusses the cause that acts upon matter, such as the elements or their qualities, in so far as they are present in a mixed [body], or the substantial forms resulting from such a combination. For Ptolemy, in the book called *Alarba* (*Quadripartitum*),[3] teaches that the effects of the stars are so varied and uncertain because their influence reaches things below indirectly and accidentally: indirectly, through the powers of the elements which produce forms; accidentally, since it reaches things below only because it is everywhere, and it is [confused][4]

[1] The relation between *soul* (or *form*) and *matter* is treated in Aristotle's *The Soul*, especially the beginning of Book II, and *Metaphys.* (*First Philosophy*), Books VII and VIII.

[2] Aristotle criticizes Plato's theory of Ideas in a number of places, notably *Metaphys.*, Books XIII–XIV.

[3] The Greek title is *Tetrabiblos* (see Appendix C, 2); the passage here paraphrased is in I, 2.

[4] *inconfusum*, but the sense requires *confusum*.

and uncertain in its distribution, since sometimes the material is capable of receiving the heavenly power and sometimes it is not, sometimes it receives only a little and sometimes a great deal. There are many who prophesy by the stars who do not understand this, and so they often say what is not true, and by their lies give the science a bad name, although it is really good and very useful.

But what Avicenna says about monsters itself seems monstrous. For what he calls *imagination* is not at all fitting for the heavenly intelligences unless they have thoughts other than those displayed in the motion of the heavens and the qualities of the elements: for there is nothing disorderly in those. This will be fully shown elsewhere, since many things must be [left out][5] here; but these things must be treated in a fitting manner. But enough here is what has been stated completely about such things in the books on *Physics* and *The Heavens*,[6] so far as scientific consideration permits: for the intelligences are active and by themselves supply form to the work of nature, and the motion of the heavens uses them as an instrument. Nor has the Mover any other thought than this. But why He directs His thought towards one thing or another is partly explained in the book on *The Heavens*, and is to be determined more fully in *First Philosophy*.[7]

CHAPTER 4: THE TRUE CAUSE OF THE POWER OF PRECIOUS STONES

Albert's own explanation of the powers of stones is based on Aristotle's concept of form *(cf. I, i, 6).* Matter *without* form *is inconceivable, and so can hardly be said to exist;* form *is, in a sense, what holds* matter *together, and is responsible for its essential activities or functions. When* form *is destroyed, the constituent elements are freed to return to their natural places.*

Now that all these opinions have been refuted, we state, in agreement with

[5] *permitti*, error for *praetermitti*.

[6] Albert is probably thinking of his own commentaries: in the *Phys.*, VIII, he interprets Aristotle's unmoved mover as the Christian God; and in *The Heavens*, I, he added several chapters on theology.

[7] Again this seems to refer to Albert's own versions of the *Physics* (see note 6, above) and *Metaphysics*, especially Book XII, where he refutes Avicenna's opinion that the celestial movers are separate souls or angels, and insists that they are intelligences subject to God's will.

Constantine[1] and some others, that the power of stones is caused by the specific substantial form of the stone. There are some powers of mixed [bodies] that are caused by the constituents [in the mixture], and some caused by the specific form itself. And this is more clearly seen in [bodies] which are most particularly distinguished by specific forms—such as man who, functioning as a man, has intelligence, which is not the result of anything in his [physical] constitution. And the same [is true] of brutes and plants, as is shown in the *Ethics*:[2] for everything has its own proper work, its own good, according to the specific form by which it is shaped and perfected in its natural being. Every combination is thus the instrument of a specific form, since the form encloses everything; and when it ceases to exist, the combination is destroyed and dissolved. For the form encloses the matter, as being its divine good, and is not enclosed by it. Nor does form naturally have any desire for matter, because it has no need of matter except when it exists as an individual [thing], but not when it exists as something divine. These things will be explained more clearly in the books on *The Intellect*[3] and *First Philosophy*:[4] form, therefore, is [intermediate] between two [things]—the heavenly powers by which it is conferred, and the matter of the combination into which it is infused.

Thus, if we consider [form] purely in itself, it is a simple essence, capable of only one function,[5] for whatever is unique can have only a single function; and whatever is unique comes from something unique, as all philosophers agree. But if we consider this form, first in relation to the heavenly powers, propagated by means of things both above and below, and by all the constellations and their circles, which the twelve Signs [of the Zodiac] bring successively above the horizon of anything

[1] Perhaps Constantine the African (Appendix B, 9), or perhaps Costa ben Luca (Appendix C, 5). I have not identified the quotation.

[2] *Nichomachean Ethics*, VI, 2, 1139 a 16: 'the virtue of a thing is relative to its proper work'.

[3] Albert, *De intellectu et intelligibili*, II, 1: 'All forms are given to matter by the First Intelligence which universally surrounds matter, and therefore every form which is in matter is an intermediate between the two—that is, between the Intelligence from which it flows, as the forms of artifacts flow from the intellect of the artisan, and the matter in which it is, through the essential being which it gives to the matter.'

[4] Aristotle, *Metaphys.* XII, 1, 1069 a 30, distinguishes three kinds of *substances*: Those perceptible to the senses, which may be either (1) perishable, like individual plants or animals, made up of elements (Earth, Water, Air, Fire); or (2) imperishable, the heavenly bodies, made of Ether. Still others (3) are not perceptible to the senses and are imperishable, the objects of mathematics (or Plato's Ideas). Later, in *Metaphys.* XII, 3, 1070 a 25, he suggests that the human soul, or at least the intelligent part of it, may be of the last kind.

[5] See I, i, 6, note 1.

which the form is entering; and secondly, in relation to the powers of the elements as they affect its function—then that form itself will [seem to] be multiple, according to the natural potencies surrounding its simple essence. And therefore it will be productive of many effects, even though perhaps it has one function that is particularly its own. For it cannot be said that the powers of the causes do not somehow remain in the effects. And this is why nearly everything is good not merely for one purpose, but for many, when its functions are understood.

But in comparison to the material which it shapes, form may be either more potent or less potent, as Hermes[6] correctly stated. And this is why, among stones of the same specific form, some are found to be more potent and some less potent in their effects; and perhaps some are even found to lack completely the effect [characteristic] of the specific form, because the material in them is disordered—just as a man, simply because he is a man, does not necessarily behave like a human being. For although specific forms do not take part in things according to a fixed proportion, greater or lesser, yet we see that form is present in almost all things, in accordance with their very existence and their greater or lesser activity. Thus things are found to be more efficacious or less efficacious with respect to those powers that result from the specific form; or they may even be entirely incapable of the actions that are performed by the powers naturally resulting from the specific form.

We must recall what we have said in the second book of the *Meteorology*[7]—that the specific form of individual stones is mortal, just as men are; and if [stones] are kept for a long time, away from the place where they were produced, they are destroyed, and no longer rightly deserve their specific name—although [so far as] shape and colour [are concerned], the name might cease to be used only after a very long time. And just as

[6] Perhaps from *The Sacred Book of Hermes Trismegistus addressed to Asclepius*, II, 15 (Scott, 1924, Vol. 1, pp. 314–15): all things differ in goodness because of the properties of matter, which is capable of producing both good and bad.

[7] Evidently an error for the *fourth* book of the *Meteorology* (IV, 12, 389 b 28 ff.), which emphasizes that *form* is the real essence of a thing, by which it is able to function—a dead man is a man only in name, etc. To this Albert (*Meteor.* IV, iv, 7) adds another illustration that is relevant here:

> For minerals in their own way suffer death just as animals do; but the loss of their essential being is not noticed unless the change is very great. For a 'dead' *saphirus* still retains its colour, transparency, and shape just like a 'live' one that is capable of producing the effect of a *saphirus*; and therefore it is called *saphirus*, just as a 'live' one is. But after a long-drawn-out change it grows dull and begins to disintegrate; and then we realize that it is not really a *saphirus*, but only the likeness of a *saphirus*. And the same terms, 'live' or 'dead', are applicable to gold, silver, and other minerals.

in the making of animals, sometimes there is in the combination such disorder that they do not attain to a human soul, but only to a somewhat human appearance, so it is also in the production of stones, either because of disorder in the material, or because of very strong heavenly powers acting in opposition, as we have said in the second book of our *Physics*.[8]

These, then, are as many statements as can be made about the powers of stones in general.

[8] Aristotle, *Phys.* II, 7, 199 a 33 ff., explains monsters as 'mistakes' of nature. Albert, *Phys.* II, iii, 3, enlarges on this, quoting Ptolemy (*Tetrabiblos*, III, *8*) on the influences of opposing stars in causing monsters to be born.

TRACTATE ii
PRECIOUS STONES AND THEIR POWERS

CHAPTER 1: PRECIOUS STONES BEGINNING WITH A

This whole tractate, often quoted as a sample of Albert's mineralogy, is less his own than many other parts of the Book of Minerals, *being directly based on contemporary works (see Appendix B: 'Albert's lapidary in the* Book of Minerals').

An alphabetical order is common in thirteenth-century encyclopedias, but Albert did not entirely approve: he says, in introducing the alphabetical lists in the Animals *(XXII, ii, 1) that 'this method is not suitable in philosophy'—that is, it is not a scientific classification—but nevertheless he will adopt it for the benefit of unlearned readers. In mineralogy, however, no really scientific classification was possible in Albert's time, and the alphabetical order is at least convenient. The alphabetization is rather imperfect: names beginning with the same letter were brought together but little attention was paid to the following letters or to variations in spelling; and additional items might be inserted in a manuscript wherever there was room. I have not altered Albert's order nor, in most cases, his spelling, though I have noted what I believe to be the 'correct', or at least the oldest, names.*

I have also given for each mineral references to the lapidaries that seem to be most closely related to Albert's (see Appendix B):

Marbod (Migne, P.L., *Vol. 171).*
Arnold of Saxony (Stange, 1904–5).
Bartholomew of England (Heidelberg, 1488).
Thomas of Cantimpré (British Museum MS. Egerton 1984; occasionally Evans, 1922).

Full titles for these, and for other works cited in the footnotes, will be found in the Bibliography (p. 293 ff.).

Minerals have been identified by their modern names, if identification is possible; but some 'stones' are not really minerals at all, and a few are mythical. For a summary of Albert's knowledge of minerals and rocks see Appendix E.

LET us now list below the names of the most important precious stones and their powers, as they have come down to us, either by experience or from the writings of authorities. But we shall not report everything that is said about them because this is of no advantage to science. For it is [the task] of natural science not simply to accept what we are told but to inquire into the causes of natural things. And for the most convenient order in Latin, let us proceed alphabetically with the names of the stones and their powers, as the medical men are accustomed to do in describing medical simples. In the first chapter, therefore, are found those beginning with A—nine stones famous among philosophers, namely, *Abeston, Absinthus, Adamas, Agathes, Alabandina, Alecterius, Amandinus, Amethystus,* and *Andromanta.*

ABESTON

Marbod, XXXIII, *Abeston*; Arnold, p. 69, *Abeston*; Bartholomew, XVI, 12, *Abeston*; Thomas, 127v–128r, *Abeston.*

This is asbestus (Greek, 'incombustible'), a fibrous variety of either amphibole (actinolite) or serpentine (chrysotile). The description comes down from Pliny (XXXVII, 54, 146, asbestos)*; but elsewhere (XIX, 4, 19), he says* asbestinon *is the down of a plant, used to weave fireproof cloth.*

Abeston (asbestus) is the colour of iron and is mostly found in Arabia. Stories are told of its marvellous power, which is shown in temples of the gods:[1] for once kindled it can hardly ever be quenched, because[2] it has

[1] Arnold omits this phrase, but it is in Bartholomew and Thomas, and goes back to Isidore of Seville (*Etym.* XVI, 4, 4), who got it from Augustine's account of an ever-burning lamp in a temple of Venus (*City of God*, XXI, 6).

[2] What follows seems to have been added by Albert. The 'salamander's down' (*pluma* or *penna salamandrae*) perhaps comes from Jacques de Vitry's *History of Jerusalem* (I, 89), which says that the salamander is a very poisonous lizard that lives in fire and has an incombustible wool (which is not, however, identified with asbestos). Albert mentions this also in his *Meteora* (IV, iii, 17):

> ... that wool which in common speech is called 'salamander's down'. It is like cloth woven out of wool. If made into lint [i.e. as a wick] it gives a flame and yet it is not burned by fire; and this is certainly for the reason we have stated, because the moist humour that holds it together is inseparable from the dryness that is held together by it. And so, unless the greatest violence [of heat] is used, it is not burnt. For as soon as it is touched by the fire its pores are closed up and its internal moisture is shut in and cannot be extracted by the fire.

And in his *Animals* (XXV, 47) he says that although the salamander is said to live in fire, he does not believe this, adding:

> But my own experience of this kind of wool that has been brought to me indicates that it is not animal wool. Some people say that it is the down of a certain plant, but I have had no experience of this. My own experience indicates that it is produced from iron: for where large masses of iron are being worked, sometimes the iron splits and gives off a fiery vapour; and if this is collected on a cloth or in the hand, or of its own accord clings to the roof of the workshop, it is like wool, greyish or sometimes white; and some people call it 'salamander's wool'.

What this may be is difficult to say, but we may note that Agricola (*De re metallica*, Hoover, p. 274) describes something similar, produced in roasting pyrite at Goslar.

the nature of a wool that is called 'salamander's down', with a little moist, unctuous fatness inseparable from it; and this nourishes a fire kindled in it.

ADAMAS

Marbod, I, *Adamas*; Arnold, p. 69, *Adamas*; Bartholomew, XVI, 9, *Adamas*; Thomas, 127r–127v, *Adamas*.

Adamas *(Greek 'indomitable') in antiquity included three different things: (1) originally, it meant a very hard metal, perhaps steel. By the time of Pliny (XXXVII, 15, 55–61), it had acquired two additional meanings: (2) a very hard stone, like corundum or diamond (if diamond was indeed known to the Romans); and (3) a stone that attracts iron or steel, the mineral magnetite (though probably applied only to bright crystals of that mineral, since black, massive magnetite was known by other names—*magnes, *or* heraclion).

These three meanings had not yet been completely disentangled in the thirteenth century. Thus under adamas *Bartholomew relates the test of a wife's fidelity that Albert gives under* magnes *(II, ii, 11), and Thomas mentions the mariner's compass. Albert's account shows similar confusion. But he evidently intends to describe the non-magnetic, transparent gem,* diamant, *our diamond. This is, of course, incombustible under any conditions within the range of medieval technology. It is the hardest of all gems, but the 'softer' varieties mentioned were undoubtedly other minerals—perhaps topaz or even quartz.*

Adamas, as we have mentioned above, is an extremely hard stone, a little darker coloured than rock crystal,[3] but nevertheless of a bright, shining colour, and so solid that neither fire nor iron can soften or destroy it. But it is destroyed and softened by the blood and flesh of a goat,[4] especially if the goat has for a considerable time beforehand drunk wine with wild parsley or eaten mountain fenugreek; for the blood of such a goat is strong enough even to break up a stone in the bladder, in those afflicted with the gravel. But [*adamas*] is also destroyed—and this seems even more marvellous—by lead,[5] on account of the great amount of Quicksilver in

[3] Our diamonds owe their brilliant 'fire' to skilful cutting, an art in which little progress had been made in the thirteenth century, because diamond is so hard that it can be shaped only by fragments and dust of other diamonds. Early attempts were probably confined to polishing the natural faces of octahedral crystals or cleavage pieces. But until the refraction of light was understood and diamond cutters learned to arrange the facets so as to take advantage of the strong dispersion of the stone, diamonds were less attractive in appearance than many other gems.

[4] This comes from Pliny (loc. cit.) and it is difficult to imagine any basis for it unless Pliny took literally some Alexandrian 'cover name' for a compound used in grinding or polishing gems. But the story was repeated again and again and is found in medieval handbooks on technology (see II, iii, 2).

[5] Costa ben Luca, *Letter on Incantations* (in Constantine's *Opera*, p. 320), says 'likewise

[lead]. And the stone [*adamas*] pierces iron and all other gems; but not steel, in which it sticks fast.[6] It does not attract iron because that is its own place of origin,[7] as some people have untruthfully declared. The largest stone of this sort so far discovered is the size of a filbert. It occurs in Arabia and Cyprus mostly; but that of Cyprus is softer and darker. [Another thing] that seems marvellous to many people [is that] when this stone is placed on a magnet, it restrains the magnet and prevents it from attracting iron.[8] But its power is greater if mounted in gold, silver, or steel. And the magicians say that, bound on the left arm, it is good against enemies and insanity and wild beasts and savage men, and against disputes and quarrels, and against poisons and attacks of phantasms and nightmares. Some people call the stone *diamant*,[9] and some untruthfully say that it attracts iron.

ABSINTHUS

Marbod, LII, *Absictus*; Arnold, p. 69, *Abscintus*; Bartholomew, XVI, 13, *Absictus*; Thomas, 128r, *Absinthus.*

Pliny's description (XXXVII, 54, 148) of apsyctos *(Greek, 'not cooled') suggests anthracite coal. Coal was known in the ancient world but was not much used, and reports of its long-burning qualities must have been much exaggerated. Marbod is the first lapidarist to call it a gem. Albert's notion that it is something like asbestus seems to be his own, although he was familiar with coal. In his* Meteora *(IV, iii, 19) he speaks of* carbones *(the same word was used for wood-charcoal) 'formed naturally in the earth', which make a very hot fire and 'are especially sought by smiths. Such coals are found in the earth in Germany and in France near the city of Liège.'*

Absinthus is one of the black gems, with markings and sometimes little spots of red. Its power seems to be like that of asbestus: for *absinthus*

lead breaks *adamas*, which iron cannot do'. This is a quotation from the *Lapidary of Aristotle*. See II, iii, 6, note 12.

6 Diamond was supposed to be so hard that it could be hammered down into an anvil without being broken. Pliny (loc. cit.) says it will shatter both hammer and anvil. This belief, if ever tested, must have ruined some fine stones, for diamond has a good cleavage along which it can be split by a sharp blow.

7. This rather confused statement refers not to diamond but to magnetite, which is an iron mineral.

8 This statement also refers to magnetite, and goes back to Pliny (loc. cit.), who seems to have read some account of a trick with two magnets, the iron attached to one being removed by bringing a second magnet near it. The *adamas* would have been a crystal of magnetite, with a brilliant steely lustre, and the *magnes* the much commoner black massive or granular form of magnetite.

9 *Diamant* is our word 'diamond'; but if, as has been suggested, it is connected with the French *d'aimant*, signifying an attractive or 'loving' stone, it must first have been applied to magnetite.

remains hot for seven days or more, for the same reason that has been stated for asbestus.

AGATHES

Marbod, II, *Achates*; Arnold, pp. 69–70, *Agathes*; Bartholomew, XVI, 11, *Achates*; Thomas, 127r, *Achates.*

This is now called agate, a variety of chalcedony in which the colours are irregularly distributed in layers or clouds. Pliny (XXXVII, 54, 139–42, achates) *describes 'picture agates' which have the colouring matter arranged so as to look like trees, flowers, buildings, etc. It is not certain that Albert really distinguishes such figures from those on antique gems. See II, iii, 2 and 4.*

Agathes (agate) is a black stone with white veins, and there is also found another kind of this stone that is like coral. And a third kind, which mostly occurs in the island of Crete, is black with yellow veins in it. And a fourth kind, from India, is variegated, as if sprinkled with drops of blood. The first kind is well suited to those forms that are engraved on stones; and therefore most of the stones that have the heads of kings engraved on them[10] are black. When placed under the head of a sleeper it is said to show him many dreams in his sleep. But the third kind, from Crete, Avicenna[11] says enables [one] to overcome perils and gives strength to the body; and according to Evax, King of the Arabs, it makes a man pleasing and agreeable and persuasive, and of good colour, and eloquent, and protects him against adversity. But the Indian kind preserves the sight and is good against thirst and poison. When burnt, it has a very strong odour.[12]

ALAMANDINA

Marbod, XXI, *Alabandina*; Arnold, p. 70, *Alabandyma*; Bartholomew, XVI, 14, *Alabandina*; Thomas, 128r, *Alabandia.*

Despite the above consensus, derived from Pliny XXXVII, 25, 96), who says alabandicus *is a variety of carbuncle (see II, ii, 3,* Carbunculus), *the form* alamandina *must have been in common use; it has given us our almandine, which mineralogists apply to a garnet, jewellers also to a spinel, of a very dark purple-red colour.*

[10] Antique cameos in black-and-white onyx.

[11] Reference unidentified. Perhaps it is a mistake: the statement is in Marbod, and the abbreviation *Ev.* (Evax) may have been miscopied as *Av.* (Avicenna).

[12] This statement, which cannot be true of agate, is very persistent in lapidaries. There must be confusion with jet (II, ii, 7, *Gagates*) or *onycha* gum (II, ii, 13, *Onycha*).

Alamandina is named from the place where it mostly occurs, that is, from Ephesus,[13] which is also called by the name Alabanda. It has a shining red colour and is a stone nearly as bright as sard.

ALECTERIUS

Marbod, III, *Allectorius;* Arnold, p. 70, *Alectorius*; Bartholomew, XVI, 17, *Alectoria, Allectorius*; Thomas, 128r, *Allectorius.*

Pliny (XXXVII, 54, 144) has the name alectorias, *from the Greek name for a cock. The stone has generally been supposed to be a bit of gravel found in the gizzard of a fowl. But the insistence of the medieval writers that the cock be castrated or very old suggests that the stone was regarded as something abnormal. Cf. Albert's* Animals *(XXIII, 46): 'A capon is a cock that is castrated and effeminate.... It is said that after six years a stone named* electorius *grows in its liver, and from that time on the capon does not drink. And therefore a man who wears this stone is said not to get thirsty.' In such cases the 'stone' appears to have been a fibrous growth, which, taken together with the apparent change in sex observed in capons or old cocks, also gave rise to the story of the 'cock's egg' and the cockatrice. See II, iii, 1, note 5.*

Alecterius is a gem also called 'cockstone', and it is shining white, like a dull rock crystal. It is extracted from the crop of a cock after more than four years; and some say after more than nine, and that one extracted from a feeble old cock is even better. The largest one of these ever found was about the size of a bean. This stone has the power to arouse sexual desire, to make one pleasing and constant, victorious and distinguished; it confers the gift of oratory, and makes friends agree. And held under the tongue it quenches or mitigates thirst.[14] This last is a matter of experience.

AMANDINUS

This is unidentifiable; it appears only in Thomas (128r) and Arnold (p. 70), and is perhaps a corrupt fragment of aimant *or* adamas, *or of* amianthus *(a kind of asbestus), said to resist poison and the arts of magicians (see II, ii, 8,* Iscustos*). It is not in Evax (Marbod or Damigeron), but Albert may have found the name Evax attached to a lapidary only partly derived from theirs.*

[13] Pliny (loc. cit.) says the stone came from Alabanda, which is not (as Albert says) the same as Ephesus, though both cities were in the same general region, in the south-western part of what is now Turkey.

[14] A claim is made for a number of stones, sometimes as a magic property, effective if the stone is merely worn. But Albert vouches only for the fact that sucking a pebble keeps the mouth from getting dry—no doubt from his own experience during his journeys on foot.

Amandinus truly is a gem of varied colour. Evax says that it counteracts or mitigates all poison, that it gives victory over adversaries, and makes one understand prophecy and the interpretation of dreams and even of riddles.

AMETHYSTUS

Marbod, XVI, *Amethystus*; Arnold, p. 70, *Amatistus*; Bartholomew, XVI, 10, *Ametistus;* Thomas, 127r, *Ametistus.*

Amethyst means in Greek 'not drunken'. Pliny (XXXVII, 40, *121–4,* amethystus) *ridicules the claim that it can prevent or cure drunkenness; but here as elsewhere medieval lapidarists were more credulous than Pliny. Amethyst is transparent violet, purple, or wine-coloured quartz; but the name was probably applied to other minerals of similar colours, ranging from purple corundum (extremely hard) to fluorite (very soft).*

Amethystus (amethyst) is a very common gem.[15] It is of a sort of purplish colour and a somewhat dark transparency. Many different varieties of this stone are found; but five are best known, all distinguished by their different shades [of colour]. One kind of this stone also occurs in India and is better for carving than other kinds because it is softer. It counteracts drunkenness, as Aaron[16] says, and it keeps one awake [at night] and represses evil thoughts, and confers a good understanding of what is knowable.

ANDROMANTA

Marbod, XLVIII, *Androdragma*; Arnold, p. 70, *Androdramanta;* Bartholomew, XVI, 15, *Andromaya*; Thomas, 128r, *Andromanda, Androdramenta.*

Androdamas *(Pliny, XXXVII,* 54, *144) in Greek means 'man-tamer'. No exact identification is possible: it is some mineral with a metallic lustre, occurring in cubic crystals, probably pyrite or something of similar appearance. But elsewhere (XXXVI,* 38, *146) Pliny describes it as a variety of specular hematite or magnetite which 'attracts to itself silver, copper, and iron'. If there is any truth at all in this, the 'silver' or 'copper' might have been pyrrhotite, magnetic copper ore with a metallic lustre. But see II, iii, 6, note 15.*

Andromanta is a stone of a silvery colour, which occurs mostly in the Red Sea. It is square like a die and as hard as *adamas*. It has power against rage and easy excitement of the mind and sadness and heaviness.

[15] Thomas says that amethyst would bring a higher price if it were not so abundant, and that the kind found in Germany is cheap and of poor colour.

[16] Aaron is unidentified. Perhaps the name is a mistake. In II, iii, 6 Albert attributes this statement to Aristotle (often abbreviated *Ar.*) but it is not in the *Lapidary of Aristotle*.

CHAPTER 2: THOSE BEGINNING WITH THE LETTER CALLED B

BALAGIUS

Marbod, ——; Arnold, p. 70, *Balagius*; Bartholomew, XVI, 26, *Balagius* (in *Carbunculus*); Thomas, 128v–129r, *Balastus* (in *Carbunculus*).

This name makes its first appearance in medieval lapidaries. Albert's etymology is fanciful, but the word does seem to be of uncertain origin. The Oxford English Dictionary takes balas, *the present-day form, to be a corruption of Badakhshan, a place on the caravan route from Asia. The ultimate source of the stones was India or Ceylon, where river gravels contain a mixture of heavy gem minerals—corundum, spinel, zircon, tourmaline, etc. All these occur in various colours, and since there were then few scientific methods of identifying minerals there was a tendency to call all the blue ones sapphire, all the green ones emerald, etc.* Balagius *included those of a pale red, orange, or rose colour; and balas, or balas ruby, today is spinel in this colour range. See also II, ii, 3,* Carbunculus*; 7,* Granatus*; 8,* Hyacinthus.

Balagius, which is also called *palatius*, is a gem of a red colour, of very bright material and very transparent substance. It is said to be the female[1] of the carbuncle, for its colour and powers are like those of the carbuncle, but weaker, just as the female is as compared to the male. And some say it is the 'house' [of the carbuncle], and therefore it is called its 'palace' (*palatium*). For carbuncle is frequently produced there: recently, in our own time, one has been seen that was *balagius* outside and carbuncle inside, in the [same] stone.[2] Therefore Aristotle[3] says that this stone is a kind of carbuncle.

BORAX

Borax *appears only in Thomas (128v). It has nothing to do with the mineral called borax today; the correct name is* botrax, *in Greek meaning 'toad'. Pliny (XXXVII, 55, 149) mentions a stone* batrachites, *the colour of a frog, but says nothing of its origin. The legend of the jewel in the toad's head was already known to Alexander Neckam about the beginning of the thirteenth century* (De naturis rerum, *Wright, p. 199). Mineralogical identification is uncertain: some medieval toadstones are known to be fossil sharks' teeth; those with 'pictures' of toads in them may be fossil trilobites, some species of which have rather toad-like heads with bulging eyes. See also II, ii, 12,* nusae.

[1] Theophrastus (*On Stones*, 30–31) and Pliny (XXXVII, 25, 92–93) thus distinguish two sexes in some stones.

[2] Probably a zoned crystal. Cf. II, ii, 14, *Prassius*.

[3] The *Lapidary of Aristotle*: see II, ii, 3, *Carbunculus*.

Borax (toadstone), as some say, is a stone named from a toad, which carries it in its head; and there are two kinds. One is slightly greyish-white in colour, the other is black. If it is extracted while the toad is still alive and quivering, it has in the middle, as it were, a blue eye. And if swallowed this is said to cleanse the bowels of filth and excrements. And in our own time a small green one was extracted from a toad. We have even seen some with pictures of toads in them, which were said to be of this kind. In common speech these are called toadstones (*crapodinae*).

BERYLLUS

Marbod, XII, *Beryllus*; Arnold, p. 70, *Berillus*; Bartholomew, XVI, 21, *Berillus*; Thomas, 128r–128v, *Berillus*.

This is beryl. Pliny (XXXVII, 20, 76–79) correctly described it, noting several pale colours, yellow, green, and 'the colour of sea water' (that is, the variety now called aquamarine). Medieval writers, however, took the last to mean 'clear as water' and thus confused beryl with rock crystal ('water clear' quartz). Both minerals occur in hexagonal prisms, some of which are large enough to be carved into cups, balls, or simple lenses. Spectacles were invented in the thirteenth century and seem to have been named after beryl (German, Brille*) though they were probably never made of beryl.*

Beryllus (beryl) is a stone of a pale, clear, transparent colour; and therefore we have said above that, when it is turned about, water can be seen moving inside it.[4] Mostly it is produced in India, as many other gems are. There are many kinds and varieties of this stone; but the better kind is said to be paler and to have more drops of water that can be seen [moving][5] inside it. It is said to be effective against peril from enemies and against disputes, and to give victory. It is also said to cause mildness of manner and to confer cleverness. Some medical men also say that it is good against sloth, and pains of the liver, and against shortness of breath and belching, and that it is good for watery eyes. For it is known by experience that when it is shaped into a ball[6] and is placed in direct sunlight, it burns, and kindles fire. The goldsmiths also say that it makes husband and wife agree in marriage.

[4] Liquid inclusions with movable gas bubbles are sometimes found in beryl, but much more commonly in quartz. Albert had probably seen such a specimen, since this point is not in anyone else's description of beryl.

[5] *manere*, 'staying inside it'? More likely the reading should be *movere* (as above), since it was the *movement* of the bubbles that excited curiosity. But cf. I, ii, 2, note 4.

[6] Thomas says 'round as an apple', so evidently a sphere was used as a burning glass. See also II, ii, 3, *Crystallus*.

CHAPTER 3: THOSE BEGINNING WITH THE LETTER C

CARBUNCULUS

Marbod, XXIII, *Carbunculus, Anthrax*; Arnold, p. 70, *Carbunculus, Anthrax*; Bartholomew, XVI, 26, *Carbunculus, Antrax, balagius*; Thomas, 128v–129r, *Carbunculus, Antrax, Rubith, Balastus.*

Carbuncle includes almost all brilliant red, transparent gems. Latin carbunculus *(diminutive of* carbo) *is a translation of Greek* anthrax, *'a red-hot coal'. But these words came to be used in two different senses: (1) literally, a stone that burns (whence our anthracite); (2) figuratively, a fiery-red stone (carbuncle). A fusion of the two ideas may account for the ubiquitous tales of stones that shine in the dark. Of course some minerals do exhibit luminescence or phosphorescence after being rubbed, heated, or exposed to sunlight; and it is possible that Albert had seen 'such a one'; but it is also possible that he was deceived by some trick of coating a stone with phosphorescent material from fish or fungi.*

Another interesting point is the attempt to subdivide carbuncle into subspecies. Pliny (XXXVII, 25–30, 92–104) names several varieties of carbunculus, *one of which,* alabandicus, *had already achieved independent status in medieval lapidaries (see II, i, 1,* Alamandina). *Thomas of Cantimpré, like Albert, recognizes* rubinus *or* rubith *(our ruby), and* balagius *or* balastus *(our balas ruby, red spinel). Albert adds a third,* granatus, *our garnet (see II, ii, 7,* Granatus); *but his remarks about it are partly based on a misunderstanding of his sources (see note 4 below).*

Carbunculus (carbuncle), which is *anthrax* in Greek, and is called *rubinus* (ruby) by some, is a stone that is extremely clear, red, and hard. It is to other stones as gold is to the other metals. It is said to have more powers than all other stones, as we have already said.[1] But its special effect is to disperse poison in air or vapour. When it is really good it shines in the dark like a live coal, and I myself have seen such a one. But when it is less good, though genuine, it shines in the dark if clear limpid water is poured over it[2] in a clean, polished black vessel. One that does not shine

[1] In II, i, 2 where the colour of these stones is related to the Sun and Mars.

[2] This statement certainly requires elucidation, and there are three possibilities: (1) Albert may simply be recalling an old story coming by way of Pliny (XXXVI, 34, 141–2, *gagates*) from Theophrastus (*On Stones*, 13), of a stone that burns when wet—possibly by spontaneous combustion in lignite or soft coal. (2) But if this is part of what Albert himself had seen, it was probably a trick with a 'doctored' stone. (3) He seems also to be alluding to a well-known optical trick: a small object is put into an empty basin, and the observer is placed so that the rim of the basin barely hides the object from his sight. Then the basin is filled with water, and the object can be seen (this was inexplicable to anyone who knew nothing of the refraction of light). Albert mentions this trick in *The*

in the dark is not of perfect, noble quality. It is mostly found in Libya; and although there are several varieties, so that Evax says that there are eleven[3] kinds, nevertheless Aristotle, according to Constantine,[4] says that there are [only] three kinds which we have enumerated above—namely, *balagius*, *granatus*, and *rubinus*. And—what surprises many people—he says that *granatus* is the most excellent of these; but jewellers consider it less valuable.

CHALCEDONIUS

Marbod, VI, *Chalcedonius*; Arnold, p. 70; *Calcydonius*; Bartholomew, XVI, 28, *Calcedonius*; Thomas, 129r, *Calcedonius.*

Chalcedony today means any kind of cryptocrystalline silica, but is usually applied to varieties that are translucent grey, bluish, brownish, or white, since those of other colours have other names (sard, carnelian, agate, prase, etc.). Pliny did not use this as the name of any particular mineral, but only in its original sense, 'from Chalcedon', for varieties of iaspis *and* smaragdus*; but* carchedonius *or 'Carthaginian', his term for a dark variety of* carbunculus *(XXXVII, 25, 95–96), seems later to have been confused with* chalcedonius. *Perhaps the fact that chalcedony is mentioned in the Bible, as one of the 'Twelve Stones' of the Apocalypse (see Appendix B, 7), helped to give it the status of a separate species.*

Chalcedonius (chalcedony) is a pale grey, or rather dark-coloured stone. If it is pierced by the power of the stone called [*smyris*][5] (emery) and hung around the neck, it is said to be good against fanciful illusions arising from melancholy. It enables one to win causes and preserves the powers of the body. The last is a matter of experience.

CALCAPHANOS

Marbod, LIII, *Chalcofanus*; Arnold, p. 70; *Calcofanes*; Bartholomew, XVI, 59, *Kalcophanus*; Thomas, 129v, *Calcophagus.*

Pliny (XXXVII, 56, 154) says chalcophonos *(Greek, 'brazen voice') rings when struck, so it is probably a hard igneous rock like phonolite. Pliny and Marbod say it is to be worn as an amulet; Bartholomew, that it is to be held in the mouth.*

Soul (II, iii, 12), where he is again discussing this very topic of things that shine in the dark, and seems to think that the transparency of the water somehow 'retains the light' and makes the object visible.

[3] But Evax (Marbod) says *twelve* kinds; probably a scribe wrote XI for XII.

[4] Constantine (*Opera*, p. 352) was quoting the *Lapidary of Aristotle* (Ruska, pp. 186–8; Rose, pp. 353–5), which distinguishes three kinds of *hyacinthus* (corundum gems), red, yellow, and blue, of which the red (*granatus*, 'like pomegranate seeds'), that is, rubies, are said to be the best. But Albert takes *granatus* to be the best of the *red* stones; and since his *granatus* seems to be garnet, of course it is surprising that it should be considered more valuable than ruby. For further difficulties about *hyacinthus* see II, ii, 7, *Granatus* and 8, *Hyacinthus.*

[5] *sineris*, for *smyris* (Isidore of Seville, *Etym.* XVI, 4, 27).

Calcaphanos is a stone of a black colour. Its power is said to clear the voice and to cure hoarseness.

CERAURUM

Marbod, XXVIII, *Ceraunius*; Arnold, p. 70, *Ceraunius*; Bartholomew, XVI, 32, *Ceraunius*; Thomas, 130r, *Ceraunius.*

The correct name is ceraunius *or* ceraunia (*Pliny, XXXVII,* 51, *134–5*)*, from the Greek word for 'a thunderbolt'. Many different objects have been called 'thunderstones' and supposed to ward off lightning.* (*1*) *Those described here were just bright pebbles or crystals discovered after a heavy shower had washed them out of the soil.* (*2*) *Some thunderstones were fossils, especially shark's teeth or belemnites, attracting attention because of their arrow-like shapes.* (*3*) *Still others were pre-historic stone implements, often regarded with superstitious awe. Albert believes that the last can be formed by natural processes within the thundercloud* (Meteor. *III, iii, 18*)*: 'When this earthy dry smoke has been set afire in the viscous moisture in the cloud, it is baked into a stone, black or red in colour, that falls from the cloud and splits beams and penetrates walls, and is called by the common people a 'thunder axe'. It is a stone that is thin and sharp on one side, because the vapour was first directed towards that side while it was being baked'.* (*4*) *Finally, there are also meteorites, which do really fall from the sky. Avicenna gave a description of these* (*Holmyard and Mandeville, 1927, pp. 47–48*)*, which Albert paraphrased in his* Meteor. (*III, iii, 20*)*: 'It is especially iron that falls. . . . Because it is thoroughly baked by Fire in the cloud, it falls in the form of the best steel, which is hard and purified iron. And because it hardens to iron in the interior of the cloud and distils like drops from its internal vapour, it forms a mass made up of grains like millet.'*

Ceraurum (thunderstone) is said to be like rock crystal, tinged with a sky-blue colour. It is said to fall sometimes from a cloud with the thunder, and it is found in Germany and Spain; but the Spanish kind glows like fire. It induces sweet sleep, they say; and it is also said to be effective for winning battles and causes, and [to protect] against the danger of thunder.

CELIDONIUS

Marbod, XVII, *Chelidonius*; Arnold, p. 70, *Celydonius*; Bartholomew, XVI, 30, *Celidonius*; Thomas, 129v, *Celidonius.*

Chelidonius *or* chelidonia (*Pliny, XI,* 79, *203; XXX,* 27, *91; XXXVII,* 56, *155*) *is named from the Greek word for the swallow, a bird that figures in many folk superstitions. Pliny says that if young swallows are blinded, their sight is restored by the old birds, by means of the juice of the herb swallow wort. Only Thomas and Arnold give the contradictory statement that the herb and the stone together 'obscure the sight', and this is probably a confusion with another stone* (*see II, ii, 5,* Eliotorpia).

Celidonius (swallowstone) has two varieties. One is black, the other reddish brown; but both are taken from the stomach of a swallow. The reddish one, if wrapped in a linen cloth or a calfskin and worn under the left armpit, is said to be good against insanity and chronic weakness and lunacy. And [Costa ben Luca][6] says that it is good against epilepsy, if worn in the manner described above. Evax moreover reports that it makes one eloquent and pleasing and agreeable. But the black one, as Joseph[7] says, is effective against harmful humours and fevers, and angry threats. If it is washed in water,[8] it cures the eyes; and it brings to a conclusion any business that is undertaken. And if it is wrapped in the leaves of the celandine (swallow wort), it is said to dim the sight. These are very small stones. We have recently seen some extracted by members of our Order from the stomachs of swallows in the month of August;[9] for those taken at that time are said to have more strength. And nearly always two are found together in one swallow.

CELONTES

Marbod, XXXIX, *Chelonites*; Arnold, pp. 70–71, *Celonites*; Bartholomew, —— (but see II, ii, 17, *silenites*); Thomas, 130r, *Celonites.*

The correct name is chelonites *or* chelonia *(Pliny, XXXVII, 56, 155) from the Greek word for a tortoise, and Pliny says the stone comes 'from the eye of an Indian tortoise* (testudo).' *But to Albert* testudo *is just a shell, and he is plainly describing mother-of-pearl. There is obviously some confusion between this and the stone called* silenites *(II, ii, 17).*

Celontes is a stone of a purple colour, and it is said to be found in the body of a shellfish; for some very large shellfish have dwellings that gleam with a pearly lustre. It is said that if one holds it under the tongue it makes [him able to divine the future].[10] But it is said to have this power only on the first day of the [lunar] month, when the moon is rising and waxing, and again on the twenty-ninth day when the moon is waning. Also it is said that this stone is not injured by fire.

[6] *Constantinus*: but Albert is citing the *Letter on Incantations* of Costa ben Luca (see Appendix C, 5). This, however, was sometimes ascribed to Constantine and is printed with his works (*Opera*, pp. 317–20).

[7] Joseph is unidentified; but the statement is in Evax (Marbod).

[8] Usually this means that the stone was soaked in water and then the water used as a remedy; but the wet stone may have been applied to the eye. Cf. II, ii, 17, *Saphirus.*

[9] *in mense augusti*: this is probable enough, but the *Letter on Incantations* says *in augmento lunae*, 'when the moon is waxing'.

[10] *apud divinatorem quod facit eum.* I have taken the reading of Thomas and Arnold: *et divinatorem facit eum.*

CEGOLITES

Marbod, LV, *Gecolitus*; Arnold, p. 71, *Cegolitus*; Bartholomew, ——; Thomas, 130r, (C)*egolites*; 132r, *Gecolitus*.

The correct name is tecolithus, *Greek 'stone-dissolver'* (*Pliny XXXVII,* 68, *184*). *This is a fossil exhinoid or sea-urchin; different species were known by different names, but all were supposed to relieve kidney or bladder stones or strangury. See also II, ii, 7,* Gecolitus *and 8, Judaicus lapis.*

Cegolites is a stone like an olive stone in colour and size. They say that experience shows that shavings of it, dissolved in water and drunk, dissipate a stone in the kidneys or bladder.

CORALLUS

Marbod, XX, *Corallus*; Arnold, p. 71, *Corallus*; Bartholomew, XVI, 33, *Corallus*; Thomas, 129r–129v, *Corallus*.

Coral was supposed to be a plant that grows in the sea and is changed to stone when brought up into the air (*Pliny, XXXII,* 11, *21–24; XXXVII,* 59, *164,* curalium). *Thomas adds that it terrifies demons because its branches frequently form a cross.*

Corallus (coral) is of two kinds. It is taken from the sea, as we have said above, and especially from the sea around Marseilles. One kind is reddish [brown] like old ivory; the other is white, shaped like the twigs of plants. And it has been found by experience that it is good against any sort of bleeding. It is even said that, worn around the neck, it is good against epilepsy and the action of menstruation, and against storms, lightning, and hail. And if it is powdered and sprinkled with water on herbs and trees, it is reported to multiply their fruits. They also say that it speeds the beginning and end of any business.

CORNELEUS

Marbod, XXII, *Corneolus*; Arnold, p. 71, *Corneolus*; Bartholomew, XVI, 34, *Corneolus*; Thomas, 130r, *Cornelus, Corneolus*.

All the descriptions fit carnelian, a translucent, orange-to-red chalcedony, named from its likeness to flesh (caro, carnis). *But in I, ii, 2 Albert mentions a bluish or brownish mineral* corneola, *which is probably also chalcedony, named from* cornu, *'horn-coloured'. The two names are easily confused.*

Corneleus (carnelian), or [*corneolus*][11], as it is called by some, is a stone the colour of flesh, that is, red; when broken it is like the juice of meat. This

[11] The text merely repeats the same name, *corneleus*; I have supplied *corneolus* as in other lapidaries (see above), but perhaps it should be *carneleus*, 'flesh red'.

is very often found near the River Rhine;[12] it has a very red colour like *minium* (vermilion),[13] and when polished it shines brightly. It has been found by experience that it reduces bleeding, especially from menstruation or hemorrhoids. It is even said to calm anger.

CHRYSOPASSUS

Marbod, XV, *Chrysoprassus*; Arnold, p. 71, *Crisoprassus*; Bartholomew, XVI, 27, *Crisoprassus*; Thomas, 129v, *Crysopassus.*

The name should be chrysoprasus, *from Greek words for 'golden 'and 'leek-green'. Chrysoprase today means green chalcedony, and this is probably, at least in part, the stone Pliny describes (XXXVII, 34, 113). Later lapidarists call it a green stone with golden spots in it; if they had any actual mineral in mind it might have been green aventurine feldspar or quartz containing glistening scales of hematite or mica, or perhaps a green copper mineral with veins of 'golden' sulphides. But there was much confusion among all the names beginning with* chryso-, *'golden'.*

Chrysopassus is a stone that comes from India. It is rare and therefore is considered valuable. Its colour is like hardened [leek][14] juice, with golden spots in it; and that is why it is so named, for *chrysos* means gold in Greek. It is very similar to *chrysolitus.*

CHRYSOLITUS

Marbod, XI, *Chrysolithus*; Arnold, p. 71, *Crisolitus*; *Bartholomew*, XVI, 29, *Crisolitus;* Thomas, 130r, *Crisolitus.*

This name is from the Greek meaning 'golden stone.' In Pliny's time (XXXVII, 42, 126) chrysolithus *was applied to the transparent yellow stone now called topaz, while Pliny's* topazos *was the stone called chrysolite. This exchange of names took place in the Middle Ages. Isidore of Seville* (Etym. *XVI, 15, 2) likens the colour of* chrysolithos *to the sea, and all subsequent writers describe it as green. Albert's* chrysolitus *appears to be chrysolite, a pale green variety of olivine (darker green olivine is now called peridot). See also II, ii, 18,* Topasion.

Chrysolitus is a stone of a pale, bright green colour, and in direct sunlight it sparkles like a golden star. It is not rare. It is said to come from Ethiopia. It has been found by experience that it eases the breathing and therefore it is powdered and given to those who suffer from asthma. It is reported

[12] This is Albert's own observation, probably referring to the Nahetal. The famous gem-cutting industry of Idar-Oberstein is said to have begun in the sixteenth century, but the local raw materials, agates, carnelians, and other quartz minerals, were very likely known long before an organized industry began.

[13] *minim*, for *minium*, a red pigment, either red oxide of lead or cinnabar.

[14] *pyri*, 'a pear', is an error for *porri*, 'a leek', in all other lapidaries.

that if it is pierced, and an ass bristle put through the hole, and is bound on the left wrist, it drives away terrors and melancholy: this is said in [books on] physical ligatures. And if it is worn in a gold setting, it drives away phantasms, they say. It is also affirmed that it expels stupidity and confers wisdom.

CRYSTALLUS

Marbod, XLI, *Crystallus*; Arnold, p. 71, *Cristallus*; Bartholomew, XVI, 31, *Cristallus*; Thomas, 129v, *Cristallus.*

This is 'rock crystal', clear, colourless quartz. Its regular six-sided form is noted by Pliny (XXXVII, 9–10, 23–29) and repeated by later writers, so that the mineral has become the prototype for our general term 'crystal'. Very large quartz crystals are sometimes found, suitable for carving into cups, balls, or ornaments. Pliny (loc. cit.) mentions the use of a quartz sphere as a lens for cauterization. See also II, ii, 2, Beryllus *and 8,* Iris.

Crystallus (rock crystal, quartz) is a stone that is sometimes formed by the action of cold, as Aristotle says[15]; but also it is sometimes formed in the earth, as we have often found by experience in Germany, where a great many [quartz crystals] are found. Both modes of origin will easily be made plain by what has been said above. If [rock crystal] is placed in direct sunlight, and if it is cold, it throws out fire; but if it is warm it cannot do this. The reason for this we have given in the book on the *Properties of the Elements.*[16] It is said to decrease thirst, if placed under the tongue; and it has been found by experience that if it is powdered and mixed with honey and taken by women, it fills the breasts with milk.

[CHRYSELECTRUM]

Marbod, LIX, *Criselectrus*; Arnold, p. 71, *Crisolectus*; Bartholomew, XVI, 29, *Crisolentus* (in *Crisolitus*); Thomas, 129v–130r, *Crisolitus.*

Printed text repeats chrysolitus *here, but this is obviously a different mineral. Thomas also has this duplication of names, and Bartholomew's source probably was the same, for*

[15] See I, i, 3, note 9.

[16] Albert, *The Properties of the Elements* (I, i, 5):

If cold water is put into a glass vessel, clean and suitably round, like a urinal, and placed directly in a beam of sunlight, the heat is strengthened by the reflection of the beam on the glass, and that heat is strongly repelled by the coldness of the water behind the glass. And if a cloth that is clean, dry, and slightly charred is placed there, it is ignited and fire is kindled from it. And this does not happen if warm water is put into the glass, because warm water does not repel and concentrate, but rather attracts and rarefies; and therefore it weakens the heat produced by the reflection of the beam. For the heat is concentrated by the glass placed opposite to it because [heat] flees from the coldness of the water. For heat and cold are contraries, and one puts the other to flight.

he combines two accounts in one. But the confusion seems to go back to Pliny, who describes (XXXVII, 12, 51) chryselectrum, *which is a yellow amber* (electrum), *and also (XXXVII, 43, 127)* chryselectroe, *the colour of 'golden amber', probably citrine quartz or possibly chrysoberyl. A further source of confusion is that* electrum *itself means both amber and a gold-silver alloy (see V, 9). I believe that Albert was thinking of the latter (and therefore almost certainly had* chryselectrum *in the manuscript he used), since he identifies this mineral as* marchasita, *pyrite or some similar mineral that 'looks like metal'. See II, ii, 11 and V, 8.*

[Chryselectrum] is a gem of a golden colour; and in the morning hours it is very beautiful to see, but at other hours it looks different.[17] It is destroyed and disappears in the fire and, as some people say, it bursts into flame: and therefore it is said to fear the fire.[18] But some say that there is another variety of this stone that is formed by the solidification of an ignoble substance;[19] and this is not true. It is [really] a golden *marchasita*, a substance in a way intermediate between stones and metals, as we shall show later. There is said to be a third kind with a colour between blue[20] and red. The powder of this stone is universally said to be a cure for scab and ulcers. Held in the hand, it reduces the heat of fever.

CHRYSOPAGION

Marbod, LX, *Crisopacion*; Arnold, p. 71, *Crisopasion*; Bartholomew, XVI, 29, *Crisolimpbis*; Thomas, 130r–130v, *Crisopasion.*

The name seems to have been originally chrysolampis, *Greek 'golden torch' (Pliny, XXXVII, 56, 156). But the story has been told, and improved in the telling, by many writers about many stones. Perhaps some genuine observation of phosphorescence is at the bottom of it. The comparison with rotten wood and fireflies is in Arnold and Thomas, but Albert refers to his own treatment of the topic (see note 22 opposite).*

Chrysopagion is a gem that comes from Ethiopia. It is said to shine in the dark and fade at the coming of light, retaining only a faint, dull colour

[17] This curious statement is made by Pliny (loc. cit.) but is really commonplace enough: in his chapter on detecting false gems (XXXVII, 76, 198) he says that they should be examined in a morning light. This is good advice, since stones do 'look different' in different lights. But it is possible that Pliny's *chryselectroe* was chrysoberyl, in which such differences are very marked; it may show different shades of yellow and green, depending on whether it is viewed in one direction or another, or by transmitted or reflected light, or by artificial or day light.

[18] Inflammable *chryselectrum* must have been amber, though Albert rejects this identification.

[19] urine of the lynx: see II, ii, 10, *Ligurius.*

[20] *caeruleum.* But Thomas, in the same expression, has *croceus*, 'saffron yellow'. Perhaps a paraphrase using *blavus* or *flavus* accounts for the discrepancy (see I, ii, 2, introductory note). Or Albert may mean the iridescent purple tarnish on some sulphide minerals, such as bornite.

with a pale tinge of hidden gold. And as daylight and darkness alternate, it shows a corresponding change in its indeterminate colour,[21] like that in rotten oak wood or a firefly. We shall explain the complete and true reason for all these things in the book on *The Soul*.[22]

CHAPTER 4: NAMES BEGINNING WITH THE FOURTH LETTER, WHICH IS D

DIAMON

Marbod, ——; Arnold, p. 71, *Demonius*; Bartholomew, ——; Thomas, 130v, *(D)emonius*.

Diamon *might be a variant of* diamant (*II, ii, 1,* Adamas), *but is apparently an error for* daimon, *given as* demonius *in Arnold and Thomas, neither of whom, however, mentions the rainbow. But the connexion between rainbow and* daimon *may be entirely Albert's, since he uses the phrase 'bow of the daimon' in his account of the rainbow in his* Meteora (*III, iv, 6 and 26*). *Mineralogical identification is impossible; very likely it is the same as* iris (*II, ii, 8*).

Diamon [daimon] is reported to be named 'stone of the daimon', being of two colours[1] like the rainbow, which is called 'bow of the daimon'.[2] They say that it is prescribed for those suffering from fever, and expels poison.

DIACODOS

Marbod, LVII, *Diadochos*; Arnold, p. 71, *Dyacodes*; Bartholomew, XVI, 36, *Diadocos*; Thomas, 130v, *Dyathocos*.

The correct name is diadochos, *meaning 'a substitute' in Greek. Pliny (XXXVII, 57, 157) says only that it resembles beryl. Perhaps it really was beryl, or even quartz. The mysterious powers attributed to it by later lapidaries come from Damigeron (XV) and seem to have to do with its use in some ritual of hydromancy or crystal-gazing.*

[21] Aristotle (*The Soul*, II, 7, 419 a 1 ff.) makes the point that phosphorescent things produce a sensation of light in darkness, but this light is 'not of any particular colour', certainly not the same colour as the same things show in daylight.

[22] Albert (*The Soul*, II, iii, 12), amplifying Aristotle's account, tries to bring under one explanation everything that shines in the dark—dead fish, rotten eggs, fireflies, animals' eyes, sparks seen in combing the hair, sea water, etc. His theory is that all these contain Fire—not 'ordinary' fire, but a very subtle kind, sometimes evident as the heat of putrefaction or fermentation, which rises to the surface and appears as light. See also II, ii, 3, *Carbunculus*.

*

[1] *bicolor*. This is also in Arnold and Thomas, but perhaps it should be *tricolor*, 'of three colours', the usual description of the rainbow (see I, ii, 2, note 5).

[2] *arcus daimonis*. But *daimon* in Greek, *daemon* in Latin, meant simply 'a spirit'; it is only later, in Christian writings, that a 'demon' was generally understood to be an *evil* spirit.

Diacodos is a pale stone said to be somewhat similar to beryl. And it is said to be so effective in calling up phantasms that magicians use it a great deal; but nevertheless, if it touches a corpse it loses its force, so that it is declared to have a horror of death. A possible theory about these things comes from books of the magicians, Hermes and Ptolemy and Thebit ben Corat;[3] but I do not intend to discuss them here.

DYONYSIA

Marbod, LVIII, *Dionysia*; Arnold, p. 71, *Dyonysia*; Bartholomew, XVI, 35, *Dyonisius*; Thomas, 130v, *Dyonisia*.

This stone, named after Dionysus, god of wine (Pliny XXXVII, 57, 157), may be the same as Medius *(II, ii, 11), which Pliny (XXXVII, 63, 173) says has 'the flavour of wine'. If so, the wine must have been very sour for the 'flavour' of the stone is due to sulphates.*

Dyonysia is a stone black as iron, with sparkling red spots in it. Its breath is like wine; and yet that very odour of wine dispels drunkenness—a matter of wonder to many people.[4] For the cause of this is that wine induces feeble drunkenness not by its odour but by its oppressive fumes; and the simple odour of this stone is active in clearing out and dispelling the fumes of the wine.

DRACONITES

This is not in Marbod, Arnold, or Bartholomew, but Thomas has it as dracontides *(130v). The story comes down from Pliny (XXXVII, 57, 158,* dracontias*).* Draco *is not really a 'dragon' but a large snake, such as a python. The jewel in the snake's head belongs to the same tradition as the toadstone (III, ii, 2,* Borax*; 12,* Nusae*). Albert's own snakestone was probably a fossil ammonite, a flat spiral shell that looks like a tightly coiled snake, and has been so regarded in many countries.*

Draconites (snakestone) is a stone extracted from the head of a large snake, and it is brought from the East, where there are many large snakes. Its power, like that of the toadstone, is effective only if it is extracted while the snake is alive and quivering. [Men] steal up on the snakes while they are asleep, and cut off the head suddenly; and while the snake is still

[3] Thebit ben Corat's *Liber prestigiorum*, a book of magic tricks or illusions, in which Hermes and Ptolemy were quoted. See Appendix C, 4.

[4] All that follows here is Albert's own attempt to account for the alleged effect of the stone.

quivering, they tear out the stone. For[5] the activity of the soul confers many properties even on residues which are produced in animals; and these undergo a change at death, whether the animals die a natural death by the decay of their bodily humours, or whether they lie dead and decaying after being [violently] slain. I myself have seen in Swabia in Germany a stone upon which more than fifty serpents[6] had collected, in a certain meadow among the mountains. And when the lord of the land was passing by that way, his soldiers, drawing their swords, cut the serpents into many small pieces. But at the bottom lay one large serpent cut into many parts; and under its head there was found a black stone shaped like a truncated pyramid. It was not transparent, and it had a pale-coloured [stripe] around it, and a very beautiful picture of a serpent on it. This stone was presented to me by the wife of that nobleman, along with the head of the serpent, and I kept it. [A snakestone] is said to dispel poisons, especially those due to attacks by venomous animals; and they say it also bestows victory.

CHAPTER 5: THOSE BEGINNING WITH THE LETTER E

ECHITES

Marbod, XXV, *Ethites*; Arnold, p. 71, *Ethytes*; Bartholomew, XVI, 39, *Echites*; Thomas, 131r, *Echites*.

The name was originally aetites *or* aetita, *Greek 'eaglestone' (Pliny, X, 4, 12; XXXVI, 39, 149–51). It is a hollow geode or concretion containing loose crystals, pebbles, or earth; and this structure obviously suggested all the associated notions about eggs, fertility, pregnancy, etc. Albert's version is rather muddled, as if he were using two sets of notes and never revised the manuscript. The speculations about why the birds use the stones, and all the remarks about cranes, are his own additions.*

Echites (eaglestone) is the best of gems. It is of a dark red colour and it is called by some *aquileus* and by others *erodialis*, because eagles (*aquilae*) sometimes place it in their nests among the eggs, just as the crane[1] places

[5] All that follows, except the final sentence, is Albert's own.

[6] *serpentes* are smaller than *dracones*. In cold countries, some snakes collect in large groups to hibernate.

*

[1] *grus*, the crane, is a large wading bird that lays its eggs on the ground; so stones might easily be found in the 'nest', though not by any intention of the bird. Young cranes can run almost as soon as they are hatched and Albert had watched their rearing 'in Cologne, where cranes that have been domesticated bring up their young' (*Animals*, VI,

a stone between two eggs. For we have observed this at Cologne, where cranes have reared their young, for many years, in a certain garden. Most kinds of *echites* are found near the shores of the Ocean, where the best kind is that of the birds called *erodii*,[2] the 'heroes' among birds. It is also said to be found sometimes in Persia. It is the kind [of stone] that contains another stone inside that rattles when it is moved in the hand and shaken. It is reported that, suspended on the left arm, it strengthens pregnant women, prevents abortion, and lessens the dangers of childbirth. And some say that it prevents frequent attacks in epileptics. And an even more marvellous thing, according to Chaldean tradition, [is that] if anyone is suspected of poisoning food, and if this stone is placed in the food, it prevents the food from being eaten; and if the stone is taken out, the food can be eaten at once. Why the eagles place the stone in their nest is not well understood. We have found by observation that cranes do not notice what sort of stone they place among their eggs, but sometimes they put one kind and then, another year, another kind. And some people say that they do this to moderate the heat of the eggs or of the eagle's body, so that the eggs may not get too hot; and this is probable. But some say that the stone contributes something to the formation and quickening [of the eggs]. And still others say that the birds put the stone among the eggs to keep them from breaking, but this is entirely false; for they would break much sooner by bumping against a stone than against each other. And some say that if anyone is suspected of being a poisoner, and if this stone is put into his food, if he is guilty he immediately chokes on the food, but if it is taken out, he eats the food. But if he is innocent, he eats the food even if the stone has been put into it.

ELIOTROPIA

Marbod, XXIX, *Eliotropia*; Arnold, p. 71, *Elyotropia*; Bartholomew, XVI, 41, *Elitropia*; Thomas, 131r, *Elitropia*.

Heliotrope is dark green chalcedony with red spots, which suggested its common

i, 4). No doubt their wings had been clipped, for although Albert repeats the well-known story about the cranes' migration to Africa he says that these cranes remained in Cologne all the year round, in spite of the cold climate (*Animals*, VII, i, 6).

[2] *erodii*: Albert's etymology is fanciful, but he knew these birds too from his own observation (*Animals*, VI, i, 6):

The great eagle (golden eagle) which is found in our country and is called *herodius* is rarely found to have more than one eaglet, although it lays two eggs. This we have learned by visiting the nest of a certain eagle every year for six years. But in such cases it is difficult to make observations because of the height of the mountains on which they nest; and we were able to observe this only by letting someone down the cliff from above on a very long rope.

English name, bloodstone, and its supposed efficacy for bleeding. Heliotropium *means 'sunturner' and Pliny (XXXVII,* 60, *165) says that it was used in observing solar eclipses; he mentions putting it in water, but this was obviously merely to wet a polished surface so that it could serve as a dark mirror; and he was scornful of the magician's tale of invisibility. But in Damigeron (XIX) and Marbod heliotrope has become a purely magical stone. Its original connexion with eclipses has been forgotten, and it is now said that if placed in water its power darkens the sun, makes the water boil, and calls up thunderstorms; if anyone wears it, he can predict the future. This is the version that Albert had, and he does his best to 'make sense' of it by adding 'scientific' explanations. He seems to imagine that the stone in the water starts a chemical reaction—like the effervescence of soda or limestone in acid—and that the resultant fumes account for the other reported phenomena.*

Eliotropia (heliotrope, bloodstone) is a stone almost as green as *smaragdus*, sprinkled with blood-red spots. The necromancers say that this is a Babylonian gem and is called heliotrope because if rubbed with the juice of the herb of the same name and placed in a vessel full of water, it makes the sun look blood-red, as if there were an eclipse. And the reason for this is that it makes all the water boil up into a mist, which thickens the air so that the sun cannot be seen except as a red glow in the condensing cloud; and afterwards the mist condenses and falls as drops of rain. [The stone] must be consecrated by a certain incantation, combined with magic signs; and if any of those present are possessed,[3] they speak words of prophecy. And therefore pagan priests commonly used this stone a great deal in their idolatrous festivals. And it is said to give a man a good reputation, and health, and long life; and to be good against bleeding and [poisons][4]. It is also said that if rubbed with the herb of the same name, as we have said before, it deceives the sight so much as to make a man invisible. It is found very often in Ethiopia, Cyprus, and India.

EMATITES

Marbod, XXXII, *Emathites*; Arnold, pp. 71–72, *Emathytes*; Bartholomew, XVI, 40, *Emathites*; Thomas, 130v, *Emathites.*

Haematites, *Greek 'bloodstone' (Pliny, XXXVI,* 37–38, *144–8; XXXVII,* 60, *169) is hematite, red oxide of iron. If well crystallized it is shining black with a metallic lustre; if finely divided, as in earthy deposits, or as powder produced by grinding, it is 'blood-red'. Part of Albert's text is in Thomas and part in Arnold (including phrases which Bartholomew attributes to 'Dyascorides'): all three seem to come from some*

[3] *areptitii*, 'carried away', thrown into a trance.

[4] *venerea*: but probably should read *venena* as in other lapidaries.

medical work, perhaps Constantine's Book of Degrees (Opera, *pp. 358 and 382*), *combining the properties of hematite and of alum.*

Ematites (hematite) is a stone found in Africa and Ethiopia and Arabia. It is the colour of iron, with blood-red veins in it. It is a powerful styptic, and therefore experience shows that if crushed and drunk mixed with water, it is a remedy for a flux of the bladder or bowels, or menstruation; and it also heals a flux of bloody saliva. Powdered and mixed with wine, it heals ulcers and wounds, and eats away superfluous flesh that forms in wounds. And it helps and cures dimness of sight caused by moisture, and improves roughness of the eyelids.

EPISTRITES

Marbod, XXXI, *Epistites*; Arnold, p. 72, *Epystrites*; Bartholomew, XVI, 43, *Epistides*; Thomas, 131r–131v, *Epistutes.*

The correct name is hephaestites, *for the Greek god of fire* (*Pliny, XXXVII,* 60, *166*). *The stone is probably pyrite* (*which also means 'fire', since it can be used to strike a spark*). *Pyrite is a shining metallic yellow mineral, and might perhaps have been made into a concave mirror to serve as a burning glass, though this seems rather unlikely. But Agricola* (De natura fossilium, *published in 1546, Book V*), *identified Pliny's* hephaestites *as pyritic coatings* (armatura) *on fossil ammonites or the like, and reported one found near Hildesheim 'as big as a dish' which could be used to start a fire.*

Epistrites is a brilliant reddish stone occurring in the sea.[5] In [books on] incantations and physical ligatures it is said that, worn over the heart, it keeps a man safe, and restrains sedition; and it is also said to restrain locusts and birds and clouds and hailstorms, and to keep them off the crops. It has been found by experience that, if placed in direct sunlight, it emits fire and fiery rays. And it is said that if this stone is thrown into boiling water, the bubbling ceases and presently [the water] grows cold. The reason[6] for this is merely that [the stone] is extremely cold, and when it is affected by the heat of the boiling water the coldness of its constitution begins to act.

ETINDROS

Marbod, XLVI, *Enhydros*; Arnold, p. 72, *Enydros*; Bartholomew, XVI, 42, *Enidros*; 101, *Ydachites*; Thomas, 131v, *Elidros, Enidros.*

[5] This has suffered some attrition: Pliny (loc. cit.) says the stone is found in *Corycus*, but Damigeron (XX) says *Corinthus*. Marbod, writing in verse, adopts a phrase from Ovid (*Metam.* V, 407), *in bimari Corintho*, 'in Corinth-between-two-seas' (on the isthmus.) Arnold says merely *in Bimari*, and here it is reduced to *in mari*.

[6] What follows is Albert's own explanation. See also II, ii, 18, *Topasion.*

Enhydros today means a nodule of translucent chalcedony containing water, and that is what Pliny described (*XXXVII*, 73, *190*, enhygros, *Greek 'water inside'*). *Solinus, however, misunderstood Pliny or confused this with some other stone, for he said* (Coll. *XXXVII*, *24*, *enhydros*) *that it 'exudes water', and later writers echo him. Bartholomew* (*op. cit.*, enidros), *like Albert, suggests that the moisture is really formed on the outside of the stone.*

Etindros is a stone similar in colour to rock crystal. It continually distils drops, which are said to be good for those suffering from fever. But nevertheless the stone does not grow smaller or waste away. The reason for this is really that the drops do not distil from the substance of the stone at all; but because it is extremely cold, the Air in contact with it continually changes into Water, as often happens with hard, polished stones, when the weather gets warmer.

EXACOLITUS

This appears only in Thomas (*131v*) *and Arnold* (*p. 72*) *and is probably an error made by a scribe whose eye was caught by* exacontalitus, *just below. What may have stood in this place* (*as in some other lapidaries*) *is* exhebenus, *which, to judge by the description of Pliny* (*XXXVII*, 58, *159*), *was a white clay mineral or polishing powder.*

Exacolitus is said to be a stone of varied colour. It has a solvent action, according to skilled medical men; and therefore, if mixed with wine and drunk, it is said to be good against colic and internal pains.

EXACONTALITUS

Marbod, XXXVIII, *Exacontalites*; Arnold, p. 72, *Exacontalitus*; Bartholomew, XVI, 44, *Exolicetos*; Thomas, ——.

Hexecontalithos, *according to Pliny* (*XXXVII*, 60, *167*), *is called 'sixtystone' because it is marked with many* (*presumably sixty*) *colours. Albert and his contemporaries suppose it to be opal, which is reputed to have a bad effect upon the eyes. See also II, ii, 13,* Ophthalmus *and 14,* Pantherus.

Exacontalitus (sixtystone) is a stone marked with sixty colours. It is very small in size and is frequently found in Libya and among the Troglodites.[7] It is very harmful to the nerves, and therefore it is said to make a man's eyes tremulous.

[7] Cave-dwellers somewhere in Africa mentioned by Pliny, loc. cit.

CHAPTER 6: THOSE BEGINNING WITH THE SIXTH LETTER, WHICH IS F

FALCONES

Marbod, ——; Arnold, p. 72, *Falcanos, Arsenicum, Auripigmentum*; Bartholomew, XVI, 6, *Auripigmentum, Arsenicum*; Thomas, ——.

This is an arsenic mineral, or rather a mixture of two—red realgar, Pliny's sandaraca, arrhenicum *(XXXIV, 55–56, 177–8) and yellow orpiment,* auripigmentum, *'golden paint' (XXXIII, 22, 79). Since it is not a 'precious stone', some lapidaries do not include it. Albert's first three sentences are in Arnold and in Bartholomew (who attributes them to 'Dyascorides'). Most of the rest is in Constantine's* Book of Degrees (Opera, *p. 383), though Albert probably got some details of the procedure from alchemical books. See also V, 5,* Arsenicum.

Falcones is called by another name *arsenicum*, and in common speech *auripigmentum* ('golden paint') means the same. It is one of the yellow and red stones, and the alchemists call it one of the 'spirits'.[1] It has the same nature as sulphur in heating and drying. And when it is calcined with fire it becomes black,[2] and on sublimation it immediately becomes white.[3] And if it is calcined again, it again becomes black, and if the [sublimation][4] is repeated, it becomes very white. And if this is repeated three or four times, it becomes so caustic that if it is combined with copper it makes holes in it at once, and it violently burns all metals, only excepting gold. And if it is applied to copper, it changes it to a white colour.[5] Therefore counterfeiters use it when they wish to make copper [look] like silver: for it is very effective for this.

FILACTERIUM

This odd item is found only in Arnold (p. 72), and seems to be a misplaced gloss from Damigeron (XVII) or Marbod (XI), who describe chrysolitus *as a phylactery, or protective amulet.*

Filacterium, the jewellers say, is the same gem as *chrysolitus* and has the same power.

[1] 'Spirits' are volatile, easily sublimed.

[2] Metallic arsenic, produced from the sulphides (realgar or orpiment) by heating in a reducing atmosphere—that is, in contact with organic matter, charcoal, or (as Constantine suggests) sodium carbonate (*nitrum*).

[3] Heated in air, the sulphides are oxidized to 'white arsenic'.

[4] *calcinatione*, but obviously an error for *sublimatione*.

[5] Arsenic with copper forms a silvery bronze.

CHAPTER 7: THOSE BEGINNING WITH THE SEVENTH LETTER, WHICH IS G

GAGATES

Marbod, XVIII, *Gagates*; Arnold, p. 72, *Gagates*; Bartholomew, XVI, 49, *Gagates*; Thomas, 131v, *Gagates*.

Gagates *is jet, a shining black hydrocarbon, closely related to coal. But Albert constantly confuses jet with amber (see II, ii, 10,* Ligurius *and 17,* Succinus), *perhaps because his sources mention two kinds, black and grey; or perhaps because there are real similarities—both amber and jet are found on seashores, both can be burnt, emitting a strong odour, and both can be electrified by rubbing. Pliny (XXXVI,* 34, *141–2) says that jet can be used to test virginity, but the details are given only in the thirteenth-century lapidaries (Bartholomew cites 'Dyascorides'). See also II, ii, 9,* kacabre.

Gagates (jet) is *kacabre*, which I consider to be one of the gemstones. It is found in Libya and in Britain near the seashore; and a great deal is found in the sea along the northern coast of Teutonia.[1] In England (*Anglia*),[2] too, it is frequently found. It is of two colours, namely black and yellow, but the yellow is nearly as transparent as *topasion*.[3] Some is also grey, rather pale with a yellowish tinge. If rubbed it attracts straws, and if ignited it burns like incense. It is said to benefit those who suffer from dropsy; and it tightens loose teeth, they say. It is known from experience that water in which it has been washed, or its fumes applied from beneath, will provoke menstruation in women. It is also reported to put serpents to flight;[4] and it is a remedy for disorders of the stomach and belly, and for phantasms due to melancholy, which some people call 'demons'. They say, too, that experience shows that if water in which it has been washed is strained and given with some scrapings [of the stone] to a virgin, after drinking it she retains it and does not urinate; but if she is not a virgin, she urinates at once. And this is the way virginity should be tested. And they say that it is good against the pains of childbirth.

GAGATRONICA

Marbod, XXVII, *Gagatromeus*; Arnold, p. 72, *Gagatromeo*; Bartholomew, ——; Thomas, 132r, *Gegatroyneus*.

[1] Amber found on the Baltic coast in east Prussia.

[2] At Whitby, Yorkshire, jet occurs in cliffs that are being eroded by the sea, so that fragments are washed up all along the coast.

[3] This seems to mean topaz, but see II, ii, 18, *Topasion*.

[4] This again is jet, or some bituminous hydrocarbon, used to 'smoke out' vermin.

This makes its first appearance in Damigeron (XXV). The stone is unidentifiable, perhaps entirely fabulous.

Gagatronica is a stone of varied colour like the skin of a wild goat. Avicenna[5] says that its power makes those who wear it victorious. They say that this was shown by the experience of the prince Alcides [Hercules];[6] for whenever he had this stone with him he was always victorious by land and sea; but when he did not have it, he is said to have succumbed to his enemies.

GELOSIA

Marbod, XXXVII, *Gelacia*; Arnold, p. 72, *Galacia*; Bartholomew, XVI, 51, *Gelacia*; Thomas, 131v–132r, *Gelasia.*

The name was originally chalazias, *Greek for 'hailstone' (Pliny, XXXVII, 73, 189). This is probably a pebble of some transparent, colourless, and highly refractory mineral, such as a rough diamond or corundum. No doubt the original account said (truly) that it could not be melted or damaged by fire; and its 'icy' or 'frosty' appearance was responsible for the (untrue) addition that it would not even get hot.*

Gelosia is said to be a stone having the shape and colour of a hailstone and the hardness of *adamas.* And it is reported to be so cold that it can never be made hot by fire, or hardly ever. The reason[7] for this is that its pores are so contracted that they do not permit the fire to enter. People say, too, that it moderates anger and licentiousness and other hot passions and desires.

GALARICIDES

Marbod, XLII, *Galactida*; Arnold, p. 72, *Galactydes*; Bartholomew, XVI, 50, *Galactiles*; Thomas, 132r, *Galaritides.*

The various names, derived from the Greek 'milk' (Pliny, XXXVII, 59, 162, galaxia, galactites), *could refer to any white earth or soft stone that makes a 'milky' mixture with water—most likely chalk or soft limestone. But the persistent report that it affects the mind or the memory must refer to some vegetable drug.*

Galaricides (milkstone), which some people call *galarictides,* is a stone like ash, and it is mostly found in the Rivers Nile and Achelous. Its powder has a taste of milk; and its juice held in the mouth disturbs the mind. According to [books on] physical ligatures, if bound around the neck, it

[5] Reference unidentified; perhaps *Av.* written for *Ev.* (Evax), since the statement is in Damigeron and Marbod.

[6] Alcides, patronymic of Hercules, used by Marbod; it is also in Thomas.

[7] Albert, here as elsewhere, attempts to explain the alleged fact, alluding to *Meteor* IV, 9, 387 a 19.

fills the breasts with milk; and if bound on the thigh it eases childbirth. The shepherds of Egypt say that if it is crushed with salt and mixed with water and sprinkled at night around the sheepfold, the udders of the sheep are filled with milk and the scab is driven away from them. In fact, it is generally said to be a remedy against scab.

GECOLITUS

This is the same as cegolites *(II, ii, 3), under which references are given. This duplication is also in Thomas (130r, 132r)*

Gecolitus is reported to be a stone like the stone of an Eastern olive. If crushed and drunk with water, its power is said to break up and expel a stone from the bladder or kidneys.

GERACHIDEM

Marbod, XXX, *Gerachites*; Arnold, p. 72, *Gerachitem*; Bartholomew, XVI, 52, *Geraticen*, 102, *Yerachites*; Thomas, 132r, *Gerachirea.*

Pliny (XXXVII, 60, 167) says of hieracitis *only that it is coloured like a small falcon or kite (Greek,* hierax*). But this seems to be the stone to which Damigeron (XXXVIII,* gerachites*) attached the properties reported here. Possibly this is, in part, a distorted account of the use of arsenic to kill insects (cf. the name* falcones *in II, ii, 6). Constantine* (Opera, *p. 383) says that* arsenicum *'mixed with oil kills lice . . . ground up and mixed with milk, it destroys flies'. But certainly arsenic minerals should not be put in the mouth, so something else must be included here.*

Gerachidem is reported to be a stone of a black colour. The genuineness of the stone may be tested in this way: while wearing the stone [a man] smears his whole body with honey and exposes [himself] to flies and wasps, and if they do not touch him, the stone is genuine; and if he lays aside the stone, at once the flies and wasps fall upon the honey and suck it up. And they say that if the stone is held in the mouth it confers [the ability] to judge opinions and thoughts. And it is reported that the wearer is made agreeable and pleasing.

GRANATUS

Marbod, XIV, *Granatus*; Arnold, pp. 72–73, *Granatus*; Bartholomew, XVI, 54, *Granatus*; Thomas, 131v, 132v, *Granatus.*

Granatus *is included in the description of* hyacinthus *(see II, ii, 8) by all except Thomas, who, like Albert, also gives it a separate section; and this is so similar to Albert's as to indicate a common source. Thomas does not name this source, but Albert* *recognizes part of it as a quotation in Constantine* (Opera, *p. 352*) *from the* Lapidary of Aristotle. *A few details, however, seem to be taken from earlier descriptions of* carbunculus (*II, ii, 3*). *The name* granatus *covers dark red stones, most of which are probably garnets.*

Granatus (garnet), as Constantine reports Aristotle's statement, is a kind of carbuncle. It is a red, transparent stone, in colour like wild pomegranate flowers.[8] It is slightly darker red than carbuncle, and when it is mounted in a seal [ring] with black[9] beneath, it is more brilliant. There is also a kind that has a violet colour mingled with the red, and therefore is called *violaceus*; and this is more precious than other kinds of *granatus*. It is said to gladden the heart and dispel sorrow; and according to Aristotle it is hot and dry. But as to the statement of some people—that it is a kind of *hyacinthus*—that is not true. [*Granatus*] is found mostly in Ethiopia and sometimes near Tyre in the sea sands.

CHAPTER 8: THOSE BEGINNING WITH THE LETTERS H, I, AND J

HIENA

Marbod, XLIV, *Hyaena*; Arnold, p. 73, *Jena*; Bartholomew, XVI, 56, *Ienia*; Thomas, 132v, *Iena.*

The 'hyaena stone' cannot be precisely identified. Perhaps it is an 'eye agate', chalcedony with concentric rings of different colours. But Pliny (*XXXVII,* 60, *168,* hyaenia; *VIII,* 44, *106*) *says that the hyaena's eyes are of many* shifting *colours; so the stone is more likely to be an iridescent or chatoyant mineral—cat's eye or tiger's eye, or perhaps opal. Indeed, it may not be any specific mineral, but just a gem-dealers' term, claiming a power against the Evil Eye.*

Hiena stone is named from the beast called hyaena, because it is taken from [a hyaena's] eyes when they are turned to stone. But the ancient

[8] *similus balaustiis qui sunt flores malorum granatorum.* But the name *granatus* really refers to the red *seeds* or 'grains' in the pomegranate fruit. If Albert used Thomas, or Thomas's source, the word was probably *balastus*, another red stone (see II, ii, 2, *Balagius*) rather than the unfamiliar (Greek) *balaustium*, 'wild pomegranate', which needed explanation.

[9] This is contrary to the usual practice of jewellers, who enhance the colour of a transparent stone by backing it with a bright metallic foil. But the statement is also in Thomas. Possibly there is some (now lost) connexion with the remark that carbuncle shines if placed in a *black* vessel (see II, ii, 3, *Carbunculus*).

authorities, Evax and Aaron,[1] say that if placed under the tongue it confers the power of predicting the future by divination.

HYACINTHUS

Marbod, XIV, *Jacintus, Hyacinthus*; Arnold, pp. 72–73, *Jacinctus*; Bartholomew, XVI, 54, *Jacinctus*; Thomas, 132r–132v, *Iacinctus.*

The name hyacinth, or jacinth, has had a complex history. Today jewellers use it for a cinnamon-brown stone, either zircon or garnet, but this was certainly not the older usage. Pliny (XXXVII, 41, 125) places hyacinthus *immediately after amethyst, as having a similar but paler colour, like a hyacinth flower 'fading away' (I believe he meant rose quartz, having perhaps heard some exaggerated report of its tendency to fade on exposure to sunlight). But Solinus* (Coll. *XXX, 32) described* hyacinthus *as violet or blue, and 'watery' (perhaps meaning transparent sapphire); and this description persisted in medieval lapidaries. Further confusion was introduced when Constantine of Africa used* hyacinthus *in translating from the* Lapidary of Aristotle *(Ruska, pp. 186–7; Rose, pp. 353–4; Constantine's* Opera, *p. 352):*

Hyacinthi *are of three kinds, red, yellow, and blue. The red ones* (granati, *'like pomegranate seeds') are the best of all. They have this property, that if they are put in the fire and we blow the fire, the more we blow, the redder they become; and any blackish markings there may be in them are destroyed by the fire, and they become completely transparent. But the yellow ones do not bear the fire so well, and the blue ones cannot bear it at all. And Aristotle said that they are all hot and dry.*

This is of interest as indicating that heat treatment of gems was already practised before the eleventh century. The description indicates corundum gems, which are often unevenly coloured; some streaky red stones (rubies) can be improved by heating, but others lose their colour completely. This fact, together with statements about their extreme hardness, shows that hyacinthus *was mostly corundum, though similarly coloured zircon (jargon) may have been included.*

The nomenclature was still in some confusion, in the thirteenth century and indeed remains so today. We now call red corundum ruby, and blue corundum sapphire; but corundums of other colours have no names, being known either as yellow, green, purple, etc., 'sapphire'; or else (to distinguish them from commoner stones of these colours) as 'Oriental' topaz, emerald, amethyst, etc. Albert here tries, in his own way, to straighten out the difficulties: (1) First he (mistakenly) rejects all red *stones as not belonging to this group (see* Granatus, *II, ii, 7); (2) next, he makes a distinction between 'watery' and deep-coloured stones—his 'watery' jacinth is thus a very pale blue or pink sapphire; (3) he identifies deep-blue stones as sapphire—though* saphirus *is treated again in II, ii, 17; (4) he mentions stones of other colours (yellow or green?)*

[1] Aaron is unidentified, but the statement is in Evax (Marbod).

but gives them no names. The magical powers are those of all hyacinthus, *not only of the last-mentioned kind.*

Hyacinthus (jacinth) is of two kinds, namely *aquaticus* (watery) and *saphirinus* (sapphire). The 'water jacinth'[2] is pale blue, as if the clearness of water welled up from its transparent depths and struggled to predominate [in it]; and this is less valuable. There is also a watery red one of this sort, in which the transparency of water predominates. But the sapphire is a very bright blue, having nothing watery about it; and this is more valuable. Thus there are three names [i.e. *hyacinthus, aquaticus, saphirinus*], for the jacinth is sometimes called sapphire. This is mostly found in Ethiopia. And some people say that there is a fourth kind [green?][3] like *topasion*. This is extremely hard and generally worthless because it can hardly be engraved. It is known from experience that it is cold, as a green stone is, and it benefits the body just like anything that is cold and restricts the powers of the body. In *Physical Ligatures*[4] its use is that suspended from the neck or worn on the finger it keeps a traveller safe, and makes him welcome to those who entertain him, and protects him in unhealthy regions. And it is known from experience that it induces sleep because of its cold constitution. And sapphire is said to have a special property, and this is its power against poison. They say also that it confers riches and natural cleverness and happiness.

IRIS

Marbod, XLVII, *Iris*; Arnold, p. 73, *Jyrim*; Bartholomew, XVI, 55, *Iris*; Thomas, 132v, *Iris*.

Iris *is Greek for 'rainbow'. The stone is just a transparent quartz crystal used as a prism. Pliny (XXXVII, 52–53, 136–8) notes the characteristic hexagonal form.*

Iris (rainbowstone) is a stone similar to rock crystal, and it is usually hexagonal. Evax says that it comes from Arabia and occurs in the Red Sea. But we have found[5] a great many of these stones in the mountains of Germany between the Rhine and Treves. And although they are of different sizes, they are all hexagonal. They are formed in other stones and

[2] I have adopted 'water jacinth' as the least misleading translation of *hyacinthus aquaticus*, since 'water hyacinth' today means a plant, and 'water sapphire' is iolite, a pale blue or violet variety of cordierite.

[3] *caeruleum*, 'sky blue', but blue stones have already been described and this is another kind; moreover *topasion* (II, ii, 18) is yellow or green. Perhaps *flavus* has been mistaken for *blavus* and paraphrased as *caeruleus* (see I, ii, 2, introductory note).

[4] Costa ben Luca's *Letter on Incantations* (printed in Constantine's *Opera*, p. 319), quoting the *Lapidary of Aristotle*.

[5] The whole account of occurrence and origin is Albert's own.

are made hexagonal by being closely compressed by the [surrounding] stone, though they are naturally round—just as the cells in the middle of a honeycomb are hexagonal, although those at the edges are round. This is a very dry stone, as its great hardness indicates. It is formed from dried out moisture escaping from the material of a stone produced from red clay; and because this moisture has been intensely attacked by dryness, the stone is very dry and hard. If it is held up indoors so that part of it is in sunshine and part is kept in the shade, it casts a reflection of a beautiful rainbow on the opposite wall or anything else; and therefore it is called *iris*. The cause of this has been explained above.[6] Another substance similar to this occurs in gypsum,[7] which is extremely transparent and very dry; and some people use it instead of glass in windows.

ISCUSTOS

This name is a corruption of schistus *or* schiston, *Greek for 'easily split', applied by Pliny to 'fissile' alum (XXXV, 52, 183–90) and hematite (XXXVI, 38, 147): but he also mentions a variety of asbestus,* amiantus, *'undefiled' because it can be cleansed by fire (XXXVI, 31, 139), which is 'like alum'. In Isidore of Seville* (Etym. *XVI, 4, 18–19)* schistos *is immediately followed by* amiantus; *and here the two have coalesced into one. Albert probably got this item from Thomas (Evans, p. 231,* isciscos), *or from Thomas's source, since it is not in Marbod, Arnold, or Bartholomew.*

Iscustos (asbestus), as Isidore and Aaron[8] agree, is a stone frequently found the remotest part of Spain, near Gades [or the Gates] of Hercules, in the third or second clime[9], outside the country we now call Spain. It is a stone that splits into threads, owing to the viscosity in it which has dried up. And if a garment is woven of it, it does not burn, but is cleansed and whitened by fire.[10] And perhaps this is what they call 'salamander's feather', for this wool is something like the wool of a moist stone. But the reason why it does not burn has been discussed in the *Meteorology*.[11] And one kind of this, he says, is the stone some people call 'white carbuncle', and some 'white pebble': for it is like the carbuncle[12] in resisting

[6] In I, ii, 2, where *iris* is said to be formed from 'watery' or 'dewy' vapours.

[7] See II, ii, 17, *Specularis*.

[8] Aaron is unidentified.

[9] See II, iii, 4, note 4.

[10] Thus far most of the material is paraphrased from Isidore (loc. cit.); the remainder is presumably from Aaron.

[11] See *Abeston*, II, ii, 1, note 2.

[12] Probably the resemblance to carbuncle, as originally stated, was in resisting fire: cf. *Meteor.* IV, 9, 387 b 18, carbuncle (Greek *anthrax*), an incombustible stone.

phantasms and illusions; and it is a remedy for pains in the eyes due to moisture; and reduced to powder, it cures scab.

[JUDAICUS LAPIS]

The heading is omitted in the printed text. This is the same as cegolites *(see II, ii, 3 where references are given). This description is taken almost* verbatim *from Isidore of Seville,* Etym. *XVI, 4,* 12.

[Judaicus lapis (Jewstone).] Isidore likewise says of the Jew stone that it is white and about the size of an acorn, and inscribed with marks like letters, which the Greeks call γράμματα. Avicenna[13] says it is called Jewstone because it is frequently found in Judaea.

JASPIS

Marbod, IV, *Jaspis*; Arnold, p. 72, *Jaspis*; Bartholomew, XVI, 53, *Jaspis*; Thomas, 132r, *Iaspis.*

Jasper is cryptocrystalline silica, differing from chalcedony only in being less translucent. Pliny (XXXVII, 37, 115–18, iaspis) *mentions many colours, but since he began with green jasper his successors generally consider jasper a green stone, and probably include other green stones—prase, chrysoprase, and perhaps jade.*

Jaspis (jasper) is a stone of many colours, and there are ten kinds of it. But the best is translucent green with red veins, and it should properly be set in silver. It is found in many places. Experience shows that it reduces bleeding and menstruation. They say, too, that it prevents conception and aids childbirth; and that it keeps the wearer from licentiousness. In books on magic[14] we read that if incantations are recited over it, it makes one pleasing and powerful and safe, and gets rid of fevers and dropsy.

CHAPTER 9: THOSE BEGINNING WITH THE LETTER K

Borgnet's title for this chapter reads 'the ninth letter, which is K'. The count must have been lost in the preceding chapter, where H, I, and J are lumped together. But even though in the Latin alphabet I and J may be taken as one, K would still be the tenth letter. This mis-numbering continues to T, which is called 'the eighteenth letter'. To avoid confusion, I have hereafter omitted these ordinals, as is done in the edition of 1518.

[13] *Canon of Medicine,* II, ii, 394.

[14] What follows is all in Marbod, but Albert may have found it in some other lapidary that emphasized magic.

KACABRE

Marbod, ——; Arnold, p. 73, *Kacabre*; Bartholomew, ——; Thomas, 133r *Lagapis?*

This is the Arabic name for jet. See II, ii, 7, Gagates.

Kacabre (jet) is the same as *gagates*, as we have stated; but nevertheless some people say that *kacabre* is better, although really it differs from *gagates* neither in colour nor in powers.

[KABRATES]

Marbod, ——; Arnold, p. 73, *Kabrates*; Bartholomew, XVI, 58, *Kabrates*; Thomas, ——.

This is spelled kacabres *in Borgnet's text and printed as if part of the preceding, but it is certainly a different mineral. The description is attributed by Bartholomew to 'Dyascorides'. Identification is hardly possible, but perhaps it is just quartz.*

[Kabrates] is a stone similar to rock crystal. And it is reported to confer eloquence and honour and grace, and to be a remedy for dropsy.

KACAMON

Marbod, ——; Arnold, p. 73, *Kauman*; Bartholomew, XVI, 57, *Kamen*; Thomas, ——.

Arnold's account is very similar to Bartholomew's (attributed to 'Dyascorides'). Identification is uncertain, and perhaps two or three different things have been confused. (1) Both Bartholomew and Arnold say that the name means 'fire' (a corruption of Greek kauma*?), 'for it is found in sulphurous, hot places'. It may then be an artificial product, such as* cadmia *(furnace calamine, zinc oxide); and in fact Pliny (XXXIV, 22, 103) mentions a kind of* cadmia *called* onychitis *because it is marked 'like onyx'. (2) The fact that figures were carved on it suggests that it was a* cameo. *This is evidently what Albert thinks, and he is the only one to mention onyx in his description. But, as will appear later (II, ii, 13,* Onycha*; II, iii, 2 and 4), he does not always distinguish natural from artificial 'figures' on stones.*

Kacamon is a stone that is frequently white, either wholly or in part; for it is varied in colour, and most frequently it is found mixed with onyx. Its power is said to be due to the images and carvings found on it, and in the *sigils* which will be discussed in a later tractate.

CHAPTER 10: THOSE BEGINNING WITH THE LETTER L

LIGURIUS

Marbod, XXIV, *Ligurius*; Arnold, p. 73, *Lygurius*; Bartholomew, XVI, 60, *Ligurius*; Thomas, 132v, *Ligurius.*

The correct name is lyncurium, *Greek, 'lynx water'. Pliny (VIII, 57, 137; XXXVII, 13, 52–53) took from Theophrastus* (On Stones, *28*) *the story of its origin, but refused to believe it; he also denied that* lyncurium *is the same as amber (see II, ii, 17,* Succinus). *Possibly the stone is tourmaline, which can be electrified by heating.*

Ligurius is a stone formed from the urine of the lynx, and Pliny says that these are eastern animals;[1] but nevertheless they are found in great numbers in the forests of Teutonia and Sclavonia. Pliny says that these animals conceal their urine in the sand as if they were envious of the good use which is made of the stone. Bede[2] says that this stone occurs in human kidneys. And Pliny says that it is sparkling red like the carbuncle, except that it does not shine by night. But that more commonly found is of a dark brownish yellow colour. And experience shows that if rubbed it attracts straws, which is [a property] of nearly all precious stones.[3] And it is said to be good against pains in the stomach, and jaundice, and diarrhoea.

LIPPARES

Marbod, XLV, *Liparea*; Arnold, p. 73, *Lypparia*; Bartholomew, XVI, 61, *Lipparia*; Thomas, ——.

The original name was liparea. *Pliny* (Nat. Hist. *XXXVII, 62, 172*) *said only that it was used for fumigation and 'calls forth all beasts'; it was probably bitumen (or sulphur from the Lipari Islands?). But Marbod takes it to have a* magic *power of attracting wild animals, as a hunter's charm. Arnold's poor version of this says merely that the animals hasten to come to look at the stone. Where Albert's version came from is uncertain, but he seems to think it is a rather tall story.*

Lippares is said to be a stone that is frequently found in Libya. It is reported to have marvellous power: for all wild beasts, when harassed by hunters and dogs, run to it and regard it as a protector. And they say that dogs and hunters cannot [harm][4] a wild beast so long as it is in the presence of the stone. If this is true, it is very marvellous, and undoubtedly is to be

[1] Pliny (VIII, *30*, 72) gives the habitat of the *lynx* as Ethiopia, but the animal he calls *chama* (VIII, *28*, 70) seems to be the European lynx.

[2] English historian and scholar (673–735). I have not been able to find this statement in Bede's writings. In his *Ecclesiastical History* (I, i) he lists among the products of Britain jet, which Albert confuses with amber (cf. II, ii, 7, *Gagates*). Or perhaps the text is imperfect, the original sense having been something like 'Bede says this stone occurs in [Britain and others say it is good for] human kidneys.'

[3] Many gemstones are electrifiable. Credit for this discovery is generally given to William Gilbert, in his book *On the Magnet* published in 1600 (Thompson, pp. 46–50), but it seems to have been known much earlier.

[4] *noscere*, evidently for *nocere*.

ascribed to the power of the heavens: for, as Hermes[5] says, there are marvellous powers in stones and likewise in plants, by means of which natural magic could accomplish whatever it does, if their powers were well understood.

CHAPTER 11: THOSE BEGINNING WITH THE LETTER M

MAGNES

Marbod, XIX, *Magnetes*; Arnold, p. 73, *Magnetes*; Bartholomew, XVI, 63, *Magnes*; Thomas, 133r, *Magnes.*

This is the mineral magnetite. Its magnetic properties have excited wonder from early times (Pliny, XXXIV, 42, 147–8; XXXVI, 25, 126–30): the swift 'embrace' of magnetite and iron—for which William Gilbert in 1600 used the term coitus*—obviously suggested its use as a love charm, etc. But it has been confused with* adamas *(II, ii, 1) and accounts of the two stones commonly overlap. There is more about the polarity of the magnet in II, iii, 6.*

Magnes or *magnetes* (magnet, magnetite, lodestone) is a stone of an iron colour, which is mostly found in the Indian Ocean, [where] it is said to be so abundant that it is dangerous to sail there in ships that have the nails outside.[1] It is also found in the country of the [Troglodites].[2] I myself have seen one found in the part of Teutonia called the province of Franconia, which was of large size and very powerful; and it was extremely black, as if it were iron rusted and burnt with pitch. [Magnet] has a wonderful power of attracting iron, so that its power is transferred to the iron and then that, too, attracts: and sometimes many needles are seen, thus suspended from one another. But if the stone is rubbed with

[5] This sentiment (though not ascribed to Hermes) is found at the end of the *Prologue* of Marbod's poem: 'Let no one doubt that the powers of gems are divinely implanted. Great power is given to herbs, but the greatest of all to gems.' Or perhaps Albert recalls a similar passage in the *Secret of Secrets* (Steele, 1920, p. 114): 'Great and wonderful power is conferred both on plants and on stones, but hidden from mankind.' This is not ascribed to Hermes either, but it is in the section immediately preceding *The Emerald Table* (see Appendix D, 7).

*

[1] The danger is that the magnetic rocks will pull the nails out, so that the ship will go to pieces. This is from Constantine (*Opera*, p. 378), quoting from *Lapidary of Aristotle.*

2. *Traconitidis*, apparently for Troglodites, cave-dwellers.

garlic[3] it does not attract. And if an *adamas* is placed on it, again it does not attract, so that a small *adamas* in this way [can] restrain a large magnet.[4] In our own time a magnet has been found that attracted iron from one corner and repelled it from another.[5] And Aristotle says that this is another kind of magnet.[6] One of our Order, a careful observer, has told me that he had seen a magnet belonging to the Emperor Frederick,[7] which did not attract iron, but on the contrary, the iron attracted the stone. Aristotle[8] says that there is still another kind of magnet that attracts human flesh. In magic[9] it is reported that [magnet] is marvellous for calling up phantoms, principally or especially if incantations and magic signs are used, according to the teachings of magic. And taken in honey-water, it is reported to cure dropsy. They say,[10] too, that if the stone is placed under the head of a sleeping woman, it makes her turn at once to her husband's arms, if she is chaste. But if she is adulterous, she is so alarmed by nightmares that she falls out of bed. They say also that thieves entering a house place burning coals in the four corners of the house and sprinkle upon them the powder of this stone;[11] and then those who are sleeping in the house are so harassed by nightmares that they rush out and leave the building. And then the thieves steal whatever they want.

MAGNESIA

This does not usually appear in lapidaries, since it is not a 'precious stone' but a substance used in technology and alchemy. Pliny (XXXVI, 25, 127–8) says that the name magnes *or* magnetes *indicates the place of origin, 'in Magnesia'. But there were several places called Magnesia, and therefore several different 'Magnesian stones'. The magnet (magnetite: see above) is one of them, but when Pliny (XXXVI, 66, 192) says that* magnes *is used in glassmaking, this can hardly be magnetite, which contains iron and would make the glass very dark-coloured. It may have been either of the other two substances which have also inherited the name of the 'Magnesian stone'*

[3] This is not in any of the sources listed above, but Albert could have found it in many other places, for instance in Ptolemy's *Quadripartitum* (*Tetrabiblos*, I, 3, 13), which he cites on astrology (see Appendix C, 2).

[4] See II, ii, 1, *Adamas*, note 8.

[5] Bartholomew cites this statement as from 'Dyascorides': it probably comes from the *Lapidary of Aristotle*.

[6] Also from the *Lapidary of Aristotle* (see notes on II, iii, 6). Pliny, too, thought that a magnet that repels is a different mineral from one that attracts.

[7] See I, i, 7, note 7.

[8] See II, iii, 6, note 17.

[9] 'Magic' may have been sleight-of-hand tricks with concealed magnets.

[10] All that follows appears in Damigeron (XXXIV) and is repeated by Marbod and Albert's contemporaries.

[11] Something other than magnetite must be meant—perhaps bitumen, or perhaps some drug 'from Magnesia'.

—magnesia (that is, dolomitic limestone) or manganese. Albert's description indicates the latter—black manganese minerals, such as pyrolusite, manganite, etc., used to decolorize and clarify the glass.

Magnesia, which some call *magnosia*, is a black stone frequently used by glassmakers. This stone melts and fuses if the fire is very strong, but not otherwise; and then, mixed with the glass, it purifies its substance.

MARCHASITA

This is an alchemical term for metallic sulphides, such as pyrite or marcasite. It is seldom found in lapidaries, though the same minerals are described under different names: see II, ii, 14, Perithe*; 18,* Topasion *(in part);* 19, *Virites. And* marchasita *is discussed again in V, 6.*

Marchasita, or *marchasida*, as some people say, is a stony substance, and there are many kinds of it: for it takes the colour of any metal whatever, and so it is called 'silver' or 'golden' *marchasita*, and so on for the other metals. But the metal that colours it cannot be smelted from it, but evaporates in the fire, leaving only useless ash. This stone is well known among alchemists, and is found in many places.

MARGARITA

Marbod, L, *Margarita, Unio*; Arnold, p. 73, *Margarita*; Bartholomew, XVI, 62, *Margarita, Unio*; Thomas, Evans, p. 231, *Margarita, Unio.*

This is pearl. The account of its origin is an echo of Pliny (IX, 54–59, 106–24) and the medical uses are from some medical work (cf. Constantine, Book of Degrees, (Opera, *p. 351,* perna)*); but Albert has added some of his own observations.*

Margarita (pearl) is a stone found in dark-coloured shells. The best come from India, but many also come from the British Sea, now called the English [Channel]; and they are also found [on the side] towards Flanders and Teutonia: so that I myself have had ten in my mouth at a single meal, which I found while eating oysters. The young shellfish have the better [pearls]. Some are pierced and some are not.[12] Their colour is very white, but as if a little light were shining through it, and so they gleam although they are white. It is said that during a thunderstorm the oysters, mis-carrying, as it were, cast them out. And so they are found in rivers, in the

[12] Some of the pearls imported from the Orient were already pierced and there seems to have been a general belief that the holes were natural. Indeed Bartholomew distinguishes between pearls pierced *arte* and *naturaliter* (the latter 'are better').

Moselle and some rivers in France, among the sands.[13] Their power has been found by experience to relieve difficulty in breathing and heart attacks and fainting fits; and it is good against bleeding and jaundice and diarrhoea.

MEDIUS

Marbod, XXXVI, *Medus*; Arnold, p. 73, *Medo*; Bartholomew, XVI, 67, *Medus*; Thomas, 133r–133v, *Medus.*

The stone 'from Media' was probably a mixture of impure metallic sulphates, described again as atramentum *(V, 3).*

Medius is named from the country of the Medes, where much of it is found. There are two varieties of it, one black, the other green. They say it has power against chronic gout, and dimness of the eyes, and kidney troubles. And it is said to strengthen those who are weak and weary and feeble. They say that if fragments of the black kind are dissolved in hot water, and anyone washes in that water, the skin peels from his body; and if he drinks it, he will die of vomiting.

MELOCHITES

Marbod, LIV, *Melochites*; Arnold, p. 73, *Molochites*; Bartholomew, XVI, 68, *Merochites*; Thomas, Evans, 1922, p. 232, *Melonites.*

This is malachite (Pliny, XXXVII, 36, 114, molochitis*) named from the mallow plant because of its bright green colour. It is a copper carbonate, too soft for jewellery, but effective in ornamental veneers, mosaics, small sculptures, etc. In ancient times it may have been included under* smaragdus *(II, ii, 17).*

Melochites (malachite), which some people call *melonites*, is an Arabian stone of a thick green, not transparent like *smaragdus*; and it is soft. It is said to have the power of protecting the wearer from harm, and [of guarding] the cradles of infants.

MEMPHITES

Marbod, ——; Arnold, ——; Bartholomew, XVI, 65, *Menophitis*; Thomas, 133r, *Memphites.*

This stone 'of Memphis' comes from Pliny (XXXVI, 11, 56) by way of Isidore (Etym. XVI, 4, 14), of whom Bartholomew gives a direct quotation and Thomas a paraphrase

[13] Pearls occur in fresh-water mussels, and so could get into river sands, but they are so soft that they would soon be destroyed by friction in transportation, and a good one would be a rare find. In his *Animals* (XXIV, 74), Albert says: 'In our country they [pearls] are found in three ways: for sometimes they are found attached to the shells, sometimes in the oysters themselves, and sometimes among the stones under which the oysters hide themselves. Those that come from the Orient are better.'

very similar to Albert's. The substance is not a stone, of course, but probably a vegetable drug.

Memphites is named from the city in Egypt called Memphis. It is said to be as hot as fire, with a power that is seen by its effect. For if crushed and mixed with water, and given as a drink to those who have to be cauterized or cut, it induces insensibility, so that the pain is not felt.

CHAPTER 12: THOSE BEGINNING WITH THE LETTER N

NITRUM

Marbod, ——; Arnold, p. 73, *Nitrum*; Bartholomew, XVI, 70, *Nitrum*; Thomas, 133v, *(N)itrum.*

Nitrum is mostly soda or borax (not nitre). It is more fully described in V, 7. The brief statement here is evidently from the source used by Arnold, Thomas, and Bartholomew (who calls it 'Dyascorides').

Nitrum approaches the solidity of stone. It is somewhat pale and transparent. And it has been proved to have the power of dissolving and attracting. It is a remedy for jaundice, and it is a kind of salt.

NICOMAR

Marbod, ——; Arnold, pp. 73–74, *Nycomar, Alabastrum*; Bartholomew, XVI, 3, *Alabastrum, Nicomar*; Thomas, 133v, *Nuchamar, Alabastrum.*

The classical name was alabastrites *(Pliny, XXXVI, 12, 60–61). Bartholomew says the name* nicomar *is from 'Dyascorides'. The mineral is alabaster, a fine-grained, translucent form of gypsum; some onyx marble (calcite) was probably included.*

Nicomar is the same as alabaster, which is a kind of marble; but because of its marvellous power it is placed among precious stones. And experience shows that by its coldness it preserves aromatic unguents; and therefore the ancients made ointment boxes[1] of it. And by its coldness it also preserves the corpses of the dead from smelling extremely offensive; and therefore ancient monuments and tombs are found [made] of this stone. It is shining white. And they say that it gives victory and preserves friendship.

[1] *pyxides.* Isidore (*Etym.* XVI, 5, 7), in his description of *alabastrites*, refers to the woman who brought an alabaster box of ointment to Jesus (Matt. xxvi. 6–7; Mark xiv. 3; Luke vii. 37–38).

NUSAE

Marbod, ——; Arnold, p. 74, *Nose*; Bartholomew, XVI, 71, *Noset*; Thomas, 133v, *Noshe.*

This is the toadstone again (cf. II, ii, 2, Borax), *but from another source, which Bartholomew identifies as 'Dyascorides'.*

Nusae. Some people say that there is a stone of this name and that it is a kind of toadstone, and is found in many toads. There are two kinds. One is whitish, as if milk were mingled with blood and predominated in it, and thus blood-red streaks appear in it, they say. The other is black, and sometimes has inside it a figure of a toad[2] with feet outstretched before and behind. They say, too, that if both stones are shut up together in the presence of poison, they burn the hand of anyone who touches them. They say that a proof of the stone's genuineness is that, if it is shown to a live toad,[3] the toad stretches up towards it and touches it if possible. It is also said that in the presence of poison the whitish kind takes on varied colours.[4]

CHAPTER 13: THOSE BEGINNING WITH THE LETTER O

ONYX

Marbod, IX, *Onyx*; Arnold, p. 74, *Onyx*; Bartholomew, XVI, 72, *Onichinus, Onix*; Thomas, 133v–134r, *Onix, Onichinus.*

Onyx, then as now, was applied both to a banded calcareous travertine ('onyx marble') and to a variety of chalcedony having thin, distinct layers of contrasting colours. The latter is harder and more suitable for gems, the layers being exploited in cutting cameos.

Onyx is said to be a gem of a black colour;[1] there is found a better kind of it which is black, streaked with white veins. It comes from Media and

[2] Probably a fossil: see II, ii, 2, *Borax.*

[3] Another story about a stone and a live toad (perhaps a conjuror's trick) is told by Albert in his *Plants* (VI, ii, 1):

Recently there was seen in our country a *smaragdus*, small in size but remarkably beautiful. And when its power was to be tested, a bystander said that if a circle were drawn around a toad with the *smaragdus*, one of two things would happen: either the stone, if its power were weak, would be broken by the toad's gaze; or else the toad would burst if the stone really had its own natural vigour. Without delay, they did as he said. And after a short time, during which the toad gazed fixedly upon it, the stone began to crack like a nut, and one piece of it sprang right out of the ring. Then the toad, which until now had been keeping perfectly still, began to move away, as if it had been freed from the power of the stone.

[4] Stones reputed to have this power were sometimes mounted on dishes or drinking cups. Cups of *electrum* (see V, 9) were valued for the same reason.

*

[1] Onyx actually shows a wide range of colours, but Albert relegates grey, brown, and especially flesh-coloured varieties to *onycha*, below. Stones with layers of red and white are called *sardonyx* (II, ii, 17).

Arabia. Five varieties are found, based on differences in their veining and colours. They say[2] that, worn around the neck or on the finger, it induces sorrow and fear and terrible dreams in sleep; and it is reported to increase sorrows and dissensions; and they say that it increases saliva in children. But sard, if present, restrains the onyx and keeps it from doing harm. If[3] [onyx] really has all these [properties], surely this is because it has the power of affecting black bile, especially in the head; for all these disorders come from the motion and vapour [of black bile].

ONYCHA

(References as for ONYX, above.)

The word 'Onyx' is from the Greek for fingernail (Pliny, XXXVII, 24, 90–91), and Albert, like Bartholomew and Thomas, seems to distinguish stones of this colour from black-and-white onyx *(above). But the word was applied also to other things having the colour and horny lustre of a fingernail. Pliny (XXXII, 46, 134) uses* onycha *of the translucent horny operculum of a sea snail, the* murex *from which the famous Tyrian dye was made. And in his book on incense trees he says that certain gums (XII, 19, 36,* bdellium*; 35, 70, myrrha) show bright marks 'like fingernails', as if this were a technical term, perhaps for conchoidal fracture. Medieval writers use* onycha *as the name of an aromatic gum, and Albert discusses these different meanings of* onycha *in his* Plants *(VI, i, 28). In the present passage some of his statements seem to refer to a gum rather than a mineral.*

Onycha, or *onychulus*, as some people say, is really the same as onyx, since it is very similar, or may be a variety of it. Its colour, however, is not always, but only sometimes, black; but it is [more commonly] like the colour of the human fingernail, as we have said above. But the stone named *onychinus* is found of many colours, white, black, and reddish; nevertheless, all these are formed in some substance that is very like the human fingernail. They say, too, that drops of gum from a tree called *onycha* harden into stone; and this is the reason why it has an odour in the fire. They also declare that this is the reason why, more frequently than other stones, it is found marked with images.[4] For the drops are soft at first and easily formed into figures; and the gum retains these figures

[2] This and the next three statements come from Costa ben Luca's *Letter on Incantations* (Constantine, *Opera*, p. 319), quoted from the *Lapidary of Aristotle*. Bartholomew gives the same as from 'Dyascorides'.

[3] What follows is Albert's own explanation, based on the theory of bodily humours. Black bile (*melancholia*) was supposed to be the cause of depression and sadness.

[4] antique cameos; but Albert seems to consider these figures natural (cf. II, iii, 2 and 4).

when it consolidates and hardens into stone. They say that this stone can be put into the eye without being felt, and this is marvellous. But I myself have seen a *saphirus* put into the eye, and a cockstone,[5] and another stone whose name I do not know, without damage to the eye. For a smoothly polished thing does not damage the eye, unless it should touch the centre, or pupil, the sensitive part opposite the opening of the eyeball.

OPHTHALMUS

Marbod, XLIX, *Optallius*; Arnold, p. 74, *Optallius*; Bartholomew, XVI, 73, *Optallius, Opallus*; Thomas, 134r, *Ostolanus, Olthamus.*

This is precious opal, as is clear from Pliny's description of the play of colours (XXXVII 21, 80–82, opalus). *But something seems to have been lost from the source used by Arnold, Thomas, and Albert. Thomas, too, complains that the books do not say what the stone looks like, but adds that this is so that it may not be easily found (presumably because it could be put to bad uses). Albert's spelling is consistent with his attempt to derive the name from* ophthalmia. *This association of opals and eyes is persistent: see II ,ii, 8,* Hiena; *14,* Pantherus. *And the ambivalent feelings with which such 'eye stones' were regarded lingers even today in the superstition that opals are unlucky.*

Ophthalmus is a stone named from *ophthalmia* (an eye disease). Its colour is not stated, perhaps because it is of many colours. It is said to protect the wearer against all bad diseases of the eyes; but to dim the sight of those near by. And therefore it is known as the protector of thieves; for those who wear it are, as it were, invisible.

ORISTES

Marbod, XLIII, *Orites*; Arnold, p. 74, *Orites*; Bartholomew, XVI, 74, *Orites*; Thomas, 134r, *Orities.*

The correct name is orites, *Greek 'mountain stone'. Pliny (XXXVII, 65, 176; XXXVII, 67, 182) says it is the same as* sideritis *(Greek 'iron stone'), which causes discord. So perhaps this is another report of the 'repulsive' rather than the 'attractive' power of magnetite. But the stone cannot be identified with certainty.*

Oristes has three varieties. One of these is black and round. Another is green with white spots. The third is partly rough and partly smooth and its colour is like a plate of iron. And its constitution is such, they say, that if rubbed with rose oil it preserves the wearer from misfortune and from the harmful bites of reptiles. It is also said in [books on] physical ligatures that if worn by a woman it prevents her from conceiving; and if she is pregnant, she will miscarry.

[5] See II, ii, 1, *Alecterius*; also 17, *Saphirus.* Perhaps putting a small smooth stone into the eye stimulated tears and helped to wash out foreign matter or pus.

ORPHANUS

This is not the name of any species of mineral, but probably designates an individual gem, famous enough to have a name of its own (like the Kohinoor and others today). The description indicates a fire opal. It is mentioned in medieval accounts of the Crown of the Holy Roman Empire, but by the fourteenth century it had been lost and was replaced by a sapphire (Schmidt, 1948, pp. 68, 91–93).

Orphanus is the stone in the crown of the Roman Emperor, and has never been seen anywhere else, and therefore it is called the orphan. Its colour is like wine, of a delicate wine-red, as if gleaming or shining white snow were mingled with clear red wine, and were overcome by it. It is a brilliant stone, and tradition says that at one time it used to shine by night; but nowadays it does not shine in the dark. It is said to preserve the royal honour.

CHAPTER 14: THOSE BEGINNING WITH THE LETTER P

PANTHERUS

Marbod, LI, *Pantheron*; Arnold, p. 74, *Pantherus*; Bartholomew, XVI, 80, *Panteron*; Thomas, 134v, *Panthera.*

This is opal again. The correct name is panchrus *(Greek, 'all colours': Pliny, XXXVII 66, 178). Damigeron (XLIV) and Marbod are responsible for connecting it with the 'many-coloured' beast, the panther.*

Pantherus is a stone having many colours in a single stone, [namely] black, green, red, and many more; and it is also found pale purple, and rose-coloured. They say it impairs the sight. It is found mostly in Media. The wearer should look at it early in the morning when the sun is rising, in order to be successful and victorious. It is said to have as many powers as it has colours.

PERANITES

Marbod, XXXIV, *Peanites*; Arnold, p. 74, *Peanites*; Bartholomew, XVI, 79, *Pionites*; Thomas, 134v–135r, *Peanites.*

Pliny (XXXVII, 66, 180) calls this paeanites *(probably from Greek* Paian, *physician of the gods, with some reference to its supposed help in childbirth) or* geanis *(Greek 'earthstone'). Like the eaglestone (II, ii, 5,* Echites*), itis a geode containing small pebbles or crystals, which are 'born' when the 'mother' stone is broken.*

Peranites is a stone occurring in [Macedonia.][1] It is of the female sex; for at a certain season it is said to conceive and give birth to another natural stone like itself. And it is said to be good for pregnant women.

PERITHE

Marbod, LVI, *Pyrites*; Arnold, p. 75, *Pirites, Virites*; Bartholomew, XVI, 78, *Pirites*; Thomas, 134r, *Perites, Peridonius.*

This is pyrite, named from the Greek word for 'fire', since it can be used to strike a spark (Pliny, XXXVI, 30, 137–8). The story that it burns the hand also goes back to Pliny (XXXVII, 73, 189) and is not entirely fabulous, though somewhat exaggerated: pyrite on weathering produces sulphuric acid that would irritate the hands of anyone who handled it very much. The mineral is repeated under other names: marchasita *(II, ii, 11 and V, 6);* topasion *(II, ii, 18);* virites *(II, ii,* 19*).*

Perithe, or *peridonius,*[2] is a stone of a yellowish colour. It is said to be good for coughs. And a marvellous thing is reported of this stone—that if it is strongly gripped in the hand, it burns the hand; and so it should be touched lightly and cautiously. There is said to be another variety of this which is similar to *chrysolitus*, except that it is greener.

PRASSIUS

Marbod, XL, *Praxus*; Arnold, p. 74, *Prassius*; Bartholomew, XVI, 77, *Prassius*; Thomas, 134v, *Prasius.*

Pliny's prasius *(XXXVII,* 34, *113) is named from its colour, Greek 'leek-green'. It is green chalcedony, including dark green prase, bright green plasma, and probably green jasper and similar green stones. The red-spotted kind has already been described (II, ii,* 5, Eliotropia*).*

Prassius is a stone which is very often the matrix and 'palace' of *smaragdus.*[3] It is of an opaque dark green colour like the plant *prassius*, or horehound.[4] It is found sometimes with red spots, and sometimes with white. Experience shows that it benefits the sight, and it has some of the properties of jasper, and some of those of *smaragdus.*

[1] *de micheton,* error for *Macedon* (as in Pliny).

[2] *peridonius* is different from pyrite, probably peridot, and if so belongs with the last sentence, which refers to the olivines—pale yellow-green chrysolite and dark green peridot. But see II, ii, 3, *Chrysolitus* and *Chryselectrum.*

[3] See also II, ii, 2, *Balagius.* The statement comes, by way of Pliny (XXXVII, *19,* 75), from Theophrastus (*On Stones,* 27), who says that green *smaragdus* is formed from jasper, the proof being that a stone was once found that was half-and-half, the transformation still incomplete. It was probably a zoned or patchily coloured stone, or perhaps an aggregate of green copper minerals: see II, ii, 17, *Smaragdus.*

[4] *prassium quod est marrubium*: but the name is really derived from Greek *prason,* 'a leek'.

[PYROPHILUS]

Borgnet has no heading here, and below prints the name as prophilis. *Thomas (134v,* Pyropholos) *gives an account very similar to Albert's, citing the same authorities, which I have not identified.*

[Pyrophilus]. In a letter, certain Aesculapian philosophers[5] told Octavian Augustus that some poison is of such coldness that the heart of a man slain by it is preserved from the fire. And if that heart is placed in the fire for a long time, so that it is converted into stone by baking, that stone is called [*pyrophilus*] from the fire, and it is called *humanus*[6] from its [human] material. It is said to be [precious][7] because it brings victory and protects from poison.

A story is told,[8] although it may be nothing but a story, about Alexander of Macedon, who wore this stone in his girdle in battle. And when he was returning from India, he wanted to bathe in the Euphrates, and laid aside his girdle; and a serpent bit off the stone and broke it, and spat it out into the Euphrates. Aristotle is said to have mentioned this in a book on *The Nature of Serpents*, which has not come down to us. This stone is red with a mixture of shining white.

CHAPTER 15: THOSE BEGINNING WITH THE LETTER Q

QUANDROS

Marbod, ——; Arnold, p. 74, *Quanidros*; Bartholomew, XVI, 84, *Quandros*; Thomas, 135r, Quinidros.

All these accounts are so similar as to point to one source, which Bartholomew says is 'Dyascorides'. *The stone belongs to the same category as the cockstone (II, ii, 1,* Alecterius).

Quandros is a stone sometimes found in the brain of a vulture. Its power is said to be good against any kind of misfortune; and it fills the breasts with milk.

[5] The letter of the Aesculapians would seem to have some connexion with the statement of Pliny (XI, 71, 187) that Germanicus Caesar (who died in A.D. 19) was believed to have been poisoned, because his heart was not consumed on the funeral pyre. But the Emperor at that time was Tiberius; Octavian died in A.D. 14.

[6] Thomas adds that the stone called *humanus* protects a man from actual death, but not from illness and suffering.

[7] *praeconsus*: the word may be from *praeconari*, 'to praise'. Or it may be an error for *preciosus* (ed. 1518).

[8] This is printed as if part of the preceding, but it is probably a separate, though nameless, stone. The theme is ancient, and in stories of this type the hero suffers from misfortune after the loss of his talisman.

QUIRITIA

Marbod, ——; Arnold, p. 74, *Quirin*; Bartholomew, XVI, 83, *Quirin*; Thomas, 135r, *Quirin.*

These, too, are all very similar and indicate a single source, and again Bartholomew says 'Dyascorides'. The hoopoe, a bird with spectacular black-and-white markings and a large crest, was supposed to eat, and to nest in, filth. In Albert's Animals *(XXIII, 111) he says that the hoopoe's blood, smeared on the forehead before one goes to bed, brings nightmares; and that its brain, tongue, and heart are used in incantations that he has no intention of describing.*

Quiritia is a stone sometimes found in the nest of the hoopoe, a bird entirely [devoted to] illusions and augury, according to the magicians and soothsayers. This stone reveals secrets and produces hallucinations, if placed on the breast of a sleeper.

CHAPTER 16: THOSE BEGINNING WITH THE LETTER R

RADAIM

This is only in Arnold (p. 74, Radaym, Donatides), *who gives no source. The stone is another version of* alecterius *(II, ii, 1).*

Radaim and *donatides* are said to be the same stone. And they say that it is shining black. It is reported that, when the heads of fowls are given to ants to eat, after a long time this stone is sometimes found in the head of a cock. And it is said to enable [one] to obtain whatever he wishes.

RAMAI

Marbod, ——; Arnold, p. 74, *Ramuy, Bolus armenicus*; Bartholomew, XVI, 85, *Rabri, Bolus armenicus*; Thomas, ——.

Here again both accounts seem to come from a common source, which, however, is not named. But Bolus armenicus *does occur in medical books, e.g. Constantine's* Book of Degrees (Opera, *p. 353). 'Bolus is cold and dry in the first degree. It is prescribed for bleeding, diarrhoea, dysentry, haemorrhoids and tenasmus', and other ailments for which Galen and Dioscorides are cited. The mineral is a kind of clay or ochre, supposed to come from Armenia.*

Ramai, which is mentioned in medical and alchemical [books], is the same as *Bolus armenus*. It is a reddish stone. Experience gives certain proof that it overcomes looseness of the bowels, and especially the bleeding of dysentery and menstruation.

CHAPTER 17: THOSE BEGINNING WITH THE LETTER S

SAPHIRUS

Marbod, V, *Sapphirus, Syrtites*; Arnold, p. 74, *Saphirus, Syrtites*; Bartholomew, XVI, 87, *Saphirus, Sirtites*; Thomas, 135r–135v, *Saphyrus.*

The sapphirus *of the ancients (Pliny, XXXVII,* 39, *120; Theophrastus,* On Stones, *37) was lapis lazuli, a brilliant blue opaque aggregate of sodalite minerals (see II, ii, 20,* zemech). *By the thirteenth century, however,* saphirus *was beginning to mean* transparent *blue gems, especially blue corundum, our sapphire. The inconsistencies in Albert's account spring from the difficulty of reconciling descriptions of these two different kinds of* saphirus. *The other name,* syrtites *(Pliny, XXXVII,* 67, *182), did not really belong to either of these; it was a 'honey-yellow' stone with 'faint stars' in it—probably our sunstone, aventurine feldspar or quartz. But lapis lazuli often contains 'golden' specks of pyrite, and these were evidently taken to be the 'stars' of* syrtites.

Saphirus is a very famous stone, and most of it comes from the East, from India. It is [also] found in an underground mine in the neighbourhood of the city of [Le Puy],[1] in Provence; but this is not so precious as to be exactly like the Oriental [kind]. Its colour is a transparent blue like a clear sky, but the blue colour predominates; and [oriental] the better kind is not quite transparent. The best has dark clouds with a reddish tinge; but a good kind is found that has small white clouds; its substance is like a dusky cloud, but rather translucent. I [myself][2] have observed the power of one that cured two abscesses. They say, too, that this stone makes a man chaste and cools internal heat, checks sweating, and cures headache and pain in the tongue. I myself have seen one put into the eye to remove dirt from the eyes;[3] but it should be placed in cold water beforehand and likewise afterwards. As to the statement that it loses its power and colour after it has once cured an abscess, that is not true; for I have seen one that cured two abscesses in succession, with an intervening period of nearly four years. They say that it invigorates the body, and brings about peaceful agreements, and makes one pious and devoted to God, and confirms the mind in goodness. This stone is also called by

[1] *in hypodromo apud Thodanum provinciae regionem et civitatem: Thodanum* must be an error for *Podium,* a *puy,* an old volcanic cone in Auvergne. The locality is more specifically named, Le Puy de Notre Dame, in a thirteenth-century French lapidary (Studer and Evans, 1924, pp. 140–1).

[2] *ergo,* error for *ego.*

[3] See II, ii, 13, *Onycha,* note 5.

another name *sirites* or, as others prefer, *sirtites*, because it is found in sandbanks (*syrtis*).[4]

SARCOPHAGUS

This is mentioned by Pliny (XXXVI, 27, 131), but Albert and Thomas (136r) quote Isidore of Seville (Etym. *XVI, 4, 15*). *The stone is marble or alabaster (see II, ii, 12,* nicomar) *but the tale about consuming corpses is a confusion with a similar tale about quicklime.*

Sarcophagus is a stone that devours dead bodies, for in Greek σάρκος means 'flesh' and φαγῶ 'eat'. Some of the ancients first made coffins for the dead of this stone because in the space of thirty days it consumed the dead body. For this reason our stone monuments are called *sarcophagi.*

[SAGDA]

Marbod, XXXV, *Sada*; Arnold, p. 75, *Sadda*; Bartholomew, ——; Thomas, 136v, *Sarda.*

The name is printed as sarda (*which is also in Thomas*), *but this is wrong, since the stone is not sard (see* sardinus *below) but a barnacle shell, first described by Pliny (XXXVII,* 67, *181,* sagda).

[Sagda], which others call *sardo*, is a stone that is related to planks of wood as magnet is related to iron, and so it clings so tightly to the planks of ships that it cannot be removed except by cutting away the plank to which it clings. In colour it is [green like prase].[5]

SARDINUS

Marbod, X, *Sardius*; Arnold, p. 74, *Sardius*; Bartholomew, XVI, 89, *Sardius*; Thomas, 136r, *Sardius.*

The usual medieval name seems to be sardius, *but Pliny called it* sarda, *'from Sardis' (Nat. Hist. XXXVII,* 31, *105–6). Sard is translucent reddish or yellowish-brown chalcedony, not so red as carnelian (see II, ii, 3,* Corneolus)*; Albert may have included red or brownish-red jasper, which is not translucent.*

Sardinus (sard) has been included since antiquity among precious stones. It is of a thick red colour, but somewhat translucent, as if red earth were imagined [to have] some transparency. And there are five varieties, based on the different degrees of transparency in each. And perhaps this is the

[4] *Syrtis* also referred to banks off the coast of North Africa in the Gulf of Sidra; but gemstones are sometimes found in alluvial deposits, and rumours of the gem gravels of India may have reinforced the (mistaken) identification of *syrtitis* and *saphirus*.

[5] *purissimum nitens*, 'very pure and shining': but (ed. 1518) *prasinus hoc est virens* must be correct, since all other accounts say it is green.

matrix of other [stones], and the 'house'[6] in which they are produced. It is reported to have been found formerly near the city of Sardis, and therefore it is so named. And they say that it arouses the soul to joy and sharpens the wits; and by its counteracting powers it restrains onyx from doing harm.

SARDONYX

Marbod, VIII, *Sardonyx*; Arnold, p. 74, *Sardonycem*; Bartholomew, XVI, 90, *Sardonix*; Thomas, 135v–136r, *Sardonix*.

Sardonyx, as the name indicates, is onyx in which there are red layers of sard or carnelian (Pliny, XXXVII, 23, 86–89). But the statement that sard has an effect contrary to that of onyx comes from Costa ben Luca Letter on Incantations *(Constantine,* Opera, p. 319), *and is a quotation from the* Lapidary of Aristotle.

Sardonyx, which some call *sardonycem*, is composed of two stones, namely sard and onyx. Therefore it is red, and this colour predominates in it because of the sard; and it is also white and black and the colour of the fingernail, which it gets from the onyx. The kind that is more admired has these colours in distinct layers, and is somewhat more compact in substance. There are found five varieties, and perhaps more, based on different mixtures of colour and different compactness. [Sardonyx] is frequently found in India and Arabia. It is said to drive out licentiousness and to make a man chaste and modest. But its greatest power is due to the fact that, although there is onyx in it, it cannot do any harm because it has sard combined with its substance.

[SAMIUS]

The printed text has Sarmius, *and* Sarmia *for the island; but Thomas (136r) has the correct* samius, *the 'Samian' stone from the island of Samos, described by Pliny (XXXVI, 40, 152–3). It is probably compacted chalk or white clay, which in softer form was called 'Samian earth' (Pliny, XXXV, 53, 191).*

[Samius] is a stone named from the island of [Samos], where it is found. Gold is polished with this stone. It is also said that, taken in drink, it cures dizziness and settles the mind; but it is said to have this disadvantage, that if it is bound to the hand of woman in childbirth, it hinders the birth and keeps it back in the womb.

[6] See II, ii, 14, *Prassius*, note 3.

SILENITES

Marbod, XXVI, *Silenites*; Arnold, p. 75, *Sylenites*; Bartholomew, XVI, 92, *Silenites*; Thomas, 136v, *Synolites*.

Selenites *was named from the Greek* selene, *'moon' stone (Pliny, XXXVII, 67, 181). Today the name selenite is used for transparent crystals of gypsum (see* Specularis *below), and our 'moonstone' is chatoyant or iridescent feldspar. The original 'stone of the moon' may have been either of these, or it may have been some other chatoyant gem, such as cat's-eye or opal. But Damigeron (XLV) says the stone is 'like jasper', which Marbod interprets as green (see II, ii, 8,* Jaspis*). Albert's account here closely follows Thomas's, which differs from others in combining some items from* celontes *(II, ii, 3) with some from* silenites *(as given in other lapidaries). But Albert seems to feel some uncertainty about the actual properties of this stone.*

Silenites (stone of the moon) is a stone of which there are varying reports. For some people say that it occurs in a certain kind of Indian shellfish, and is of most beautiful varying colours, red, white, and purple.[7] But others say that it is green and is frequently found in parts of Persia. And they also say that it increases with the waxing of the moon and decreases with its waning.[8] They say, too, that wearing it confers a knowledge of future events, if it is carried under the tongue, especially on the first and tenth days of the moon. For they say that on the rising of the new moon it has this power for only one hour; but on the tenth day of the moon, it has this power in the first and sixth hours. The method[9] of divination is this: putting it under the tongue, one should think about whether some matter ought to be undertaken or not; if it should be, the heart is seized with a firm conviction that cannot be shaken off; but if it should not be, the heart immediately recoils from it.[10] It is reported, too, that it cures languid and feeble consumptives.

SMARAGDUS

Marbod, VII, *Smaragdus*; Arnold, p. 75, *Smaragdus*; Bartholomew, XVI, 88, *Smaragdus*; *Thomas*, 135v, *Smaragdus*.

The smaragdus *of antiquity (Theophrastus,* On Stones, *23–27) included so many green stones that its translation is very uncertain. The word has come down to us in the form 'emerald', which now means a transparent, deep-green beryl; and this was*

[7] Thus far, the description is that of *celontes* (II, ii, 3), but what immediately follows is *silenites*, according to other lapidaries.

[8] What follows is again *celontes*, though the days of the moon differ in different versions.

[9] These directions are found only in Thomas.

[10] This is the end of *celontes*; the remainder is ascribed to *silenites* in other lapidaries.

certainly one of the stones described by Pliny (XXXVII, 16–19, 62–75) and included here. Others were green minerals described elsewhere under other names (see II, ii, 8, Hyacinthus, Jaspis; *11,* Melochites). *Still others were rocks—green marble, alabaster, or serpentine; or even green glass. The story about the griffins comes from Pliny (VII, 2, 10), who tells it not about emeralds but about gold, which the griffins of Scythia mine, warring with the one-eyed Arimaspians, who try to rob them. But Solinus's geographical plan* (Coll. *XV, 22–27) juxtaposed Scythian griffins and Scythian* smaragdus, *and so the two became linked in later accounts.*

Smaragdus is a stone more precious than many others, and it is not rare. Its colour is very green and translucent, so that it seems to tinge the air around it with its own greenness. The best shape for it is smooth on the surface, for then one part does not cast a shadow on another part. And the best do not change [colour] in light and shade. They say that there are twelve varieties, depending on differences in their smoothness and colour; for sometimes it has a kind of black gall,[11] like little rods in it. Some varieties are named from their places of origin—those of Scythia, or of Britain,[12] and of the Nile; and [then there are] those that occur in veins of copper; and some that are spotted; and some [called] 'Chalcedonian',[13] containing a mixture of that stone [chalcedony]. The best of all are those of Scythia. It is reported that they are taken from the nests of griffins, which guard this stone with great ferocity. And a traveller from Greece[14], a truthful man and a careful observer, has said that this stone occurs in submarine ledges of rock, and that it is frequently found there. A reasonable explanation is that it occurs in veins of copper, and is transparent because it has not yet actually become copper;[15] for the 'rust' of copper [i.e. verdigris] is green. It has been found by experience in our own time that this stone, if it is good and genuine, will not endure sexual intercourse: because the present King of Hungary[16] wore this stone on his finger when

[11] *fel*: Pliny (loc. cit.) enumerating the flaws of *smaragdus*, speaks of *fellis color*, 'a too-yellow colour', but also of *sal*, 'salt', i.e. little granules. And *sal* (not *fel*) is also in Solinus (loc. cit.) and Isidore (*Etym.* XVI, 7, 1–3), so it may be the correct reading here.

[12] *Britannici* may be a corruption of *Bactriani*, 'from Bactria', in other lapidaries; but possibly Albert knew of some green stone from Britain (Cornish serpentine?) which he called *smaragdus*.

[13] Pliny mentions *smaragdus* 'from Chalcedon'; but Albert may be alluding again to the theory that an inferior stone can develop into a more precious one (see II, ii, 14, *Prassius*).

[14] Green copper minerals occur with silver ores at Laurium in Attica; and Cyprus was an ancient centre of copper mining.

[15] See Book III for further discussion of Albert's theory that many minerals found in ore deposits are 'on the way' to becoming metals.

[16] If Albert had named this King of

he had intercourse with his wife, and as a result it was broken into three pieces. And therefore what they say [of this stone] is probable—that it inclines the wearer towards chastity. They say, too, that it increases wealth, and confers persuasive speech in [pleading] causes; and suspended from the neck, cures hemitertian fever and epilepsy.[17] And it has been found by experience to strengthen weak sight and to preserve the eyes. They say also that it improves the memory, and averts tempests, and is good for divination; and therefore it is sought after by magicians.

SPECULARIS

This is in Thomas (136v), and is described by Pliny (XXXVI, 45, 160–2). The name, from Latin speculum, *'a mirror', includes a number of minerals capable of being split into thin shining cleavage plates. The kind used for window panes is either selenite (large crystals of gypsum) or muscovite mica (the name 'muscovy glass' was first used by English travellers who saw mica so used in sixteenth-century Russia).*

Specularis (mirrorstone) is so called because it is transparent like glass. It is said to have been found first near the city of Segovia in Spain. I myself have seen it found in such quantities that carts were filled with it, in various parts of Teutonia.[18] I have also seen it found in France along with gypsum[19]: for it seems to be the purest [form] of gypsum. It is quarried and split into pieces as thin as desired, and windows are made of it, just as of glass, except that, in place of the leads, light pieces of fir wood should be used. There seem to be three varieties of this: one is clear as glass; and another as black as ink;[20] and the third is yellow, which they call *auripigmentum* (orpiment) or *arsenicum*,[21] as we have said above; and this is more valuable and noble.

Hungary, it might have helped us to date the *Book of Minerals*. Probably he was Bela IV, who reigned 1235–70.

[17] From Costa ben Luca's *Letter on Incantations* (Constantine *Opera*, pp. 318–19), quoting the *Lapidary of Aristotle*.

[18] Selenite occurs in several places in Teutonia that Albert might have visited, notably at Eisleben in Saxony. Muscovite is found in large plates (in pegmatite) near Salzburg in Austria and at Zillerthal in the Tyrol.

[19] This is selenite, probably from the quarries of Montmarte near Paris; most of that deposit, however, is massive granular gypsum, which was burnt to make 'plaster of Paris'. In Theophrastus, Vitruvius, and Pliny, *gypsum* seems generally to mean this burnt material, used for plaster; but Albert uses it as we do, for the 'raw' mineral.

[20] Biotite mica is shining black to bronzy brown; thin plates, are translucent brown to yellow.

[21] Orpiment is bright yellow and fissile (see II, ii, 6, *falcones*; V, 6, *arsenicum*).

[SUCCINUS]

Marbod, ——; Arnold, ——; Bartholomew, XVI, 38, *Electrum*; Thomas, 136r–136v; *Succinus, Electrum, Lambra.*

The printed heading, Suetinus, *is obviously an error, since the derivation from* succus, *Latin 'juice, sap', is given just below. This is amber, which was well known, but is described in some lapidaries as* lincurius (*see II, ii, 10,* Ligurius). *The Greek name was* electron, *Latin* electrum. *The account of its origin come originally from Pliny (XXXVII, 11–12, 30–51), who says it is the gum of a species of pine; but he did not know that the tree is extinct and the gum fossilized. Insects in amber are mentioned in* Meteor. *IV, 10, 388 b 18 ff., and Albert amplifies this in his own* Meteora *(IV, iv, 3):*

Electrum *is a kind of gum, and* electrum *and all kinds of 'tears' distilled from trees finally grow firm and solidify by cooling. . . . Evidence that 'tears' and resins solidify in this way is that animals, such as ants and flies, first falling into the 'tear' when it is soft and thinly spread out, are caught in its stickiness and held fast; and then more 'tears' flowing out cover them over in the gum of the tree. And they can be seen inside because of the transparency of the gum; and their bodies do not decay because the cold that solidifies the gum keeps the natural heat of the animals from escaping; and so their natural moisture is preserved and they stay as they are, without decaying.*

The most famous locality for amber was the Baltic coast of east Prussia, which Albert may have visited as Prior Provincial of his Order in 1255, or as Preacher of the Crusade in 1263.

[Succinus] (amber) is a stone of a yellow colour, which the Greeks call [*electrum*].[22] Sometimes it is found as transparent as glass. The name comes from the material, for it is made of the juice (*succus*) or gum of a tree called pine. A popular name for it is [*lambra*].[23] If rubbed it attracts leaves, straws, and threads, as the magnet [attracts] iron. They say that it makes those that wear it chaste. Experience shows that if burnt it drives away serpents;[24] and it helps pregnant women to an easy birth. The better kind is formed from the juice that runs out in the hot summer; the darker kind, from the juice of the other [seasons].[25]

[22] *eliciam*: but Thomas has *electrum*, and his whole account is so similar to Albert's that I have used it for corrections.

[23] *lubra*: but Thomas, *lambra*. The origin of our word 'amber' is said to be Arabic *el ambari*, which may, however, refer to ambergris, obtained from whales and used in perfumes.

[24] This seems to be a confusion with jet (II, ii, 7, *Gagates*), but it is also in Thomas.

[25] *corporis*: but Thomas, *temporis*.

SYRUS

This is in Thomas (136r) and is derived from Pliny (XXXVI, 26, 130) by way of Isidore (Etym. *XVI, 4, 10). It is pumice from the island of Syros (modern Syra), perhaps washed up there after volcanic outbursts at Thera. Isidore is responsible for turning it into a 'Syrian' stone. The final sentence has been added by Albert.*

Syrus is a stone from Syria, according to Isidore, which floats when it is whole and [sinks][26] when broken into bits. Surely the reason for this is that when it is whole, the pores contain Air, which escapes from the powder of the broken stone.

CHAPTER 18: THOSE BEGINNING WITH THE LETTER T

TOPASION

Marbod, XIII, *Topazion*; Arnold, p. 75, *Topazion*; Bartholomew, XVI, 96, *Topazius*; Thomas, 136v–137r, *Topazius.*

This is another name that changed its meaning in the Middle Ages, and the inconsistencies in Albert's references to it, here and elsewhere, show that in his time it was applied to three different stones: (1) Originally, in Pliny (XXXVII, 32, 107–9), topazos *was a green stone from an island,* Topazos *(now St. John's), in the Red Sea. This was olivine, and Pliny's two varieties,* prasoides *('like a leek') and* chrysopteron *('golden wing') were dark green peridot and yellow-green chrysolite respectively (see II, ii, 3 ,*Chrysolitus*). (2) Later writers continued to mention two kinds, but emphasized the 'golden' one, until the name came to mean a transparent yellow or orange stone, our topaz; other yellow stones were included, especially citrine quartz, which even today sometimes masquerades as topaz. (3) But in the source used by Arnold and Bartholomew (who names it as 'Dyascorides')* topasion *is confused with another stone that causes water to stop boiling and reflects objects like a concave mirror—that is,* hephaestites *(see II, ii, 5,* Epistrites*). Albert seems to accept the last interpretation.*

Topasion is a stone named from the place of its first discovery, which is said to have been an island [called] *Topasis*. It presents a certain similarity to gold. There are two varieties of these stones. One of them is entirely similar to gold, and this is more precious. The other is yellow, but more transparent[1] than the colour of gold, and this is less valuable. It has been

26 *fluctuat*, 'floats', but the sense requires *mergitur* as in Thomas, Isidore, and Pliny.

*

1 *magis tenuis*, literally 'thinner'. If Albert means opaque marcasite, this does have a paler, more silvery, colour than gold. But perhaps 'thinner' means 'more transparent' (as *crassus* or *spissus*, 'thick' is used for opaque colours), and if so, *topasion* is, at least in part, topaz.

found by experience in our own time that if it is put into boiling water it makes the water stop bubbling, so that soon[2] the hand can be put in, to take it out; and a member of our Order actually did this at Paris.[3] They also say that it is a remedy for haemorrhoids and for attacks of lunacy[4]. And it is certain that this stone is a mirror and reflects the image of an object [inverted][5] as a concave mirror does. And the reason for this is merely that it has grown together on the inside and hardened so that the surface is concave.

TURCHOIS

Marbod, ——; Arnold, p. 75, *Turcoys*; Bartholomew, XVI, 97, *Turchogis, Turkois*; Thomas, ——.

Turquoise received its name only in the Middle Ages, when it was imported 'from the Turks'; but it was probably described by earlier writers under other names.

Turchois (turquoise) is a stone of a brightly shining blue colour, as if milk had penetrated the blue colour and risen to the surface through it. They say that it preserves the sight and protects the wearer from misfortunes.

CHAPTER 19: THOSE BEGINNING WITH THE LETTER V

VARACH

This is only in Arnold (p. 75). The name 'dragon's blood' goes back to Pliny's story (XXXIII, 38, 116) that certain red earthy pigments are the blood spilled in combats between elephants and large snakes (dracones). *Albert's account here is essentially the same as Arnold's, but the description of the red powder seems to be his own. The mineral is either red ochre or cinnabar.*

Varach, which is called 'dragon's blood' (*sanguis draconis*), is a stone,

[2] *statim*, in classical Latin 'immediately;' in late Latin 'afterwards'.

[3] This is evidence that the statements of 'authorities' were sometimes tested. Any cold stone would, of course, stop the boiling, but the water would still be painfully hot, unless *statim* (note 2 above) is rather liberally interpreted.

[4] *lunaticam passionem*. This rests on an old misunderstanding: Pliny says *topazos* 'feels the file' (*limam sentit*), that is, it can be scratched by steel; this is true of olivine, which is softer than most precious stones. But Marbod, through some miscopying or misreading of the text, says 'it is thought to feel the *moon*' (*lunam sentire putatur*), and this, of course, connects it with other 'moon stones' and with lunacy, supposed to be influenced by the moon.

[5] *convexum*: but in Arnold and Bartholomew, *inversum*.

according to Aristotle.[1] But some medical men[2] say that it is the juice of a certain plant. But [Aristotle's] statement is proved correct by [the appearance of] the powder, for its surface is shining and rough, like stone broken into little pieces. And it is extremely red. It is a remedy for any sort of flux, especially of blood. From this and quicksilver, *algala* is made.[3]

VERNIX

Marbod, ——; Arnold, p. 75; *Vernix*; Bartholomew, ——; Thomas, 137r, (*V*)*ernix*.

Arnold, like Albert, gives the synonym lapis armenicus, *which may be the same as* bolus armenicus (*II, ii,* 16, ramai). *Thomas gives* lapis aromaticus, *which might be an incense gum.*

Vernix is also called 'Armenian stone'. It is of a palish colour, and is a sure remedy against black bile, and against disorders of the spleen and liver, and against heart attacks.

VIRITES

Only Arnold (p. 75) has this form of the name, which may be merely a limner's error in inserting the initial in (P)irites *or may be a confusion with* viridis, *'green', since Albert mentions a green stone* (peridonius) *in his duplicate account of this* (*II, ii, 14,* Perithe).

Virites (pyrite) is the gem that we have called [*perithe*][4] above. Its colour is brilliant like fire, as we have said before. It should be touched lightly and cautiously, or it burns the hand of anyone who touches it. For indeed an animal that shines by night sometimes burns the hand, as I myself have often found by experience.[5]

[1] Reference unidentified, but Arnold also cites Aristotle here.

[2] For example, Constantine (*Opera*, p. 378) says 'Dragon's blood comes from trees growing in Persia and Armenia'. This would be the red gum used in varnishes.

[3] A recipe for *algala* is given in the *Book of the Priests* (*Liber sacerdotum*, Berthelot, 1893, Vol. 1, p. 215): 'Of dragon's blood one pennyweight should be mixed with two pennyweights of quicksilver.' Berthelot (op. cit., p. 185) thinks these recipes concern soldering or gilding; so perhaps *algala* is amalgam, used in such work.

[4] *perirites*, evidently referring to *perithe* (II, ii, 14).

[5] *animal noctiluca* may have been a stinging jellyfish.

CHAPTER 20: THOSE BEGINNING WITH THE LETTER Z

ZEMECH

Marbod, ——; Arnold, p. 75, *Zimech*; Bartholomew, XVI, 103, *Zimiech, Lapis lazurii*; Thomas, 137r, *Zunichus, Lapis lazurii.*

This is lapis lazuli, a rock containing several constituents, of which the most conspicuous are bright blue minerals of the sodalite group. It is opaque, ranging in colour from azure to deep greenish and purplish blues; small 'golden' grains of pyrite are commonly present. This was the 'sapphire' of the ancients (see II, ii, 17, Saphirus). *It was imported from the East and was ground for use as a pigment called* azurium *or ultramarine.*

Zemech is the stone [also] called lapis lazuli; in it there is a pale blue colour with small golden specks. The pigment azure (*azurium*) is made from it. It is taken as a sure remedy for black bile and quartan fever, and for fainting caused by the vapours of black bile.

ZIGRITES

Marbod, ——; Arnold, p. 75, *Zignites*; Bartholomew, XVI, 104, *Zingnites*; Thomas, 137r, *Zegnites.*

This is unidentifiable, probably fabulous. The name seems to have been corrupted, and the text used by Arnold, Thomas, and Bartholomew (who calls it 'Dyascorides') is defective. Damigeron (XXX) has a lignites *(perhaps originally* lychnites, *Greek 'a lamp') said to be glassy, to protect against night terrors, and, if the house should catch fire, to put the fire out. A verse paraphrase of this, dubiously attributed to Marbod (Migne,* P.L., *Vol. 171, col. 1779) calls the stone* ignites, *perhaps because of its effect on fire (Latin* ignis), *perhaps just by loss of the initial letter. Since coloured initials were put in after the text was written, sometimes by a different scribe, such mistakes are not uncommon. And, indeed, the Z in Albert's source may have been introduced in this way: if this stood at the end of a list, either because it was spelled* Ygnites *or because it was inserted as an afterthought, the limner may have supposed it was to be supplied with a Z. Albert's version is much poorer than the others, so shrunken as to be hardly recognizable.*

Zigrites is a stone of the colour of glass; and by another name it is called *evax*.[1] It is said that, worn around the neck, it reduces bleeding and dispels delirium.

[1] *evax*: Arnold and Thomas, *idem est quod euas*. This seems to be the old French word *euage* or *ewus* (Studer and Evans, 1924, Glossary, p. 398) meaning 'watery'—a gloss on *coloris vitri*, 'the colour of glass'.

Enough has now been said about individual stones. For if we wished to speak individually about the power of every stone whatsoever, we should exceed the limits of this volume. But as we have said at the beginning, if anyone wished to experiment, he would find that there is hardly any little stone that does not have some power or other. But by what has been said here it is easy to judge all the rest.

TRACTATE iii
THE SIGILS OF STONES: HOW THEY ARE TO BE DISCUSSED, HOW MANY KINDS THERE ARE, AND WHAT IS KNOWN OF THEM BY EXPERIENCE

CHAPTER 1: IMAGES AND SIGILS IN STONES

A sigil (sigillum) *is a seal or stamp used for authenticating documents. According to the medieval doctrine of sigils (sometimes called the 'doctrine of signatures'), things in nature are marked with a 'sign' indicating their purpose or use—for instance the shapes or markings of leaves, flowers, or roots, appropriate to their medicinal properties. Stones, too, might show significant colour (e.g. 'blood' stones) or markings ('picture' agates). But there were also artificial sigils, carved or engraved on stones to enhance their effects; this practice is mentioned by Pliny and Damigeron. All this is a kind of 'natural magic', and Albert is at pains to reassure his readers that it is 'good doctrine', that is, not against the Christian faith.*

Albert intends to distinguish between artificial and natural sigils in stones, and this first chapter deals with the latter. His classification of them shows keen observation. Geologists of today can recognize his three types as (1) 'pictures' formed by irregularly distributed colouring matter, especially oxides of iron and manganese, as in 'moss' agates, &c.; (2) fossils half embedded in the rock, or mineral replacements or casts of shells, &c.; and (3) fossil moulds and impressions. But the following chapters show that Albert included in the last two categories some antique cameos and intaglios, not realizing that they were man-made.

Now we must speak of the images and sigils in stones; for although this [subject] belongs to that part of necromancy which is dependent on astrology, and is called the necromancy of images and sigils, yet, because it is good doctrine, and because the members of our Order have desired to learn this from us, we shall say something here—though rejecting all incomplete and false statements—about whatever has been written of these things by many people. Few really understand the writings of the wise men of antiquity about the sigils of stones, nor is it possible to understand them without at the same time understanding the sciences of astrology and magic and necromancy.

Beginning, therefore, with the images on stones, we say that there are three kinds of images found on stones. One of these is an image on the stone neither incised nor projecting, but as if painted upon it by differences in colour, like a picture. The second [kind] is projecting, as if embossed upon the stone. The third kind is incised, hollowed out as if parts of the stone were filed away, leaving other parts untouched. Furthermore, in the images that are painted, sometimes the image is of the same colour as the stone, and then it is visible only as a sort of outline on the surface of the stone; and sometimes the image has a colour entirely different from the colour of the stone. These two sorts of colouring are [also seen] in the images that project from the surface of the stone.

I wish first to report what I myself have seen and observed; and then to explain the cause and the process by which the image is formed by nature; and third, to speak of images made by art, and to explain the powers of sigils.

I say, then, that when I was at Venice, as a young man,[1] marble was being cut with saws to decorate the walls of a church. And it happened that when one [piece of] marble had been cut in two and the cut slabs were placed side by side, there appeared a most beautiful picture of a king's head with a crown and a long beard. The picture did not seem to have any fault at all except one—the middle of the forehead seemed too high, extending up towards the top of the head. And all of us who were there understood that this picture had been made in the stone by nature. And when I was asked the reason for the disproportion of the forehead, I said that the stone had been hardened from a vapour, and in the middle the vapour had risen up too far because the heat was greater there. This picture was of the same colour as the stone. There is something of the same sort in clouds when they are not disturbed by winds, and all sorts of figures appear in them and continually melt away because of the heat that raises them. But if these vapours were subjected to the influence of a place and a [mineralizing] power, they would fashion many figures in stones. This, therefore, is clear [evidence] that the shape of a simple picture is sometimes [made] by nature.

A long time afterwards, when I was at Paris, in the number and company of scholars, it happened that the son of the King of Castile[2] came to study there. And when the cooks of this nobleman wanted to buy fish,

[1] Probably in 1222–3, when Albert experienced the earthquakes he describes in his *Meteora*, III, ii, 9.

[2] Albert was at the University of Paris from about 1245 to 1248. This prince, so interested in natural curiosities, may have been Alphonso X, El Sabio, 'The Learned' (reigned 1252–82). The Alphonsine Tables were compiled under his patronage, and a famous lapidary was made for him (Evans, 1922, pp. 38–50).

his servants bought a fish which in Latin is called *peccet*, and in the vernacular plaice,[3] for this kind was extremely plentiful. And when they gutted it, they discovered in its belly the shell of a large oyster, which this same nobleman kindly caused to be presented to me. The shell, on its concave side, which was smooth and shining, had the figures of three serpents[4] with their mouths uplifted, so perfectly represented that not even the eyes were missing, although they were very small. And on the convex outer side, which was rough, it had the figures of many—ten or more—serpents similarly represented in all details, except that all those on the outside seemed to be joined together in a sort of knot at the neck, but their heads and bodies were separate. And every one of these images had an opening beginning at the serpent's mouth and extending down to its tail; and the opening was so small that it seemed to have been made by a thread. This shell I kept for a long time, and I showed it to many people, and later I sent it as a gift to someone in Teutonia. This experience, therefore, proves that even figures projecting from [the surface of] stones are sometimes made by nature.

And a certain powerful nobleman has told me that once one of his peasants presented to him an egg, smaller in size than a hen's egg; and inside it, with its body curled up like a chick, was a fine figure of a serpent with a crest and wings; and its feet were shaped like those of a fowl.[5] And all these examples [lead to] the judgement that such forms are sometimes shaped by nature. And this I firmly believe to be the truth.

[3] *peccet, vulgariter pleis.* Albert also mentions this fish (*Animals*, I, i, 7) as *pecten quod pleidis vocamus.* It seems to be the flatfish that Alexander Neckam (*De naturis rerum*, XL; Wright, p. 152) calls *pecten* (comb), 'because its bones are arranged like the teeth of a comb for parting the hair'. Pliny (IX, *51*, 101), like more modern naturalists, used *pecten* for the scallop shell.

[4] Tubes of serpulid worms attached to the shell.

[5] This was no doubt a concretion enclosing a fossil—but what kind of fossil is impossible to guess, since Albert's informant seems to have been influenced by tales of the cockatrice or basilisk hatched from a cock's egg (cf. II, ii, 1, Alecterius). Albert believed (on the authority of ancient writers) that the basilisk might exist, but he rejected this story of its origin, and suspected that the basilisk of the alchemists was merely a 'cover name': (*Animals*, XXIII, 45): As to the statement that a feeble old cock lays an egg and places it in dung; and that the egg has no shell but only a skin so hard that it resists the hardest blows; and that the heat of the sun hatches it into a basilisk, which is a serpent just like a cock in every way except that it has the long tail of a serpent—I do not believe this is true. But Hermes says so, and many people accept it on his authority. (*Animals*, XXV, 13): And Hermes says that if the ashes of a basilisk are smeared on silver, it takes on the weight and denseness of gold. . . . Some say that the basilisk is produced from a cock's egg; but this is completely untrue and impossible. And as for Hermes's teaching that the basilisk is produced in a glass vessel (*in vitro*)—this does not mean a real basilisk but some alchemical *elixir* for transmuting metals.

CHAPTER 2: FIGURES IN STONES MADE BY NATURE

The interest of this chapter is two-fold. First, there is the great cameo once at Cologne. This was, I believe, the gem known as the Ptolemy cameo, now in the Kunsthistorisches Museum in Vienna [Plate I] (see also Furtwängler, Vol. I, Plate LIII, Vol. II, LIII; Eichler, Vol. II, pp. 47–48, Plate I at p. 146; Richter, Vol. III, pp. 254 ff., Fig. 1709). The similarities are here listed in the order of Albert's description: (1) The Ptolemy cameo is made of onyx *(sardonyx). (2) Its* size *is 11.5 × 11.3 cm. (3) It shows* two heads in profile, one behind the other*—not, however, two young men but a man and a woman. (4) These are* white *on a darker ground. (5) There is a* dark serpent *on the man's helmet—it does not connect the two heads. (6)* On the angle of the jaw *is the long cheek-guard of the man's helmet—but the figure on this is a winged thunderbolt. (7) The* Ethiopian with a beard *(Ammon with ram's horns) is on the neckguard of the helmet. (8) The man's* neck *is covered at the bottom by a darker collar. (9) The* cloth and flowers *seem to be the veil and lotusbud ornament of the woman's headdress. (10) But it is the crest and plumes of the man's helmet that form a sort of border half-way* enclosing the heads. *These similarities can hardly be due to coincidence; and the discrepancies suggest that Albert was writing from memory.*

The history of the Ptolemy cameo is obscure. The portraits have been tentatively identified as various Ptolemies and their consorts, or as Alexander the Great and his mother, Olympias. If it is really a Hellenistic gem, it has been re-worked. But Dr. D. B. Thompson (personal communication) thinks that the style indicates work of the Imperial Roman period; she has also called my attention (while this chapter was in proof) to an earlier identification of this gem as the Cologne cameo (Möbius, 1964, p. 17).

The golden shrine of the Three Kings is still in Cologne Cathedral, but the cameo described by Albert is gone, replaced by a large citrine. Perhaps it was still there in the sixteenth century, when it was described by Agricola (De natura fossilium, *Book VI); but one cannot be sure, because Agricola was obviously quoting this chapter of Albert's. I have been unable to obtain from the Cathedral Chapter at Cologne any further information about the history of the missing gem.*

The second point of interest is Albert's conviction that these figures are natural and not artificial. The ensuing discussion reveals Albert's ignorance of gem-cutting. Considering his great interest in technical processes, we must conclude that this was a lost art in his time, at least in northern Europe.

LET us therefore inquire how these are formed by nature. And let us call

I. The 'Ptolemy' Cameo

to mind what we have decided in the second book of our *Physics*,[1] in speaking of monsters. For we are not unaware that there are certain places in the heavens such that, if the luminaries meet together there, they prevent the human shape from being produced, even in material well suited [for the purpose]; and then the material grows together into a horrible monster. On the other hand, sometimes the luminaries and the other planets meet together in a place that has such great power for producing human beings that it impresses a human form even upon seed of an entirely different kind, and in opposition to the formative power inherent in that seed; and thus it sometimes happens that pigs have human faces, and calves likewise. That this cannot be the result of the mixture of human seed with that of these animals has already been sufficiently demonstrated in our *Physics*. This, then, and nothing else, is the reason why, even in stones hardened by vapours, there is impressed upon the material the shape of a man or that of some other species that nature produces, either by painting, or by making it partly or wholly in relief. And this effect is especially common in onyx (*onychinus*),[2] because of the greater softness of its material, as we have already said.

For there is at Cologne, in the shrine of the Three Kings,[3] an onyx of large size [Plate I], having the breadth of a man's hand or more; and on it, upon the material of the onyx stone, which is like a fingernail [in colour], are pictured in pure white the heads of two young men; one [profile] is behind the other, but the nose and mouth project enough to be seen. And on the foreheads is pictured a very black serpent which connects the heads. And on the jaw of one of them, just on the angle of the curve of the jawbone, between the part that comes down from the head and that which is bent towards the mouth, is the head of an Ethiopian, very black, with a long beard. And below on the neck there is again stone having the colour of a fingernail. And there seems to be a cloth decorated with flowers around the heads. I have proved that this is not glass but stone; and therefore I have assumed that this picture was made naturally and not artificially. Many others like this are found.

Nevertheless it is no secret that such images are sometimes made

[1] See II, i, 4, note 8.

[2] See II, ii, 13, *Onycha*.

[3] The Magi or Wise Men came to worship the Christ Child at Bethlehem (Matt. ii. 1–12). According to medieval legend, their relics were brought from the East to Constantinople by the Empress Helena in the fourth century; later they were taken to Milan and, after that city was conquered by Emperor Frederick Barbarossa, in 1158 they were transferred to Cologne.

artificially, by two methods.[4] One of these is [a method] in which both art and nature are employed: for the material is artificially shaped and coloured, and afterwards the whole thing is placed in water that has a strong [natural] mineralizing or petrifying force; and by this it is hardened into stone, as we have already said. The second method is more deceitful, in that images are shaped in the material by means of stamps (*sigilla*) and the figures are variously coloured, and afterwards hardened into the likeness of stone by an alchemical operation using an [artificial] hardening water or other liquid. This is chiefly done by means of what the alchemists call 'virgin's milk' (*lac virginis*),[5] which is made when litharge is thoroughly washed in water and repeatedly strained through it, until it is like 'tears',[6] and two waters are mixed together. This water is very certain in its hardening effect and whatever is hardened by it will look like stone. Materials are hardened by many other methods, so that they look like stone although they are [found] not [to be], if anyone makes an accurate test by means of a [file].[7] And sometimes colours of this sort are made in mere glass, and likewise images; and the ignorant common

[4] The distinction is that in the first procedure the 'hardening water' is natural, that of a 'petrifying' spring (as described in I, i, 7), and in the second some artificial chemical solution is used.

[5] This account of *lac virginis* is incomplete. Essentially it required two clear liquids which on being mixed together became 'milky' by forming a white precipitate. A typical recipe (quoted by Holmyard and Mandeville, 1927, p. 21) combined lead acetate (litharge dissolved in vinegar) with potassium carbonate (wood ashes leached in water) to give a precipitate of lead carbonate—'quickly producing milk and a little later changing into cheese'. In another account of *lac virginis* (*digressio* in *The Senses*, ii, 2) Albert describes two liquids: one is made by dissolving litharge in vinegar, the other is white of egg (*albumen*). One might suspect that *albumen* is an error for alum (*alumen*, see V, 4), which would give a precipitate of lead sulphate, were it not that this passage is immediately followed by some remarks about the effect of heat on egg-white; so there can be no doubt that Albert wrote *albumen*. He seems here to have extended the term *lac virginis* (without, so far as I know, any alchemical authority) to a different combination (see note 6 below).

[6] *lachryma*, something in 'drops', like incense gum or amber (cf. II, ii, 17, *Succinus*) but the term does not seem appropriate to the precipitate from *lac virginis*. Here, I believe, it must indicate a gummy or sticky compound from which imitation gems were shaped, and which later hardened. Actual recipes of this type were collected by Mrs. Merrifield (Vol. II, pp. 506–21): 'To make stones for rings, that is to say, precious gems clear and of a fine colour', 'To make amber beads', &c. The ingredients include boiled linseed oil, gum, or egg-white, mixed with alum or other sulphate, vinegar, and colouring matter. The 'hardening water' is the alum or sulphate solution.

[7] *per lunam tentaverit*, an obvious error for *per limam*; 'testing by the file' is a good way of distinguishing the silica minerals, from which most carved gems are made (harder than steel), from glass or artificial compounds such as those mentioned in the preceding note (much softer than steel).

people think that they are stone. And this is how images are artificially made, painted, or incised, or embossed.

But as for those that seem to be made by the art of engraving, I do not understand how they are made, except that it is by some artificial and not natural method. Those, however, who write about gems say that work on very hard gems is done with fragments of *adamas* (diamond or corundum),[8] which are sharp and extremely hard. But I myself do not believe this is true at all. For engraving demands instruments properly adapted [to the purpose]; and this cannot be [the case] with fragments of *adamas*, unless they should be softened with goat's blood.[9] And this would be wasteful and much too costly; for sometimes we see a gem of little value that has been engraved.

But what we have learned by observation we state here:[10] Steel is distilled and repeatedly purified until it has almost the whiteness of silver; and then engravers' tools are formed of it, with suitable sharp points. Then the juice is squeezed out of a radish, and mixed with an equal quantity of water extracted from earthworms which have been crushed and pressed through a cloth. Then the tool, heated white hot, is quenched in this water two or three or more times, or as many times as may be necessary. And it becomes so hard that it scratches gems and cuts any other iron like lead. This, then, is what is stated about the cause of the images that appear on gems.

[8] *per partes admantinas*: Pliny (XXXVII, *15*, 60; *75*, 200) mentions the use of *adamas* for working other stones; but medieval handbooks speak only of sand, brick dust, or (rarely) emery. Perhaps the low state of gem-cutting in Albert's time was partly due to lack of good abrasives.

[9] Cf. II, ii, 1, *Adamas*. Albert's difficulty is that he believes *adamas* to be perfectly irrefrangible except by application of goat's blood. But medieval artisans extended this notion to the carving of gems and even glass, which were 'softened' by the use of the blood, urine, or milk of a goat, according to Heraclius (Merrifield, Vol. I, pp. 186–91, 218–9; Hendrie, pp. 396–7, 402–5). This is a remarkable persistence of the Plinian tradition. But perhaps these substances did serve the useful purpose of keeping the surface moist, so that it was less likely to chip.

[10] Traditional methods for 'softening' stones and glass were also transformed into recipes for 'hardening' the tools—a more practical way of making the work easier. Thus earthworms, recommended by Heraclius (see note 9 above) for 'softening' glass, are here suggested only for tempering steel. Other recipes for this call for goat's fat (Merrifield, Vol. 1, pp. 196–7) and goat's skin or urine (Hendrie, pp. 222–5). It has been said that these organic materials supplied carbon to transform the iron into steel; but more probably they merely affected the surface play of colours, which was the smith's chief guide in judging the condition of the metal. (For additional notes on steel see IV, 8).

But if anyone should inquire, Why are images not found in other stones, but only in gems?—we shall repeat the observation already mentioned: that they do appear sometimes in marble. But they do not appear in other kinds of stone because the material in them is heavy, gross, and earthy, and does not respond to the moving powers; and therefore heaven cannot move it and make an impression on it. But in precious stones and certain marbles, as we have already said, the material is vaporous, and therefore images of this sort are produced in these [stones]. An example of this is seen in the seminal vapours,[11] in which images easily form, but nevertheless they may not be impressed upon the substance of brain or head or bone; for disorder and unwieldiness in the material can hinder the action of the heavenly bodies, as we have said in earlier [chapters]. It is as if a stamp (*sigillum*) were pressed upon hard earth or stone, leaving no imprint at all; but if pressed upon water, it makes an imprint, and if the water freezes, then the figure persists in the ice. These things are not pure natural science, but because they are good doctrine, they are included here.

CHAPTER 3: THE REASON WHY THE CARVING OF GEMS WAS ORIGINALLY RECOMMENDED, AND WHAT HELP THERE IS IN THE SIGILS THEMSELVES

Most of the authorities cited at the beginning of this chapter are also mentioned in the Mirror of Astronomy, *and notes on them will be found in Appendix C, 4. One difficult problem always involved in discussions of astrology is that of Free Will and Fate. Albert touches on this briefly here, and at greater length in his* Summa (*I, 68*).

NOW let us determine the reason why the carving of gems was originally recommended by wise men, and what help there is in the sigils themselves. We must learn the reason for this from the science of the magicians, which was perfected in the first place by Magor of Greece and Germa of Babylon and Hermes of Egypt; later on, it was wonderfully illuminated by the wise Ptolemy and by Geber of Seville; and Thebit [ben Corat] has given a full account of the art.

The principle of this science is that all things whatsoever, whether made

[11] Cf. I, i, 5.

by nature or by art, receive their impulse in the first place from the powers of heaven. In nature there is no doubt of this. But even in art it is recognized, because some [impulse], at the right time and not before, incites the heart of a man to make [something]. And this [impulse] can only be the power of heaven as the above-mentioned wise men say. For there is in man a two-fold principle of action, namely nature and will. And nature is controlled by the stars; but the will is free. But unless it resists, the will is drawn along by nature and becomes less flexible (*induratur*); and when nature is moved by the motions of the stars, then the will also begins to be influenced by the motions and configurations of the stars.

Plato[1] proves this from the behaviour of children who by their own free will do not resist nature and the influence of the stars. For by the power of the stars they show an aptitude for one art or another, and if they practise this, they become perfect; but if they resist it and practise some other [art], they never reach perfection, because by nature they have no aptitude for it. And we do not doubt that everything which is somehow the cause of a cause is also somehow the cause of whatever results. If, then, the force and inspiration of the stars pour some influence causing art into the artisan, surely nothing prevents their pouring something of their own power into all works made by art.

Having settled these [points], we accept from the above-mentioned philosophers the principle—which must be proved elsewhere—that the configurations of the heavens are the primary figures, having precedence over the figures of all things made by nature and by art. For that which is first in kind and order among productive powers undoubtedly pours its causal influence into everything that comes after, in a manner suitable to each [thing]. For we do not intend here to treat these configurations as they are considered mathematically, but only in so far as they bring about the variety of things that produce and are produced, in order and species, and in the nature of their form and material. And thus the configuration of heaven will have a causal influence on every figure produced by nature —for the origin of art, as we have said, is also nature, because [art] arises

[1] What follows seems to be derived from the pseudo-Aristotelian *Secrets of Secrets* (see Appendix A, 12). It is not there ascribed to Plato, though Plato is mentioned as an astronomer (or astrologer). The story tells how two boys, whose characters were foretold by astrology at birth, developed in spite of parental discipline, so that a weaver's son became a high official, and a king's son became an artisan, as the astrologers had foretold (Steele, *Secret of Secrets*, Roger Bacon's text, pp. 60, 136–7, 233–4).

from its own heavenly origin, which is the Active Intelligence; for Intelligence is the origin of art, as we have often said in *The Heavens* and in the *Physics*.[2]

Therefore we must conclude that if a figure is impressed upon matter, either by nature or by art, [with due regard to][3] the configuration of heaven, some force of that configuration is poured into the work of nature or of art. And this is the reason why wise Ptolemy recommends that all actions, comings and goings, and even the putting on and taking off of clothing,[4] be performed [with due regard to] the configuration of heaven. And therefore, too, in the science of geomancy[5] it is recommended that the figures made up of points be reduced to those [of constellations]; for otherwise they are of no use. And therefore also in considering the craft of making gems and metallic images[6] in the likeness of the stars, the first teachers and professors of natural science recommended that the carving be done at duly observed times, when the heavenly force is thought to influence the image most strongly, as for instance when many heavenly powers combine in it. And they worked wonders by means of such images.

But the heavenly images are helped by many [things]. Nevertheless, there are five things that are especially to be regarded. [The first of these is] the image of the starless sphere, because this circle imparts motion to the constellations and to life. Second, help comes from the constellations, which must be properly observed. And third, from the position of the planets in [certain] Signs [of the Zodiac] which strengthen [other] Signs. Fourth, from the amount of elevation and elongation, according to the latitude and longitude measured from the equinoctial and the ascendant. And fifth, from the relation of all these to the latitude of the clime[7]

[2] See I, i, 8, note 3.

[3] *observare* (here and just below) should read *observate*.

[4] *exitus et introitus et incisio* [*incinxio*] *vestium et vestitura:* paraphrased from the *Hundred Aphorisms* (*Centiloquium*) of Ptolemy (Ashmand, pp. 226, 228): '*Aphorism* XXII: Neither put on or nor lay aside any garment for the first time, when the Moon may be located in Leo.... *Aphorism* LIX: Beware the affliction of the eighth house and its lord, at a time of departure; and that of the second house and its lord, at a time of return.'

[5] Geomancy was a method of divination by casting a few pebbles on the ground, or making points at random. The points were then connected to form figures for interpretation.

[6] This again is based on the *Hundred Aphorisms* (Ashmand, p. 225): '*Aphorism* IX: In their generation and corruption forms are influenced by the celestial forms, of which the framers of talismans consequently avail themselves, by observing the ingresses of the stars thereon.'

[7] Clime (*clima*) is a belt on the earth's surface

[where the observation is made]. And the last must be carefully observed, since from this and the preceding [arise] the variations in the size of the angle at which the rays strike the figure of anything produced by nature or by art. And it is in accordance with the size of this angle that the powers of heaven are poured into things. Few people make these observations, and fewer still know how to make them; and when they try, without such knowledge, to practise the art of images, their own failures cause them to believe that the science is a failure, and they bring it into disrepute.[8] Such then are the recommendations, and the reasons [for them], concerning the carving of gems with the images of heaven.

But we are not unaware that, just as the natural powers endure for a certain time and no longer, so it is also with the powers of images; for a certain power is poured down from heaven only during a certain period of time, as we have said at the end of *Generation and Corruption*.[9] And afterwards the empty, useless image remains cold and dead. This is the reason why certain images do not nowadays perform what they did in times long past. And hence in astronomy various 'years'[10] are distinguished for the constellations and planets, and for certain stars there are said to be greater, intermediate, and lesser years, during which they exert their effects with greater, lesser, or intermediate strength.

bounded by parallels of latitude (see II, iii, 4, note 3). Since the times of risings and settings of stars and their height above the horizon all vary, not only with the seasons but also with the latitude of the observer, it is necessary to make proper correction for latitude in using astronomical tables that were prepared for another place.

[8] This sentence is paraphrased from Ptolemy, *Tetrabiblos*, I, 2, 6.

[9] *Gen. and Corr.* II, 10, 336 a 15 ff.

[10] A year, to the inhabitant of a geocentric universe, is the length of time taken by the sun to make a complete circuit of the Zodiac, returning to its starting-point among the fixed stars. The planets also make circuits of the Zodiac, each in a length of time that may be thought of as a 'year' for that planet. A still longer period, the Great Year, is the period of time needed for all the heavenly bodies, moving at their individually different speeds, to return again to the same positions, relative to each other and to the fixed stars. This notion was a part of the Pythagorean and Platonic philosophy, and was passed on to the Arabs. Ptolemy, however (*Tetrabiblos*, I, 2, 7), said that this 'either takes place not at all or at least not within the period of time that falls within the experience of man'. Nevertheless, some writers give estimates of the period—10,000 or 15,000 years, or even longer. The Stoics held that at the end of the Great Year the universe would perish and be reborn, every detail of its history being re-enacted in endless cycles—a view that Albert rejected with horror (*Summa*, I, 68). But the Great Year was sometimes taken to be the precession of the equinoxes; for this, Albert accepted Ptolemy's estimate of 1° per century, or 36,000 years (*Prop. of the Elements*, I, ii, 3).

CHAPTER 4: HOW AN IMAGE IS NAMED EASTERN, WESTERN, SOUTHERN OR NORTHERN

This is an introduction to the next chapter (II, iii, 5) on astrological sigils. Albert is paraphrasing Ptolemy (see Appendix C, 2) for the triplicities *or* triangles *(each comprising three Signs of the Zodiac 120° apart), and for the general notion that these are related to the four corners of the earth and the four winds; but Albert's scheme and Ptolemy's do not agree in detail (see II, iii, 5, note 1).*

THE statement found in Evax and Aaron and Diascarides[1] and some other [writers], that some figures are Eastern, some Southern, some Northern, and some Western, is altogether wrongly understood by men of our own time who concern themselves with stones. For the reason the ancients say this is that an image is carved according to one of the *triplicities*, Eastern, Western, and so on. The Signs [of the Zodiac] are divided into four triplicities, as we have said in the book on *Properties of the Elements*,[2] and there is no need to repeat that here. And the Earthy triplicity is called Southern, as Ptolemy says, for no other reason except that if the South wind arises in that [triplicity], it blows for a long time; but any other [wind] soon dies down; because the Earthy triplicity has greater force in the South than in the other quarters of the world. And for exactly the same reason the triplicity of the Watery signs is called Northern, and the Fiery triplicity is called Eastern, and the fourth, that of Air, is called Western. And an image is named [in the same way]—Northern or Southern, &c.—because it is impressed with the image of that triplicity, and not because its efficacy is greater or less in such and such a quarter. Nevertheless, if at the time the image is shaped, the wind of that triplicity blows strongly, this is recognized as a heavenly influence, and the image is presumed to be more efficacious.

But it must be thoroughly understood that the heavenly influences seek out special materials regarded as suitable, for their images. And therefore the ancients recommended that the material to be made into a figure should be, not one particular stone or metal, but sometimes one kind and sometimes another, according to the different configurations of the heavens.

And the reason why stones of this sort come rather from India and

[1] See Appendix C, 4.

[2] Albert, *Properties of the Elements*, I, ii, 2.

Egypt than from any other region is that the power of the planets is most effective in those places, because they lie either under the equator, or between the equator and the tropic, or in the fourth clime. And in places which are in the first or second of these positions, the planets spread their rays from East and West, and from North and South, thus strengthening their effects. But in the middle, or fourth, clime [there is] a mingling that strengthens the effect which the qualities of the planets have upon the elements; and therefore those images are stronger and more reliable. But in other climes the planets are never in the North, but always look down obliquely from the South; and therefore they do not pour down so much power into images made in those climes as into those made in the climes first mentioned. And the reason for this we have given in our book on *The Nature of Places*.[3]

In order to have wisdom in this way, we read[4] that King Pyrrhus wore on his finger an agate on which was a wonderfully beautiful carving of the nine Muses, and Apollo, God of Wisdom, in their midst, holding his lyre in his hand.

As to what popular tradition [reports] of the carvings that were made by the Children of Israel[5] when they journeyed out of Egypt—I neither affirm nor deny it; for I know that I have read of Moses[6] that he made rings of forgetfulness and remembrance with carvings of this kind, and gave them to his wife when she left him. For the records of philosophy

[3] Albert, *Nature of Places*, i, 9, gives an account of the seven climes, as defined by the length of the longest day at the middle of each latitudinal belt.

Clime	*Latitude N*	*Length of day*
First	16°	13 hours
Second	24°	13½ hours
Third	30°	14 hours
Fourth	36°	14½ hours
Fifth	41° 20′	15 hours
Sixth	45° 20′	15½ hours
Seventh	48°	16 hours

Regions beyond the seventh clime were supposed to be too cold for agriculture or permanent habitation.

[4] The description of King Pyrrhus's ring is from Pliny (XXXVII, *3*, *5*); but Pliny is emphatic in saying that it was produced 'by nature and not by art', that is, it was a 'picture' agate. This statement is repeated by Marbod (II). But Thomas of Cantimpré (127r) like Albert, seems to consider it man-made.

[5] An allusion to 'Thetel', who is quoted by Thomas of Cantimpré (126v–127r). See Appendix C, 4.

[6] This story is not in the Bible, nor in 'Thetel'.

have it that the mathematical sciences arose in Egypt;[7] and carvings of this sort had their beginnings in the mathematical sciences.

CHAPTER 5: THE MEANING OF THE IMAGES ON STONES

This chapter incorporates an astrological lapidary of engraved gems which is found also in Arnold of Saxony (Stange, pp. 75–77) and Thomas of Cantimpré (137r–140v) and elsewhere. The figures for the constellations seem to be derived from some illustrated manuscript such as those described by Haskins (1924), which are here cited as 'Venice MS.' and 'Munich MS.'). These are more fully discussed in Appendix C, 4.

ALTHOUGH undoubtedly what has been stated is enough for our present purpose, nevertheless, for the pleasure of our readers, we shall say something about the meaning of images; and afterwards about the uses of ligatures and suspensions; and so we shall complete this tractate on stones.

Therefore, let a general all-inclusive account be given:

The *Ram* (*Aries*) or the *Lion* (*Leo*) or the *Archer* (*Sagittarius*)[1] carved [on stones], by reason of Fire and the Eastern triplicity, indicate that these stones have a property against fevers and such infirmities as dropsy,

[7] The belief that mathematics began in Egypt is noted by many Greek and Latin writers. But *mathematici* was also used in the special sense of 'astrologers', and Albert may be referring to astrological works on images by 'Hermes of Egypt': see Appendix C, 3 and 4.

*

[1] This is the first of the *triplicities*, which the preceding chapter (II, iii, 4) mentions as if quoting Ptolemy; but the assignment of properties is quite different from that in Ptolemy's *Tetrabiblos* (I, *10* and *18*; II, 3), as may be seen by comparison: (*see opposite*)

Whether this represents a corruption of Ptolemy or an independent (Arabic?) tradition, it was apparently well established, being found not only in all versions of this lapidary that I have seen, but also in Roger Bacon's tractate on divination in his edition of the *Secret of Secrets* (Steele, 1920, p. 19), and in Abraham Ibn Ezra's *The Beginning of Wisdom* (ed. Levy and Cantera, 1939, p. 154).

Triplicities	*Ptolemy*	*Albert*
Aries Leo Sagittarius	Northern cold	Eastern hot, dry (Fiery)
Gemini Libra Aquarius	Eastern dry	Western moist, hot (Airy)
Cancer Scorpio Pisces	Western moist	Northern cold, moist (Watery)
Taurus Virgo Capricornus	Southern hot	Southern dry, cold (Earthy)

paralysis, and the like. And since heat has a beneficial effect, these are said to make their wearers skilful and clever, and to raise them to positions of honour in the world; the Lion especially [has this effect].

The *Twins* (*Gemini*), the *Scales* (*Libra*) and the *Waterman* (*Aquarius*) if duly carved on stones, by reason of the triplicity of Air and the West, temper a hot humour, and are said to predispose their wearers towards friendship and righteousness and good manners, diligent observation of laws, and concord.

The *Crab* (*Cancer*), the *Scorpion* (*Scorpio*) and the *Fishes* (*Pisces*), carved upon stones, by reason of the triplicity of Water and the North, temper hot dry fevers, like [those called] *ethica* and *causon*, and the like. But according to *The Art of Images*,[2] they produce an inclination towards lying and unrighteousness and inconstancy and licentiousness. Evidence of this is that the Scorpion is the image of Mahommet,[3] who never taught anything except lies and unrighteousness.

And if the *Bull* (*Taurus*), the *Maiden* (*Virgo*) or the *Horned Goat* (*Capricornus*) are engraved [upon stones], by reason of the triplicity of Earth and the South, they are cold and dry, so far as their effects [are concerned]; and hence they are said to cure their wearers of fainting fits and hot infirmities. And they incline their wearers towards religious devotion, and towards country occupations, such as agriculture and the planting of vineyards and gardens.

The same considerations [hold good] for the images that have been described outside the Zodiac.[4]

Pegasus [duly][5] engraved upon a stone is said to be good for soldiers and those who fight on horseback and on the battlefield, and to be efficacious against diseases of horses. The image of Pegasus is half of a winged horse.[6] Because it has these effects Pegasus, in *The Art of Images*, was [called][7] Bellerophon, that is, 'fount of wars' (*fons bellorum*).[8]

[2] This seems to be a title; the same work is cited again below (see note 8).

[3] This sentence is one of Albert's additions. Anti-Muslim propaganda had begun to be published before the end of the twelfth century, when the Koran was translated into Latin (Haskins, 1924, p. 47). Several evil astrological books are ascribed to Mahommet in the *Mirror of Astronomy*, Chap. XI.

[4] This begins the list of Northern constellations.

[5] *de luce*, error for *debite*, as in the second triplicity.

[6] Munich MS. (81v) and most modern star maps show Pegasus thus.

[7] *vocatur fuit*, error for *vocatus fuit*.

[8] This etymology is fanciful. Bellerophon was not the name of the horse, but of the hero who tamed and rode Pegasus and slew the Chimaera. But the Venice MS. (33v) calls the constellation *Equus qui est bellorum fons*, so perhaps the work that Albert cites as *The Art*

Andromeda is the image of a girl turned sideways, seated upon [a rock],[9] with straining hands.[10] And this image, engraved upon gems that are by nature conciliating in love—these have been described above—brings about lasting love between man and wife; indeed it is said to reconcile even those who have been adulterous.

Cassiopeia is a maiden sitting in an armchair, with her arms uplifted and bent;[11] and this sort of engraving upon [gems][12] that bring sleep and restore the members is said to give rest after toil and to strengthen weakened bodies.

[The constellation] of the *Serpentbearer* (*Serpentarius, Ophiuchus*) is [a man with a serpent wound round his waist];[13] he holds its head in his right hand and its tail in his left. And this image engraved upon a stone that expels poison is said to be effective against poisons, and to cure the bites of venomous creatures, whether it is worn, or whether scrapings of it are taken in drink.

The constellation of *Hercules* is a man kneeling, holding a club in his hand and killing a lion; and he holds [a lion's] skin in his other hand.[14] Hence if the image of Hercules is engraved upon a stone that pertains to victory, and the wearer has it with him on the battlefield, it is said that he will be victorious.

Near the North Pole in heaven there are pictured two *Bears* (*Ursa Major, Ursa Minor*), and between them is placed a twisting *Snake* (*Draco*).[15]

of Images was that ascribed to 'Nimrod the astronomer' (see Haskins, 1924, pp. 336 ff.).

[9] *supra cellam.* Some texts have 'with flowing hair' (*sparso crine, sparsos crines*). I am inclined to believe, however, that Albert wrote *supra scyllam,* since he uses *scylla* (*Properties of the Elements,* I, ii, 6) for reefs or skerries (probably from the *Scylla,* a dangerous rock in the Strait of Messina). Andromeda was chained to a rock as a sacrifice to a sea monster; she was rescued by Perseus.

[10] *manus renitentis* (Arnold, *manus remissae*). Both Venice MS. (33r) and Munich MS. (81v) show her with hands bound to two posts or trees.

[11] *cancellatas*: the word has to do with a lattice or barrier, but was also used for 'cancel', i.e. strike out a passage in a manuscript, either by XXXXX or by enclosing in brackets [ ]. In Venice MS. (33r) and Munich MS. (81r) her arms are not much bent, but some sky maps show them upraised and crooked at the elbows.

[12] *geminis,* error for *gemmis.*

[13] *Serpentarii autem est a se virtus serpente*; but (ed. 1518) *Serpentarii astrum est vir cinctus serpente* not only makes better sense but is in better agreement with pictures of this constellation.

[14] *cuius pellem habens in manu alia,* 'whose skin he is holding in the other hand'; but surely it must be the skin of *another* lion! Some texts have instead *vel aliud monstrum,* 'or some other monster'. Munich MS. (80v) shows Hercules with a skin wrapped around one arm for protection, while with a sword held in the other hand he attacks a snake in a tree.

[15] Venice MS. (33r) and Munich MS. (80v) show all three of these constellations in one

And if this is found engraved upon a stone that gives wisdom and skill, it will increase cunning and adroitness and bravery.

The engraving of *Saturn*[16] is that of an old man holding a curved sickle in his hand. He is not cheerful and smiling, but dark, with a scanty beard. This, by reason of its cold and dryness, is said to confer a steadily increasing power, especially if it is on a stone that has the same property. And you may know that it confers this more quickly on the ignoble, since Saturn, according to *The Art of Astrology*,[17] has no love for the noble.

Jupiter, according to Aristotle,[18] as well as other philosophers, has many figures, of which six have been observed, but one of them is enough to mention here. For if there is engraved a man with a ram's head and wrinkled [horns],[19] with long flowing hair and a narrow chest, that is the [sigil][20] of Jupiter. And if it is found engraved on a gem that confers the ability to please men, it makes a man magnanimous and able to obtain from men whatever [he may wish],[21] and fortunate, especially, they say, in those affairs which are sought by religion and faith.

But if there is engraved upon a gem giving wisdom a man who has a graceful body and a beautiful small beard, and thin, shining lips and a thin nose, and he has wings on his feet and bears in his left hand a staff with a coiled serpent fastened to the top—and this engraving is very frequently found on stones taken from ancient temples of pagan gods, especially in parts of Germany[22]—this is the sign of *Mercury* the Scribe; and it is said to confer wisdom, especially in rhetoric and business and other affairs.

Likewise the sign of *Mars*, which is a figure of a soldier with a lance, if it is carved upon a stone that confers violence and audacity, is said to make men spirited and warlike.

Of *Venus*[23] it is impossible to say anything in a brief account; for two

drawing, an S-shaped snake with the Great Bear on one side and the Little Bear on the other.

[16] This begins the list of planets.

[17] This seems to be a title, but perhaps it is the same work as *The Art of Images* cited above (see notes 2 and 8).

[18] The *Mirror of Astronomy*, Ch. XI, attributes to Aristotle a work beginning 'Aristotle said to King Alexander, "If you wish to understand . . ." '. This book was so bad that it was called *The Death of the Soul*, and if Albert is alluding to it here, his reluctance to say much about it is understandable.

[19] *rugosos calcaneos*, 'wrinkled heels', in some texts; omitted (perhaps because unintelligible) in others. My guess is *cornulos* or *corniculos*, since Jupiter Ammon is represented with back-curved, ridged goat's horns.

[20] *filia*, probably for *signum*, or *sigillum*.

[21] *volunt*; but (ed. 1518) *voluerit* is probably correct.

[22] This remark, which I have placed between dashes, is Albert's own observation.

[23] The *Mirror of Astronomy*, Ch. XI, mentions books on the cult of Venus by Hermes

large books of magic have been written dealing with nothing except her images.

And of *Sun* and *Moon*[24] there are many different [images] which we pass over for the sake of brevity.

The *Water Snake* (*Hydra*)[25]—namely, a Snake having over it the *Cup* (*Urna*, *Crater*) near its head and [the *Crow* (*Corvus*) in front of its][26] tail, above its back—if engraved upon a stone conferring riches, is said to confer riches and wisdom and protection against harm.

Centaur (*Centaurus*) is engraved as a man holding in his left hand a hare suspended with a knife, and in his right hand a staff on which is fastened a small animal, and a kettle;[27] it is said to confer constant good health. And thus the stories say that the Centaur was the tutor of Achilles, who wore such a stone on his hand.

Likewise the *Altar* (*Ara*), engraved like a shrine enclosing holy relics, is said to confer a love of virginity and chastity.

And [the *Sea Monster* or *Whale* (*Cetus*)][28] is found engraved [as a crested serpent having a great hump on its back], and it is said to confer good luck by land and sea, and prudence and amiability; and to restore things that have been lost.

The *Ship* (*Navis*, *Argo*), engraved with all sail set is said to give security in business and certain other affairs.

[The *Hare* (*Lepus*)],[29] engraved [on a stone] is reported to be efficacious against deceit and insane talk.

Orion, holding in his hand a sickle or sword, is said to confer victory, if engraved on a stone having the same power.

and by Toz Graecus—very bad books, so it is obvious why Albert forbears to quote them.

24 Sun and Moon were also treated in books by Hermes (*Mirror of Astronomy*, Ch. XI).

25 This begins the list of constellations south of the Zodiac. The description fits the drawings in the Venice MS. (36r) and Munich MS. (84r), showing these three constellations all together—a long snake, with the cup resting on its back near the head, and the crow near the tail.

26 *et cornu aut caudam*, error for *et corvum ante caudam.*

27 All these objects can be identified in the drawing in the Munich MS. (84r).

28 *caecus . . . habens cristatum serpentum in dorso et tubam magnam*, 'a blind man . . . having a crested serpent on his back and a great trumpet'. Other texts are equally confused, but at least it is clear that *caecus* is an error for *cetus* (a sea monster, the whale), and *tubam* for *tuber* (a swelling or hump). I have paraphrased, giving what seems to be the sense. This, however, does not agree with the drawing in the Venice MS. (35r), which resembles Capricorn (a sea-goat), or that in the Munich MS. (82v), which is just a fish. But later star maps show it as a rather fat sea-serpent with a horn on its head.

29 *lippus*, error for *Lepus*, the Hare beneath the feet of Orion.

The *Eagle* (*Aquila*) engraved with the *Arrow* (*Sagitta*)[30] in front of its head is reported to preserve old honours and to obtain new ones.

Likewise [the *Swan* (*Cygnus*), which is in front][31] of the Waterman (*Aquarius*), is said to cure quartan fever.

Perseus,[32] holding in his right hand a sword and in his left the Gorgon's head, is said to protect from thunderbolts and storms, and from attack by the envious.

The *Stag* (*Cervus*), engraved with the *Hunter* (*Venator*) and *Dogs* (*Canis Major*, *Canis Minor*),[33] is said to heal madmen and maniacs.

Venus,[34] engraved wearing a long garment and holding a laurel branch in her hand, is said to confer beauty and distinction.

We could include here similar [statements] about many other [images],[35] but it is not necessary, since another science [deals with] them. And these things cannot be proved by physical principles, but demand a knowledge of the sciences of astrology and magic and necromancy, which must be considered elsewhere.

[30] These and the following two constellations are out of place; they belong among the Northern constellations.

[31] *similiter autem Aquarii signum*; but (ed. 1518) *Cignus qui praeest aquario* is probably correct.

[32] Perseus belongs among the Northern constellations, next to Andromeda: see note 9 above.

[33] The list now returns to the Southern constellations. The Hunter is the same as Orion; near by are the Greater and Lesser Dogs (with the bright stars Sirius and Procyon, respectively); the Stag is the adjacent constellation, now generally called the Unicorn (*Monoceras*).

[34] Venus, of course, belongs in the list of planets: some texts combine Venus and Mars, 'an armed man and a woman in a long robe'. Others calls this Virgo, one of the signs of the Zodiac.

[35] This list does not include all the constellations in Ptolemy's *Almagest*, but it does have the traditional number—twelve Northern and twelve Southern constellations, besides the twelve in the Zodiac. Some texts include additional items from other sources; for example, Arnold of Saxony (Stange, p. 77) describes a sigil with 'a woman who holds in her hand an apple, and on her left breast is something like a square tablet; and on another part of the stone is the image of a man, and this image has the head of a bird and the feet of an eagle; and on the part where the image of the man is, these letters are engraved [ ]; this stone has the power of reconciling love between man and woman.' The brackets probably indicate an inscription missing or illegible in Arnold's original, or perhaps omitted intentionally, to render the sigil innocuous. If Albert's source contained such sigils, he rejected them, either because they were not recognizably astrological or because they might have some evil significance (see Appendix C, 4).

CHAPTER 6: LIGATURES AND SUSPENSIONS OF STONES

This final chapter on stones lists some 'practical applications' of their powers. As ligatures and suspensions, that is, bound to any part of the body or hung round the neck, stones were amulets, their effect (if any) upon the wearer being purely psychological. But certain other powers, evinced in chemical reactions and especially in magnetism, seemed just as mysterious as magic, and so are included here.

Albert cites directly Costa ben Luca's Letter on Incantation *(printed in Constantine of Africa,* Opera, *pp. 317–20) but the rest of this chapter so closely resembles Arnold of Saxony's* De virtute universale, *Ch. 8,* De lapidibus *(Stange, pp. 85–87) that it must have been taken from Arnold or from Arnold's source (see Appendix C, 5). In fact, this chapter includes nearly all the excerpts from 'Aristotle's Book of Stones' that Albert was able to find. Therefore I have here added references to the* Lapidary of Aristotle *(Latin texts as printed by Rose, 1875, and Ruska, 1912).*

THINGS that really seem more closely related to this science are ligatures and suspensions, since in these healing and help are conferred solely by natural powers. Therefore something must be said about them, based on the philosophers Aristotle and [Costa ben Luca][1] and Hermes and some others.

Zeno in his book on *Natural things* (*Liber naturalium*), as if offering an explanation for the power of ligatures and suspensions, and the powers of the stones themselves, says that there is a hidden universal power that makes stones from Fire, and likewise from Water, when it is poured out on a place called *bozon*: for then it hardens and does not return any more to its original material. And Zeno[2] adds further, speaking of stones, that 'what happens to Water and Earth also happens to animals and plants, since by a hidden power of the material, the time, or the place, they are completely disintegrated or converted into stone'. How we are to interpret the words of Zeno, the philosopher, can be understood from what has been said in Book I. For a stone is not made from Fire, except [in the sense that Fire acts] as the efficient cause.

[1] *Constabulence*, here and below: a misspelling of Costa ben Luca that no doubt facilitated confusion of his works with those of Constantine of Africa; Constantine, however, may have been the translator.

[2] Albert is quoting Zeno at second or third hand; but Zeno was quoting Avicenna (cf. I, ii, 8).

And the universal power is nothing except the power of heaven, which brings into being all things that are produced, and contributes something of the power of heaven towards certain wonderful effects. And these [powers], according to Plato and Socrates,[3] act when things are suitably bound upon any part of the body or suspended from the neck. And while Socrates says that enchantments are made in four ways—namely, by suspensions and ligatures of things, and by prayers and spells, by written charms, and by images—he also says that rational souls lose their sanity so that they fall into fear and despair, or joy and confidence; and by these accidents of the mind the body is also changed into a state of chronic illness or health.

But we do not intend [to discuss] here anything except ligatures and suspensions of stones, and what effect they have, according to eminent philosophers.

And according to the statements of [Costa ben Luca] in the book on *Physical Ligatures*, two philosophers, Aristotle and Diascorides[4] say that[5] onyx suspended from the neck increases sadness, and brings a man completely into a state of pallor and fear and melancholy, and of illness resulting from these accidental [conditions].

But Aristotle says that onyx is from corals,[6] and if suspended from the neck of an epileptic, it prevents attacks.

On the other hand, Diascorides says that fumigation with *gagates* or *kacabre*[7] hastens the attacks of an epileptic and blinds him.

And also Diascorides says that there is a stone called *galadides*,[8] and if it is placed near a fire and taken away again, the fire goes out.

[3] The remainder of this paragraph comes from Costa ben Luca's *Letter on Incantations* (pp. 317–18), where, however, these opinions are ascribed to Socrates and Galen (not Plato). But Albert knew the Platonic theory that ill-health is a lack of harmony between body and soul (*Timaeus*, 87 C, ff.).

[4] This is Albert's way of citing what Arnold calls '*The Lapidary of Aristotle*, translator Diascorides', from which the next four items are taken.

[5] I omit here *si fuerit ex gagate et kacabre*; it is not in Arnold and has obviously been displaced from the following sentence. The statement about onyx is in Costa ben Luca (p. 319) and in the *Lapidary of Aristotle* (Ruska p. 192; Rose, pp. 360–1, 387–8). See II, ii, 13, *Onyx*.

[6] This identification of onyx with coral and the properties ascribed to it are not in printed Latin texts of the *Lapidary of Aristotle*. Perhaps the stone was a silicified fossil coral, or perhaps it was simply red, like coral (cf. II, ii, 1, *Agathes*).

[7] See II, ii, 7, *Gagates*; 9, *Kacabre*. The supposed effect on epileptics is mentioned by Pliny (XXXVI, *34*, 142) and Damigeron (XXVII), but I have not found it in the *Lapidary of Aristotle*.

[8] Possibly the same as II, ii, 7, *Gelosia*, though that is not said to put out fire. See introductory also note on II, ii, 20, *Zigrites*.

Aristotle says something else—that *smaragdus*[9] bound on the neck hinders epilepsy and sometimes cures it completely; and therefore it is recommended to noblemen that they bind this stone on their children so that they may not suffer from epilepsy.

Furthermore, Aristotle in his *Lapidary*[10] says 'the corner of a certain kind of magnet has the power of attracting iron towards *zoron*, that is, the North; and mariners make use of this. But another corner of this magnet attracts in the opposite direction, towards *aphron*, that is, the South Pole. And if you bring iron near to the North corner of the magnet, the iron becomes North; and if you bring it near to the opposite corner, it immediately becomes South.'

In the same book, furthermore, Aristotle asserts that neither iron nor any stone can overcome *adamas*;[11] but lead can, since [lead] is the softest of metals.[12] For *adamas* (diamond) and *sabotus* (emery)[13] have the property of piercing all hard stones, and a force that wears them away and reveals their shining lustre.

Likewise Aristotle reports that if two or more magnets of equal power are placed above and below, and a body of *baret*, that is, iron, is placed between, it will hang suspended in the air.[14]

[9] This is quoted from Costa ben Luca (loc. cit.), who is quoting the *Lapidary of Aristotle* (Rose, p. 385). Between this and the next item in Arnold's chapter are about a dozen stones that Albert here omits, although he has mentioned most of them in II, ii.

[10] At this point begin quotations from what Arnold calls 'The *Lapidary of Aristotle* according to the translation of Gerard'. This translation is otherwise unknown. Rose (p. 339) notes that such words as *zoron*, *aphron*, indicate that it was made from the Hebrew rather than direct from the Arabic. The mariners' compass is not in Arnold's text, though it was well known. It is mentioned by Thomas of Cantimpré (127v, *Adamas*), and much earlier by Alexander Neckam (*De naturis rerum*, II, 98; Wright, p. 183). Peter Peregrinus of Maricourt in 1269 described it in detail (Hellman, *Petri Maricurtensis De magnete*). It would be interesting to know whether Peter gained some of his information from this lost translation of Gerard.

[11] This remark seems to interrupt the account of magnet, but is not really irrelevant, since *adamas* included both magnet and diamond (or other very hard stones). See II, ii, 1, *Adamas*.

[12] This is not in Arnold, but it is in Costa ben Luca. It is quoted from the *Lapidary of Aristotle*, but without real understanding, since it refers to the practice of mounting a diamond in lead while cleaving or polishing it. One text of the *Lapidary of Aristotle* (Rose, pp. 389–90) makes this quite plain: 'If you wish to break it [diamond], put it in lead, and strike it from above with lead [that is, a leaden hammer], and it will be broken.'

[13] *Lapidary of Aristotle* (Ruska, pp. 190, 195; Rose, pp. 358, 365, 391). The last of these passages says: 'It is a strong stone, cutting other stones as diamond does, but it is not so strong' [as diamond].

[14] Pliny (XXXIV, *42*, 148) tells of a plan to suspend an iron statue in this way; and Alexander Neckam (Wright, p. 183) says

Aristotle also says that there are many different kinds of magnets: for some attract gold, and others, different from these, attract silver, and some tin, some iron, and some lead.[15]

And some attract at one corner and at the other repel anything that is attracted by the opposite corner.[16]

And some attract human flesh:[17] and it is said that a man attracted by such a magnet laughs, and remains where he is until he dies, if the stone is very large.

And some attract bones, and some hairs, and some water, and some fish.[18]

that a statue of Mahomet was suspended in mid-air by magnets in the surrounding walls, roof, and floor.

[15] The *Lapidary of Aristotle* (Ruska, pp. 189, 198–9; Rose, pp. 356, 369–70) does not call these 'magnets', but only 'stones that attract' (*lapis qui trahit*) gold, silver, iron, copper, &c. The descriptions are not wholly intelligible, but it is clear that they refer to minerals used in metallurgical operations, such as parting gold from other metals, refining silver by cupellation with lead, and alloying copper to make brass.

[16] This restatement of the polarity of the magnet seems to be misplaced: it belongs with 'stones that attract iron' above.

[17] This item is not in Arnold. It is a highly condensed allusion to a story in the *Lapidary of Aristotle* (Ruska, pp. 206–7; Rose, pp. 379–80): The soldiers of Alexander the Great found some of these stones and 'all who looked upon them were stupefied and kept gazing open-mouthed as if they had lost their senses', until a bird alighted and covered the stones with its wings and the spell was broken. Then Alexander ordered his men to shut their eyes and wrap the stones in cloths, and so managed to carry away some of them, which he later built into the wall of a city. In the course of time wind-blown sand concealed them on the outer, and left them exposed only on the inner, side of the wall. A prince of Nineveh heard of this and came to see it. But the first of his soldiers who scaled the wall, 'when he saw the stones inside, opened his mouth and jumped down into the city and never came back'. The same thing happened to all who followed him, and the expedition had to be abandoned. This is a good example of the Alexander stories, several of which appear in the *Lapidary of Aristotle*, concerning magic 'stones'.

[18] Some of these are probably chemical or medical compounds; but there was a tendency to assimilate into one description a number of different things that 'have some effect on' hair, water, fish, etc. A 'stone that attracts bones' is not given in Ruska's or Rose's texts of the *Lapidary of Aristotle*, and this is perhaps a mistake for the 'stone that attracts nails' (of the fingers or toes—*ungulas*), which is said (Ruska, p. 199; Rose, pp. 370–1, 393) to remove nails without pain or blood (perhaps a medical preparation to ease the sloughing off of an injured nail), and also to collect nail-parings from the ground. The 'stone that attracts hairs' (Ruska, p. 199; Rose, pp. 370, 393) looks like hair, attracts bits of hair, removes hair or makes it grow again. The 'stone that attracts water' (Ruska, p. 202; Rose, pp. 373–4, 396–7) is spongy and absorbent, and will cure watery diseases, like dropsy; it weighs much more when wet than when dry. As for the 'stone that attracts fish' (Ruska, p. 189; Rose, p. 357), when this 'is placed in water, fish come and stay quiet above it' (perhaps it was a fish poison or bait, or perhaps an amulet to assure success in fishing).

He says, too, that white naphtha[19] attracts fire; and by means of this, pagan priests deceive the common people, so that they believe that the fire is kindled from heaven. Naphtha, however, is not a stone, but a kind of bitumen found in Chaldaea.

In the same way the fire of sulphur attracts iron and burns it strongly, and likewise stones; but has only a little effect on wood.[20]

He likewise says[21] that there is a magnet called 'oily' that attracts oil, and a 'vinegar stone' that attracts vinegar; and a 'wine stone' that attracts wine, and the foam of this stone attracts the foam of wine, and its lees attract the lees of wine. It is as if there were in these things something pleasing to the stones, or a soul by which they were moved.[22]

Furthermore, Diascorides and Aristotle say[23] that amethyst and sardonyx, placed or suspended over the navel of a man who is drunk or is drinking wine, oppose the fumes of wine and cure drunkenness, freeing [him] from its attack.

Ethices (*echites*) bound to the elbow of an epileptic is said to cure epilepsy; and it also helps a pregnant woman to give birth.

Diascorides says that *saphirus* placed and bound over an artery moderates heat; and placed over a man's heart, removes suspicion, and keeps [him] free from contagious diseases.

[Asbestus][24] if set afire by sulphur [is not quenched, so long as anything is left of it].

Also the philosopher declares that the stone *lipparius* (*lippares*) attracts to itself all wild beasts and reptiles.

19 Naphtha is a light, highly inflammable fraction of petroleum sometimes produced by natural processes. The explanatory remarks are Albert's addition.

20 See IV, 5, note 7.

21 This list of 'magnets' is in Arnold, as the last quotation, from 'Gerard's translation', but not in the printed Latin texts of the *Lapidary of Aristotle*. Like the 'magnets' of metals (note 15 above), these are presumably materials involved in technological processes —making soap by combining lye with oil; dissolving limestone, or preparing pigments from lead or copper, with vinegar; distilling alcohol; and various alchemical operations with tartar, obtained as a sediment in wine barrels.

22 The *Lapidary of Aristotle* (Ruska, p. 197; Rose, p. 367) makes this statement, but only about magnetite.

23 Albert and Arnold here return to the 'Diascorides' version. But very few of the following items can be traced in existing texts of the *Lapidary of Aristotle*. Most of them have been mentioned before; where there are variants in spelling I have added (in parentheses) the name under which each appears in the alphabetical lapidary, II, ii.

24 *ab aestu autem si inflammatum a sulphure prohibet* is evidently corrupt. Arnold has *abeston inflammatum a sulphure non extinguitur*, which is more likely; and the 1518 edition adds *quamdiu aliquid remanet ex eo*.

And he says that the stone *opitistrite* (*epistrites*) offers security from wild beasts; and if it is placed in an alembic, that is, a vessel of boiling water, the pot stops boiling.

And he says that the stone *endros* (*etindros*) turns to liquid, but what dissolves from it is restored to it again.

Also he says that the stone produced from the foam of the sea, which is called *spuma maris*,[25] bound on the hip of a pregnant woman, hastens birth; and bound on the neck of a child that has a violent cough, it soothes the cough.

Galen and Avicenna[26] say that they have learned by experience that if red coral is suspended directly over the seat of pain in the stomach, it soothes the pain.

These are the effects—as observed in natural science (*experimenta physica*) and tested by great men—which stones produce by the powers of their specific forms. And I would have set forth the *Lapidary of Aristotle*, except that the whole book has not come down to me, but only some excerpts from it.

[25] The *Lapidary of Aristotle* (Ruska, p. 207; Rose, p. 380) describes a stone, which is light and fragile and floats on a stormy sea—possibly pumice; but its properties are different from those given here. According to Pliny (XXXV, *18*, 36), *spuma maris* 'is said to be sea-foam hardened with clay, and this is why it has tiny shells in it'; it was used as a white pigment or plaster. So this name was evidently given to a number of different things.

[26] Arnold gives as his authority only Avicenna (*Canon of Medicine*). Albert added Galen, having found the same statement ascribed to him in Costa ben Luca (*Letter on Incantations*, pp. 319–20), and in Constantine's *Book of Degrees*, (*Opera*, *p*. 354).

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BOOK III
METALS IN GENERAL

TRACTATE i
THE SUBSTANCES OF METALS

CHAPTER 1: THE PLAN OF THE BOOK AND THE ORDER OF THINGS TO BE DISCUSSED

This chapter is a general introduction to the remaining books—III and IV dealing with the metals, and V with minerals 'intermediate' between stones and metals. Although Albert uses information from alchemical works and reports many interesting observations of his own, he tries to fit everything into an Aristotelian plan, as in Book I, on stones.

IT is time to take up, next in order, an inquiry into the nature of metals, now that the nature of stones has been investigated; for it is in stones that the production of metals frequently takes place, as if the substance of stones were, so to speak, a place peculiarly suitable for the production of metals. In [writing] this as well as the preceding books, I have not seen the treatise of Aristotle,[1] save for some excerpts, for which I have inquired assiduously in different parts of the world. Therefore I shall state, in a manner which can be supported by reasoning, either what has been handed down by philosophers or what I have found out by my own observations. For at one time I became a wanderer, making long journeys to mining districts, so that I could learn by observation the nature of metals. And for the same reason I have inquired into the transmutations of metals in alchemy, so as to learn from this, too, something of their nature and accidental properties. For this is the best and surest method of investigation, because then each thing is understood with reference to its own particular cause, and there is very little doubt about its accidental properties. This is not difficult to learn, just as the science of stones is not difficult to investigate; since their causes are obvious, and their bodies are not varied but *homeomerous*[2] throughout, and not like other bodies which, on account of their

[1] The *Lapidary of Aristotle*: see Appendices A, 14; B, 8.

[2] See I, i, 1, note 8.

varied character, cannot be completely investigated by anatomizing them. We place the treatise on metals after that on stones because, as we have said, stone is almost always found to be the place where metals are produced.

For I myself have seen pure gold found in very hard stone, and I have seen gold mixed with the substance of the stone. And similarly I have seen silver mixed with stone, and also pure in another stone, as if it were a vein running through the stone but distinct from its substance. And I have made similar observations regarding iron and copper and tin and lead; but these I have never seen distinct from the substance of the stone; but I am assured by men experienced[3] in such matters that [these metals] are frequently found distinct from the substance of the stone, just as grains of gold are found in sands.

As to the transmutation of these bodies and the change of one into another, this is to be determined not by natural science but by the art called alchemy. Likewise, in what places and mountains [metals] may be discovered, and by what indications, are matters partly for natural science and partly for the science of magic called treasure-finding.[4] Therefore the signs by which these places that produce metals may be recognized we shall mention below; and as to the other method of discovery, we shall [omit][5] it, because that science depends not upon [scientific] demonstrations but upon experience in the occult and the supernatural.

We shall proceed here in just the same way as in the book on the nature of stones, first inquiring into whatever things common to the nature of all metals seem to need inquiry; and with this we shall complete the third of our books on minerals.

In the fourth [book] we shall investigate the metals individually, all seven kinds of them; and with that we shall complete the science of minerals, which are the first homeomerous mixed bodies in nature, as we have stated at the end of the *Meteorology*.[6] And finally we shall say some-

[3] *experti*, prospectors; a little of their 'experience' is reported in III, i, 10 and III, ii, 6.

[4] *inventio thesaurum*: the finding of things that had been lost or stolen was frequently an aim of hydromancy or other 'magic'. One is tempted, however, to imagine that Albert is here alluding to the divining rod, which came to be applied to prospecting for ores some time in the Middle Ages and probably somewhere in Germany. Miners from the Harz are said to have introduced 'dowsing' into England, and at about the same time (sixteenth century) Agricola (*De re metallica*, Hoover, pp. 40–41) speaks of it as something well known in Germany, though he himself has no faith in it.

[5] *connitemur*, probably for *ommitemus*, since, in fact, the subject is never mentioned again.

[6] See I, i, 1, note 7.

thing about the nature of [minerals that are] intermediates [between stones and metals]. And with them we shall complete our whole plan for this science of minerals.

For there is no doubt that the nature of stone is less far removed from the elements than the nature of metals [is]. That is why [stones] seem to be made by an easier mixture, and the materials in them seem to be elements that have been somehow acted upon by each other. But this is not so with metals; for as in animal bodies there must be beforehand a blending of humours[7] in the material, so in the same way, before the blending of the forms of metals, there must be a purification of Sulphur[8] and Quicksilver, and perhaps of salt and orpiment and alum and some other things.[9] For this reason the science of stones most certainly precedes the science of metals; and it seems suitable that we, too, should follow this natural order.

CHAPTER 2: THE SPECIAL MATERIAL OF METALS

The organization of Book III is parallel to that of Book I, and this chapter, like I, i, 2, begins the discussion of causes *with the* material cause. *According to Aristotle, metals, being fusible, are made up chiefly of Water. But this does not entirely explain the behaviour of metals, which remain liquid at high temperatures where other liquids evaporate. So Albert now begins to lay the groundwork for his reconciliation of Aristotle's statements with the Sulphur-Quicksilver theory of the Arabs, to be developed later.*

ACCORDING to the art already set forth in the *Meteorology*,[1] we know that the primary material of all liquefiable things is Water. For every liquefiable substance, so long as it is liquid, seeks to be bounded by something else, having no boundary of its own. We have given this explana-

[7] Medieval physiology, derived from Galen, was based on the doctrine of four *humours* in which the primary *qualities* were combined: yellow bile (*choler*) dry-hot; blood (*sanguis*) hot-moist; phlegm (*phlegma*), moist-cold; black bile (*melancholia*) cold-dry. The proportion in which all these are mixed (*temperamentum*) determines the 'temperament' or 'temper' of a person as 'choleric', 'sanguine', 'phlegmatic', or 'melancholy'.

[8] *sulphurus*, error for *sulphuris*. This is quoted from *The Soul in the Art of Alchemy* (*De anima in arte alchimiae*, Manget, 1702, Vol. 1, p. 634), ascribed to Avicenna.

[9] The suggestion of additional constituents besides Sulphur and Quicksilver—especially salt—seems to foreshadow the *tria prima* (Salt, Sulphur, and Quicksilver) of Paracelsus and the later alchemists. This may be an interpolation; but if not, Albert does not follow up the suggestion in later chapters.

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[1] *Meteor*, IV, 10, 382 b 28 ff.

tion of the moist in the second book of *Generation and Corruption*.[2] Therefore, every liquefiable thing is such simply because of the moisture that is bound up in it; once it is melted and exhibits its own peculiar behaviour and properties, this is recognized in its name, when it is said to be moist or liquid, since it has demonstrably been liquefied. For it must be that everything that is fluid and seeks an external boundary to contain it has the same cause; that is, essentially and primarily it tends to be bounded by something else and not by itself: and this is [what] moisture [is], as has been determined elsewhere. Thus all liquefiable substances are fluid because of the large amount of watery moisture incorporated in them. Moreover, we have shown in the second book [of *Generation and Corruption*] and in the *Meteorology*[3] that anything that is hardened by cold has Water as its primary material. And there is no doubt that metals are hardened by the cold of Water; and therefore a moist humour will be the material of all of them. And for this reason Aristotle, foremost of the Peripatetics, says in the fifth book of the *Metaphysics*[4] that the material of all liquefiable things is one—that is, Water.

We know from what has been proved in the *Meteorology*[5] that watery moisture is easily converted into vapour. This is shown by alchemical experiments: because if Water, or things that contain simple watery moisture—whether natural and inherent or foreign and added—is evaporated in an alembic placed over a slow fire, by the action of gentle heat, the Water distils from it and dry [material] is left behind. But we see that metals retain their moisture even in hot fires. Therefore the moist materials of metals cannot be simple Water, but rather [Water] which has been to some extent acted upon by other elements. But if we consider the [kinds of] moisture which are difficult to separate from things that naturally contain them, we find that they are all unctuous and viscous; because, just as has been shown in the *Meteorology*,[6] their parts are connected like [the links of] a chain and cannot easily be torn apart. And therefore, since the moisture in metals is not torn out of them, even by strong heating, this, too, must be unctuous. Evidence of this is that all the radical moisture on which the natural heat of animals depends is unctuous; and certainly wise nature would provide this just because it is difficult to separate and difficult to dry out. For nature intends it to last for a long time in the

[2] *Gen. and Corr.*, II, 2, 329 b 29.

[3] *in secundo et Meteorum*: merely reiterating the references of notes 1 and 2 above.

[4] *Metaphysics*, V, 6, 1016 a 21.

[5] *Meteor*, IV, 9, 387 a 23 ff.

[6] *Meteor*, IV, 9, 387 a 12; cf. I, i, 2, note 4.

individual and for ever in the species.[7] And for this reason [nature] decreed a moisture of this sort as nourishment for the vital heat. Therefore, since the moisture of metals likewise seems to be inseparable, even in a heat that liquefies them, undoubtedly the moisture which is the material of metals will be unctuous.

But we see further that what is unctuous in oil and all fat is easily inflammable and is active in burning things with which it is joined. And we see that the Fire does not leave these things until they are consumed, as we observe with oil in lamps and the radical moisture in fevers. But we do not see anything of the sort in the moisture of metals; and therefore it may seem to some people that perhaps the moisture of metals is not unctuous. But to all objections of this sort we reply with what we have already said in the fourth book on *Meteorology*[8]—namely that in many things there are two kinds of unctuousness. One of these is, as it were, extrinsic, very subtle, having mingled with it nothing that yields any sediment or ash; and [the other] is not inflammable, but is intrinsic, fast-rooted in the thing itself so that it cannot be torn out and driven off by fire. We have given as an example of this the liquor distilled from wine, in which there is one sort of unctuousness that is light and inflammable, easily distilled and, as it were, accidental. The other sort is mixed with the whole substance of the liquor itself, and is not separable from it except by the destruction of its very substance; and this is not combustible. And it is the same in all things produced by nature.

[7] This seems like an echo of some Aristotelian statement about *form*, rather than about moisture as such. Perhaps it is an interpolation.

[8] Albert is here citing his own commentary, in which he gives an account of the distillation of alcohol (a process unknown in antiquity):

(*Meteor*, IV, iii, 18); Wine in some ways behaves like oil, and in some ways like water. For sweet wine, especially if it is old and dry, evaporates like oil, since it contains much subtle fattiness; and therefore it has many properties in common with oil. For, like oil, it is not solidified by chilling—though it must be admitted that oil is thickened by cold. And like oil it is combustible and disappears completely in burning.... Its vapour is very subtle. Evidence of this is that it emits a flame; for if it is placed on the fire and hollow reeds are inserted above it [the vapour coming out of them] flames like oil; and what is sublimed from such wine is the nourishment of a subtle flame. (*Meteor*. IV, iv, 2): But you may know that when wine is distilled in the same manner as rose-water, what is first emitted from it is a watery insipid moisture; and when that has been drawn off, the earthy parts of the wine are left imbued with an oily fat. And if that substance is further distilled over a slow fire, an oil comes off. In this respect one wine differs from another because the stronger the wine, the less water and the more oily liquid is distilled from it; and the weaker and thinner the wine, the more water and the less oily liquid.

Albert appears to be mistaken in saying that watery rather than oily liquid (alcohol) distils off first, since alcohol has a lower boiling point than water. Nevertheless, his observation may be correct if, as seems to be implied, the wine were first brought to the boil, when steam would be produced, condensing to water; and then later, if distillation were continued over a lower heat, steam would decrease and only alcohol would distil.

Evidence of this is what we see done in the art of alchemy, which is, of all arts, the best imitator of nature. For since [alchemy] has observed that there is no better way of making the yellow *elixir* than with sulphur, and has also observed in sulphur an unctuousness which is so intensely active in burning that it burns all metals, and in burning blackens all those on which it is cast while molten—[therefore alchemy] recommends that sulphur be washed in acid solutions and cooked until no more yellow water comes out of it, and that these solutions be sublimed until all the unctuousness capable of burning has been removed, so that there remains only as much subtle unctuousness as [can] endure the fire without being reduced to ash. Therefore there must be an abundance of similar unctuous moisture in the materials of metals produced by nature; and this is the cause of their malleability and fusibility. This is expressly stated by the authorities, Avicenna and Hermes[9] and many others, men of great experience in the nature of metals.

Furthermore, in all kinds of metals we see that when liquefied they do not wet anything on which they are poured out, and they do not stay still [that is, they roll about] on a flat surface, and do not spread out completely over it, as we see almost all watery, unctuous moisture do—for instance, water, wine, beer, or oil. For all these, if poured out on stone, earth, or wood, when they find a flat surface wet it and spread out over it. But molten metals do none of these things; they do not adhere to anything that touches them, nor do they spread out completely; but rather they are solid in some respects and fluid in others. And therefore a subtle, unctuous moisture cannot be the only material in them, but it must be completely mixed with subtle Earth, which prevents it from adhering to anything that touches it, or from being completely fluid, but [makes it] stick together like globules; because the subtle Earth everywhere in it seizes upon the moisture and, by gluing it together, as it were, holds it fast, providing it with a boundary, in so far as to prevent it from adhering to anything except itself. And the moisture, wherever it is present, draws the earthy dryness out of itself, so that it flows and runs on a flat surface. But if the earthy dryness were not everywhere protected by the moisture, it would be burnt up at once by a fire that causes liquefaction, and would become rough and scaly—just as in iron the fire finds out all the dry earthiness that is not covered by moisture and makes it scaly. And it is the same with nearly all metals.

[9] These and other alchemists are discussed in the remaining chapters of this tractate.

It is clear, therefore, that the primary material of metals is an unctuous, subtle moisture, which is incorporated and thoroughly mixed with subtle Earth, so that large amounts of the two are combined, not merely with, but actually in, each other.

CHAPTER 3: IN CONNEXION WITH THE PRECEDING: WHY STONE IS NOT MALLEABLE AND FUSIBLE LIKE METALS

This chapter appears like a digression, anticipating in part the discussion of fusibility and malleability in III, ii, 1–2; but the emphasis here is on differences *between metals and stones (as treated in I, i, 2–3). The ideas in this chapter are taken from* Meteor., *IV, which defines three kinds of changes brought about by heat: (1)* pepansis, *natural digestion, ripening, or maturing (as of fruit), ascribed to the gentle action of internal heat; (2)* epsesis *(Greek* hepsesis), *boiling or steaming by moist heat; (3)* optesis, *roasting or baking by dry heat.*

ON this [basis], going still further, we may easily answer a question that is often asked—Why is stone not fusible, but copper and other metals are? And furthermore why is stone broken into little pieces and reduced to a *calx*, through fire alone, which does not happen to metal at all? The answer to this is easy: for stone contains more Earth, but this is not everywhere protected by moisture, nor is the moisture in it so unctuous as that in metals; and therefore, when it is placed in a roasting-hot fire (*igne optetico*), the watery moisture vanishes and the stone is reduced to a *calx*. And since dryness predominates over moisture in stone, the stone breaks up completely into little pieces; while, on the other hand, in metals moisture predominates over dryness, and the metal will be liquefied. And this is likewise the reason why stone is not malleable, but metals are. Actually metals have a great deal of unctuous moisture, which most strongly binds the earthy parts to itself, as by hooked bonds;[1] and when a hammer blow displaces the watery part, which always tends to yield to anything that touches it, as we have said in the book on *Generation and Corruption* and in the *Meteorology*,[2] [the watery part], resisting any separation, strongly draws the earthy part along with it; and so [the metal] is drawn out without losing its continuity, and not broken up,

[1] *ensis*, but 1518 text has *ansis*, 'handles'.

[2] *Gen. and Corr.* I, 2, 329 b 29 ff. explains softness as moisture; *Meteor.* IV, 9, 386 b 11 ff. discusses ductility and malleability.

because of the viscosity and good, firm mixture of the earthy with the unctuous watery [parts]. But in stone dryness predominates, resisting anything that touches it, and it does not yield; and since it is a property of what is dry to be broken, it cannot yield to a hammer blow, but is shattered and reduced to fragments.

But the earthiness which is floating and absorbed in the moisture of metals is very subtle; and it is not destroyed nor completely forced out of the moisture, as occurs with extreme cold; rather it is digested, as it were, and ripened by gentle heat (*pepansi*), and neither boiled by [moist heat (*epsesi*)][3] nor roasted by dry heat (*optesi*), as Averroes says.[4] For the cold moisture is peculiar to itself and not foreign; and therefore it is so thoroughly cooked and digested as to become a natural part of it; so that the dryness runs and flows along with the moisture, and the moisture is held fast in the earthy dryness: just as Empedocles speaks of the joining of related heads and necks.[5]

But if it were digested by [moist heat (*epsesi*)],[6] as some unskilful alchemists say, undoubtedly there would be moisture outside as well as inside, and almost all the [inside] moisture would be[7] drawn out of it. But the opposite would be the case if it were digested by roasting (*optesi*), as some other people have unreasonably said; for then it would not be affected on the outside by moisture, but would have a little moisture left only inside it. Evidence of this is that metals which are not fully digested but suffer from a sort of rawness (*molynsim*)[8] are found to be either scaly,

[3] *coctum optesi*, an error for *epsesi*, since the following phrase is (correctly) *assatum optesi*.

[4] Albert is probably quoting Averroes's commentary on the *Meteorology*, but the explanation of these terms is in the original: *Meteor*. IV, 2–3 (379 b 10–381 b 23).

[5] Empedocles, as quoted by Aristotle in *The Heavens* (III, 2, 300 b 31) and *The Soul* (III, 6, 430 a 29) seems to have imagined that separate organs were first created and joined together at random; combinations that proved to be viable became living animals. But this quotation is not really relevant here, and the passage that Albert is paraphrasing (*Meteor*, IV, 4, 382 a 1) cites Empedocles (much more to the point) as saying that the combination of dry and moist is like 'gluing meal together with water'. I suspect that the (wrong) quotation was inserted as a gloss, where Albert had merely written 'as Empedocles says'.

[6] *optesi* again, in error for *epsesi*.

[7] I omit *non* since the point is (*Meteor*. IV, 3, 380 b 13 ff.) that in boiling (*epsesis*) the internal moisture is drawn out by the surrounding hot liquid, so that boiled meat, for instance, is drier than roast meat; in roasting (*optesis*) the internal moisture is held in by a dried-out surface crust. Albert rejects both of these, because in metals the 'moisture' (fusibility) is evenly distributed throughout, as in things digested or naturally ripened (by *pepansis*).

[8] *molynsis* (Meteor. IV, 3, 381 b 14) is, strictly speaking, the imperfect state of *epsesis*, 'imperfect boiling'.

like iron and copper; or imperfect, like lead; or else they have a 'stuttering'[9] mixture, like tin. These things will be made clear in the following [chapters].

CHAPTER 4: THE OPINIONS OF THE ANCIENTS ABOUT THE MATERIAL OF METALS

Albert now turns to alchemical theories, criticizing and rejecting those that cannot be reconciled with Aristotle's teachings. For notes on the alchemists mentioned, see Appendix D. The theories of Democritus and Gilgil are of particular interest, as showing how difficult it was for medieval chemists to understand what they were doing, or to analyse and identify their materials. Democritus shows a certain neat ingenuity evidently based on crude attempts at analysis: calx *is a residue left after burning (the prototype is quicklime, but some metals can be reduced to a* calx *of oxides in a hot fire); and* lixivium *is a solution obtained by pouring water through something that has been burnt (the prototype is lye made from wood ashes). Democritus apparently assumed that what was left after treating a metal thus with fire and water must have been* in *the metal to begin with, and therefore that recombining such residues should reconstitute the metal. Gilgil's theory was based on the analogy between glass and metal—an analogy much more convincing to the alchemists than to us. Both glass and metal come from earthy materials properly heated; both appear as glowing liquids that can be cast or plastically worked while still hot but harden on cooling. (The feeling that glass is almost a kind of metal persists in the glassmakers' term 'metal' for their molten mixture.) But Albert's counter-arguments are even less convincing to a chemist of today.*

WHAT Avicenna[1] said, both in his work, *The Physical [Stone]* and in the *Letter on Alchemy* which he wrote to Hazen the philosopher, does not disagree with the statements made here. For he says in both these books that Quicksilver and Sulphur are the material of all metals. For the moisture of which we have spoken, mingled with earthiness, as we have said, is the immediate material of Quicksilver; and the unctuous

[9] See IV, 4.

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[1] Avicenna (Appendix D, 9) wrote on physical science, but this seems to be a reference to *The Soul in the Art of Alchemy* (*De anima in arte alchimiae*, Manget, 1702, Vol. I, pp. 633–6); the final section is entitled *An exposition of the Physical Stone* (that is, the 'Philosophers' Stone' for transmutation). The *Letter to King Hasen* (Zetzner, 1613, Vol. IV, pp. 972–85) is quoted just below (note 4) and both works again in III, i, 9.

substance which we have described is the peculiar and essential material of Sulphur.

Hermes[2] and some others seem to say that metals are made up of all the elements, and this certainly cannot be denied. But nevertheless, the material of things is not defined merely by the constituents that happen to be present in them, but by those that are most abundant.

But the strangest and most ridiculous of all opinions is that attributed to Democritus in some alchemical works—namely that *calx* and *lixivium* are the material of metals. But if *calx* were the material—since *calx* [quicklime] itself is made by burning, and when mixed with water hardens like cement—then metal would become as hard as stone, and would be capable of being broken to pieces, but not of being liquefied; and moreover, on the application of fire, a metal would undoubtedly be hardened, as we see in [the case of] cement, rather than liquefied. And if *lixivium* means a sharp water, as the alchemists explain, which removes from a *calx* the saltiness and sharpness [formed by] burning, as the alchemists demonstrate with their solutions, then [the statement] that this water is the material of metals cannot be correct: because *calx* is an earthy substance; but according to what is reported in the *Meteorology*[3] we know that everything earthy, when it is burnt, has its pores contracted and closed; and *calx*, being of this sort, the entrance of Water into the interior of the *calx* is hindered, so that it never becomes well and firmly consolidated. This is why, if cement is attacked by fire, its moisture easily vanishes and it becomes powdery and falls out of a wall. Thus the statement of Democritus about the material of metals does not fit [the facts]. He was misled by insufficient evidence: for he saw that the *elixir* best for *luna*, that is, silver, began by taking in *calx* and *cerusa*,[4] and therefore he believed that there was something of the same kind in the physical and natural material of metallic bodies. This is not really necessary: for art has need of many things which nature does not need. But art does not need *calx* and *cerusa* except for producing proper hardness and colour; but nature accomplishes this in suitable material by digestion alone. For we

[2] See III, i, 6.

[3] *Meteor*, IV, 7, 384 b 21 gives this explanation for the solidity of baked earthenware.

[4] *Cerusa* is a white compound of lead, either natural or artificial (see IV, 3, note 7). It is recommended in Avicenna's *Letter to King Hasen* (op. cit. p. 980): 'Possibly we might take *calx* of *luna* (silver), and this is a white *cerusa* and it will be one of the things that cause whitening.' Since silver commonly occurs in lead ores and was refined by cupellation with lead, the notion that silver could somehow be produced out of lead was not entirely unrelated to fact.

have shown in the *Meteorology*[5] that all digestion or gentle heating causes solidification and thickening of the materials that have been cooked and digested, without anything from outside being added to them in the process.

But a certain Gilgil, of Moorish Seville, which has now been returned to the Spaniards,[6] in his *Secrets*, seems to prove that fused ash is the material of metals. He offers this unconvincing argument:—we see that by intense roasting by dry heat, ash is liquefied into glass, which hardens by cold and liquefies by dry heat, just like metal. Therefore it will be obvious that their material is the same, for things that show the same behaviour in hardening and liquefying seem to have the same kind of material, as the teaching of the *Meteorology*[7] shows, he claims. Moreover, we do not see earthiness made subtle, divided, and mixed with moisture, except by the extreme force of Fire, which makes it subtle and divides it so that it may be mixed with moisture: this is the behaviour of the earthiness that is burnt to ash in the moisture of metals. And therefore it seems to him that earthy ash is the special material of metals. And this, he says, is why all metals sink in water;[8] for they would not do this, he says, if unctuous moisture were predominant in them, as it is said to be. Furthermore, Gilgil adds, anything that contains unctuous moisture can be burnt up by Fire, as wood is; but not a single one of the metals can be set on fire or burnt up; and therefore [metal] does not appear to have unctuous moisture as its material. Therefore, he asserts, [metals] have earthy ash fused with watery moisture.

These arguments are unconvincing and stupid; for Gilgil himself was a mechanic and not a philosopher, and, relying too much on the mechanical [operations of] alchemy, he dared to make wrong statements about natural science. That he is quite wrong is clear from what is said in the *Meteorology*[9] about ashes. For there it is said that when water is poured upon ashes they do not retain it, because they are completely porous and allow the moisture that is taken in to escape. Therefore, if ash were the material of metals, it could never be stuck together by any moisture in them. Furthermore, we see that when fire acts on ashes the moisture distilled through them becomes yellow or red;[10] and therefore, if ash were the special material of metal, [fire] would impart a yellow or red

[5] *Meteor*, IV, 2, 379 b 33 ff.

[6] Seville was regained by the Christians in 1248.

[7] *Meteor.* IV, 10, 388 b 11 ff.

[8] See I, i, 2, note 1.

[9] Albert is quoting his own version, *Meteora*, IV, iv, 6.

[10] Colours due to oxides, probably of iron or lead, which might be present in many of the materials used.

colour to it; but we can prove by secret doctrine [that is, alchemy] that this is not so.

We deny, then, that the material that enters into the being of glass is ash. It is, instead, moisture of that very pure sort which is radical and intrinsic[11] in whatever is burnt to [make the] ash. It could not be completely extracted by the force of the fire that burnt it, but if the fire is extremely hot it flows out on the hearth as a frit. This is moisture that has been very intensely acted upon by dryness, as we have explained in the science of stones.[12] Therefore the material of liquefiable things—both the primary and the final material—is of one and the same kind, that is, moisture.

And if anyone were to say that [the material] cannot be mixed unless it is finely divided,[13] it must be stated that, once [the constituents are] freed, it is not the burning but the mixing that [brings about] the union of miscible things with each other, so that the most minute [portion of] Earth is mingled with the most minute [portion of] Water, and *vice versa*; and the largest [amount of] each with the largest [amount of] the other, and yet in such a way that neither one is separated from particles of its own kind. For one part of Earth is never found separated from the rest of the Earth, nor of Water separated from the rest of the Water. But this [occurs] in such a way that a large amount of one is so combined with [any amount], large or small, of the other that, as I have said, neither one is ever separated from the substance of its own kind. And this is what Gilgil did not understand.

As to what he says about metals sinking in Water, that is not satisfactory: the reason for this is not that there is an excessively great amount of dry, earthy ash in metals, but rather that the Earth is incorporated with the moisture and the pores are closed up [excluding][14] Air, because of the moisture. And this is why they all sink in Water.

Nor is his statement correct, about the unctuous moisture of things that can be burnt up by Fire. For in our *Physics* we have shown that what is oily and unctuous may be separated from such material and there will remain behind a subtle moisture that can [not][15] be burnt up by fire.

Let this, then, be an abbreviated account of the material of metals.

[11] See discussion of different kinds of moisture in the following tractate, III, ii, 5.

[12] See I, i, 9.

[13] *Gen. and Corr.* I, 10, 328 a 32 ff.

[14] *clausis poris aerem retinentibus*, 'with closed pores that *retain* the Air': this must be a mistake, since in I, ii, 6 Albert gives this as the reason why pumice *floats* on Water.

[15] I have inserted *non* (as in the 1518 edition). The reference is not to the *Physics*, but to Albert's version of the *Meteorology*, already cited: see III, i, 2, note 8.

CHAPTER 5: THE EFFICIENT CAUSE AND THE PRODUCTION OF METALS IN GENERAL

This chapter is parallel to I, i, 4–5, on the efficient cause *of stones. Albert here discusses again the effects of heat and cold, as the* instruments *directed by a power emanating from the stars, in the formation of metals, as in the formation of stones.*

LET us discuss the *efficient cause* in this way: on superficial consideration it appears that for all metals it is cold that brings them to their perfect specific form. It is by [cold] that they grow firm and solidify, and their solidification and firmness seem to bring them into being, while fusion dissolves and destroys them. Evidence of this is that in many or in all metals something[1] is separated from their substance when they are fused. But nothing at all is lost from them when they solidify. And for this reason many people declare that cold alone, which solidifies them, is the productive cause in metals. Moreover, in things that take on the specific form of life, there is nothing that limits and changes the material so as to produce its form, except heat; and therefore it may appear that it is the same with metals. And this appears all the more [probable], since metals retain their identity whether they are molten or solid. But if it were cold that conferred the specific form, metals would lose their identity except when solid and hardened. It seems, therefore, that cold is not the cause of the production of metals. Furthermore, hardening and solidification are phenomena of matter that happen in the same sense (*non aequivoce*) to many things, which are nevertheless of different specific forms and different natures; but there is no one substantial form that can in this way fit different things. From this and similar [arguments] it is established beyond doubt that cold does not impart specific form to metals. And yet certain philosophers, who have not thought deeply about the nature of metals, believe [this].

But since the material of all metals is moisture containing in it well-digested subtle Earth, which on being burnt gives off an odour of very foul-smelling[2] Sulphur; and since Sulphur is not produced except by

[1] Slag, or a scum of oxides on molten metal.

[2] I omit *non*, which must be misplaced (see note 5 below), since all accounts agree that sulphur *is* bad-smelling (*foetidus*). Metals were not clearly distinguishable from their ores, and ore minerals like silvery galena (lead and silver) or brassy chalcopyrite (copper) are sulphides which in smelting give off pungent fumes of sulphur dioxide.

heat, then it must be that heat, digesting and converting Earth and Water and mixing them together, is the cause that transmutes the material. And therefore heat will be the cause of the production of metals. Moreover, it has been stated in the *Meteorology*[3] that what thickens a fluid and makes it grow firm is heat that digests it; and it is established that since the original material of what we call metals is Water, [the fact that] it has something earthy mixed with it makes it grow firm and thicken into a metallic mixture. And this, as is clear from what has been said, is [the effect of] heat. Therefore heat must be the cause of the production of metals. Furthermore, we have often shown in the preceding books that the cause of mixing is heat. For according to their own natural motions, one element separates from another. For although Water of itself moves downwards, it moves upwards with respect to Earth; and Earth moves downwards with respect to Water. But since, then, it is not cold but heat that imparts a motion to the Earth in Water, so that it may be taken up and held fast, it must be heat that is the cause of the production of metals.

But on further consideration it will appear that heat alone cannot be the cause of their production; for as we have said in the book on the production of stones,[4] undoubtedly if heat alone were the cause, it could [not][5] act continuously without drying out the natural moisture and burning up the Earth. But we see that [the process] stops with the specific form of a metal. And therefore the heat itself must be merely the instrument directed towards an end—which is the form of a metal—without turning aside in its operation.

Furthermore, we find that many arts have been discovered, each of them carrying out its operations by means of an instrument adapted to the purpose. Thus cooks study boiling and roasting, and so with all others who attempt to convert materials by [other processes of] digestion. And it must be the same in nature, since [nature] in her operations, as in everything else, is more certain and more direct than any art. So undoubtedly there is a formative power in nature, poured into the stars of heaven, and this [power] guides towards a specific form the heat that digests the material of metals. For as we have said elsewhere, this heat has its right direction and formative power from the Moving Intelligence, and its efficacy from the power of light and heat emanating from the light of the

[3] *Meteor.* IV, 6, 383 a 14 ff.

[4] See I, i, 4–5.

[5] I insert *non*, which is required by the sense, as in the 1518 edition.

starry sphere and from the power that separates things that are alike from things that are different[6]—[that is,] the power of Fire.

For these three things are necessary where material is shaped into a specific form: first, the unsuitable materials must be consumed by the heat of Fire, which digests them; [for], there must be digestion, the combination, by their own natural heat, of the opposed passive properties [moisture and dryness]; and finally, when these have been removed from the material, the material must have a boundary imposed upon it, and be perfected in its specific form. And it is heat that has the power of doing this; but it would not have the power of imposing a boundary at all, except for the power of the boundary itself—that is, of the *form*, which is the boundary. And therefore the formative power must guide and control the heat that imposes the boundary. But this form is not the form produced in the material: therefore it must be the form of the First Cause that gives forms to all things in nature. And this cause is the Mover of the sphere, bringing forth natural forms through the motion of heaven and the qualities of the elements: just as the artisan brings forth the forms of his art through the use of axe and hammer. And for this reason Aristotle[7] says that the work of nature is like that of art, where a house comes from [the idea of] a house [in the mind of the builder], and health from [the idea of] health—by the reactions of heat and cold—in the mind of the physician.

This, then, is the particular cause that produces metals.

CHAPTER 6: THE ESSENTIAL FORM OF METALS

This chapter is parallel to I, i, 6 on the formal cause *of stones. The question What determines the form of a metal? is of fundamental importance in discussing the possibility of transmutation. Albert here reviews three theories: (1) the Platonic notion of* form *as number and proportion (an echo of the* Timaeus*); (2) the Hermetic attribution of* form *to the influences of the planets; (3) Avicenna's 'mineralizing power', already mentioned in I, i, 5–6.*

[6] *Gen. and Corr.* II, 2, 329 b 27. Albert refers to this again in his *Meteor.* IV, i, 1: 'If a single mass is composed of gold and silver and lead and iron and stones, and is heated, the heat will dissolve the mass and cause the stones to collect together with stones [that is, as slag], and the gold with gold, and each of the others with things of its own kind.'

[7] Aristotle often coupled together the examples of the builder and the physician in his discussion of *causes*, e.g. in *Phys.* II, 2, 194 a 22 ff.

THE essential form in all things is what gives them being, and in metals it seems to be something different from mere solidification; because [metals] are, as we have said, of the same number and kind, even when molten. For molten gold is still gold, and the same [is true of] silver and other metals. And this form, especially in metals, some people say, is the numerical proportion of earthly and heavenly powers. In certain alchemical books ascribed to Plato,[1] number or numerical proportion is called the form of a metal; and he postulates this proportion in the powers of the constituent elements, for he would produce everything from the proportion of earthly and heavenly powers. Now the power of Earth is cold and dry, but the power of heaven, according to his story, is that of the seven planets. Therefore if there is more of the power of Earth, according to its three properties [dryness, coldness and heaviness] than of [the power of] the planets, which send out light and nobility, then the result will be dark-coloured, heavy, and cold, as lead is. But if there is more of the heavenly power, and less of the potentiality of Earth, [the result] will be very bright and indestructible and somewhat more compact, and because it is compact, necessarily heavy; and in so far as this, or its opposite [is true], the proportion is said to be that constituting the specific form of gold. And in the same way, he says, the other [metals] are formed. For this reason they call the seven kinds of metals by the names of the seven planets: naming lead, *Saturn*; tin, *Jupiter*; iron, *Mars*; and gold, the Sun (*Sol*); copper, *Venus*; quicksilver, *Mercury*; and silver, the Moon (*Luna*); and declare that by the different numbers in their composition they acquire the constitutions of the seven planets.

Hermes, indeed, seems to have been the author of this opinion, although Plato later followed him in it. And the alchemists seem to have taken it from them, declaring that precious stones have the power of the [fixed] stars and constellations, and the seven kinds of metals have their forms from the seven planets of the lower spheres;[2] and thus the powers of the heavens are first in producing results on earth, making the planets, as it were, secondary [in importance]. In support of this declaration they say—what is indeed true—that the heavenly sphere imparts motion to Earth,[3] and this is the reason why things produced from Earth are so

[1] See Appendix D, 6. The theory of numerical proportions was adopted by some Arabic alchemists, for example *Jabir* (see Appendix D, 3).

[2] The sphere of the fixed stars is 'above' or outside the spheres of the planets, which are 'below', nearer to the earth.

[3] Earth is at the centre of the universe, so the rays of the heavenly bodies converge there with greatest effect. See also III, i, 10, note 17.

varied in their shapes and so numerous, as compared with things produced in any of the other elements. And Father Hermes Trismegistus seems to confirm this opinion when he says, 'Earth is the mother of metals and Heaven their father'[4] and 'Earth is impregnated with them in mountains, fields, and plains, and in waters',[5] and everywhere else. But we have understood this opinion to mean that the proportion of the powers of the elements—that is, both active [hot and cold] and passive [dry and moist]—is the predisposing cause of the substantial form, just as [it is] in everything else; since form is what is conferred by the formative and active principles, which are the primary active and formative powers in matter, as we have said in the science of stones.[6]

As to the attribution of the kinds of metals to the planets rather than to the other stars—this is said because stones are stable and the forms that they assume on hardening are attributed to the fixed stars and constellations, which keep their places and figures perpetually. By place I do not mean the position of a star in the sphere, since that changes for all stars, but rather its position in a constellation, with reference to other stars; for example, there are two bright stars, one in the *Horn of the Ram* (*Aries*) and the other called the *Knee of Perseus*, which are found in all seasons at the same linear distance from each other; and the same [is true of] other stars, for otherwise the constellations of heaven would be destroyed. Thus stones are found to be of the same constitution and shape as long as they endure. But metals have, as it were, a variable behaviour (*erraticum motum*), being sometimes fluid and sometimes solid. And since their material is liquid, and liquid has a variable behaviour, it seems to have something in common with the planets;[7] and the powers of the planets infused into the powers of the elements confer the specific form. And these powers, thus caused and infused, shape the specific form, in agreement with the forms of metals. In just the same way the formative power in the seed of animals is in agreement with the form conferred by reproduction, and similarly, the form of an art agrees with the artifact.

[4] This appears to be a quotation from another version of the *Emerald Table* (see Appendix D, 7).

[5] This is from Hermes's *Book of Alchemy* as quoted by Arnold of Saxony (Stange, p. 42): 'The stone which is necessary for our work is found in the plain, in mountains, and in all waters.' It is also in the text accompanying the *Emerald Table* printed by Steele and Singer (1928, p. 52). In both it is associated with other quotations from Hermes.

[6] I, i, 5–6.

[7] Greek *planetes*, Latin *errantes*, 'wandering', because the courses of the planets do not keep pace with the apparent revolution of the fixed stars.

And in this way what the Platonists say is true: for in this way the First Cause sowed the seed of all forms and species and entrusted the perfecting of it to the fixed stars and planets, as is told in the *Timaeus*.[8] And this is the reason why the number and properties and specific forms of the metals are held to agree with the planets. For we know from what is reported in the *First Philosophy*[9] of Aristotle that all things are produced from suitable material: although it may not be entirely suitable to the Idea, Form, and Purpose. And in this way all spontaneous generation can be reduced to natural generation.

As to what Avicenna seems to say—and some people falsely attribute this to Aristotle[10]—namely, that sometimes an earthy force produces forms of this sort: it is not known what this earthy force is, if it has only the potentialities of Earth; for it acts by means of other [elements, too]. For we know that what confers form has something in common with that [form], inasmuch as Aristotle says[11] that the soul is in the seed, just as the artisan is in the artifact. But the philosopher [Avicenna] calls this earthy force simply 'an earthy force in the place where metals are produced'. Yet it contains within itself heavenly powers, in the way we have explained, although perhaps it must be admitted that an earthy force that acts by cold and dryness [must act] in another way to harden moisture by thickening it [until it has] the nature and conformation of Earth. But in no way can dryness and cold be said to cause a strong and tenacious mixture such as we know exists in the material of metals. Furthermore, the earthy force, thus defined, agrees only with the specific form of Earth, and therefore it would not confer the form of [another][12] element; because it is certain and proved that everything is produced by a related cause, which is figuratively called by the same name (*aequivocata*). This is so in all pro-

[8] *Timaeus*, 41–43: The Demiurge endowed the stars with souls, and then entrusted to them the creation of mortal things.

[9] *Metaphysics*, VII, 9, 1034 a 9 ff.: Aristotle distinguishes three kinds of generation: (1) natural, the production of a thing from something of the same kind (Latin *univoca generatio*), e.g. a horse from a horse; (2) spontaneous, the production of a thing from something of a different kind (*aequivoca generatio*), e.g. worms from decaying flesh; (3) artificial, the production of works by an artisan. But the argument here seems to be that (2) and (3) are not really completely different from (1), since the material must be 'suitable', that is, it must have something in common with the *form* to be produced; so in that sense it is 'something of the same kind'.

[10] Avicenna's *De congelatione* (Holmyard and Mandeville, 1927) was sometimes attached to the *Meteorology* and thought to be part of Aristotle's work. This has already been cited in I, i, 2–3.

[11] See Albert's discussion in I, i, 5.

[12] *illam formam*: but 1518 ed. has *aliam formam*.

duction of stones and metals, for stone is never produced from stone, nor metal from metal. And if it is said that one stone conceives another,[13] yet it is not to be thought of as being produced by its own seed, but rather from some other material, whatever it may be—unless perhaps there is something intermediate between stone and plant, just as there are many things intermediate between plant and animal, such as the sponge, sea-cucumber, etc.

CHAPTER 7: THE OPINION OF CALLISTHENES, WHO POSTULATED ONLY ONE FORM OF METAL

Albert's 'Callisthenes' is a mistake for Khalid ibn Yazid ibn Muawiya (see Appendix D, 8), and the work cited is the Book of the Three Words (Liber trium verborum, *Manget, 1702, Vol. 2, pp. 189–91*), *which begins thus:*

Alchemy is the art of arts, the science of sciences, discovered by Alchinus. And chimia *in Greek means* massa *in Latin. By this art metals which are imperfect in their ores are brought to perfection, from corruption to incorruption. For just as a child in its mother's body, because of the corruption of a womb that is diseased and corrupt, although the sperm was healthy, becomes leprous and corrupt, so it is in metals, which are corrupted by nature, from corrupt sulphur or in fetid water. Because nature intended to make gold* (sol) *and silver* (luna), *in the place where they originated, but was unable to do so. And therefore metals are actually corrupt, as was said above.*

Khalid also held the doctrine of 'occult' and 'manifest' properties which Albert criticizes in the next chapter (III, i, 8).

THE experience of the alchemists, however, here confronts us with two grave doubts. For they seem to say that the specific form of gold is the sole form of metals, and that every other metal is incomplete—that is, it is on the way towards the specific form of gold, just as anything incomplete is on the way towards perfection. And for this reason metals which in their material have not the form of gold must be 'diseased'; and [the alchemists] try to find a medicine which they call *elixir*, by means of which they may remove the diseases of metals in their blending and ingredients; and thus they speak of 'bringing out' the specific form of gold. And for this [purpose] they invent many different methods for compounding and blending this *elixir*, so that it may penetrate and attack the metal, and remain [unaffected] in the fire, and impart colour, solidity, and weight.

[13] But see II, ii, 14, *Peranites*.

Therefore we must make some inquiry here into these [methods]. For if the statements of these authors are true, then undoubtedly there will be only one form of metal [that is, gold], and all other metals suffer from 'under-cooking' (*molynsis*),[1] and are like abortions of nature which have not yet attained their proper specific shape. And accordingly, if this is found to be truly proved, we need not labour [the question] whether the different kinds of metals are transmutable by alchemy or not: for according to this [view], no metal has any specific form except gold, which alchemy does not transmute.

Callisthenes, a prominent [upholder] of this opinion, says that alchemy is the science that confers upon inferior metals the nobility of the superior ones. In order to discuss this question properly I have examined many alchemical books, and I have found them lacking in [evidence][2] and proof, merely relying on authorities, and concealing their meaning in metaphorical language, which has never been the custom in philosophy. Avicenna is the only one who seems to approach a rational [attempt], though a meagre one, towards the solution of the above question, enlightening us a little.

As to the statement that the specific form of gold is the only form of metals, this is their reasoning: things composed of the same constituents mixed in the same way seem to have only one form. Now since, as Plato says,[3] forms are given to matter according to its capacity; and since, as we have said earlier, things have their origin in suitable material, therefore it is impossible that anything made from the same materials mixed in the same way should show many different specific forms. But all metals are mixtures of subtle sulphurous Earth with a radical moisture from which the oily part and the superfluous wateriness have been separated, as has been shown earlier.[4] It seems, therefore, that there is only one specific form corresponding to this set of conditions. Moreover, it is found by experience that by means of the *elixir* copper turns to silver, and lead to gold, and iron likewise to silver. It appears, then, that they are the same in material and consequently have only one form, which, as it were, perfects the pre-existing material. Moreover, they seem to differ only in accidental properties[5]—that is, in colour, taste, weight, greater or lesser

[1] *molynsis*, imperfect cooking by moist heat, *Meteor.* IV, 3, 381 a 12 ff.

[2] *sigillo*, for *signo: signum* is Albert's usual word for 'evidence'.

[3] Cf. I, i, 5, note 1.

[4] See III, i, 2.

[5] These are treated in III, ii.

compactness—and these accidental properties depend only on their material. From these and similar [arguments], then, [the alchemists] arrive at their opinion, and say that the specific form of all metals is one and the same, but the diseases of the material are many.

But the opposite of this seems [to be true]. For there is no reason why the material in any natural thing should be stable in nature, if it were not perfected by a substantial form. But we see that silver is stable, and tin, and likewise other metals; and therefore they seem to be perfected by substantial forms. Moreover, if the properties and passive qualities of things are different, their substances must be different. And the passive qualities of metals—their colours, odours, and sounds [when struck]—are altogether different; and it cannot be said that these accidental qualities are common to them all; although they are always and everywhere alike in all metal of one and the same nature. And therefore the substances and specific forms [of different metals] must be different. Moreover, if the fact that things are compounded of the same materials requires their specific forms to be the same, then everything that is produced would be of one and the same specific form, because everything is produced from the elements. It is obvious, then, that this reasoning based upon the constituent elements is unsound. For the varied forms of things are attributed to the varied proportions of their constituents; and in metals there are variations both in the constituents and in the blending, as we shall demonstrate below, when we speak of the metals individually.

And as to the experiments[6] which [the alchemists] bring forward, not enough proof is offered: because it is not certain whether [their procedure] induces the colour, weight, and odour of silver and gold, by means of whatever is added to and penetrates into copper and lead, or whether it induces the actual substance of silver and gold. And Callisthenes ought to have supplied proof that it would induce the actual substance of gold. But even if we admit that perhaps it does induce the substance of gold, still this does not satisfactorily prove that there is only one specific form of metals. For by calcination, sublimation, distillation, and other operations by which the alchemists cause the *elixir* to penetrate into the material of metals, it may be possible to destroy the specific forms of metals that originally were in their material: and then the material that is left, being

[6] *experimentum* usually means 'what is learned by experience or casual observation; but it was beginning to take on the meaning of the modern 'experiment' or laboratory procedure. The latter seems more appropriate for the operations of alchemy.

in a general sense metallic, but not the material of any specific metal, can,[7] with the help of art, be reduced to another specific form, just as seeds are helped by ploughing and sowing, or nature is helped by the efforts of the physician.

It is obvious from this that we are by no means forced to think that there is only one specific form for all metals; for we find that the places where they are produced, and their constituents, and their passive qualities, all differ widely; and that this is the result of accident is by no means certain. For, as we have just now stated, these accidental qualities are not common to all [metals], but they themselves indicate substantial differences by which they are produced in the material of metals.

CHAPTER 8: THE OPINION OF HERMES AND OTHER PHILOSOPHERS WHO SAY THAT IN ANY METAL THERE ARE SEVERAL FORMS

For notes on the alchemists cited here, see Appendix D. But it is not clear what relation (if any) there is between Gilgil's theory of the constitution of metals (III, i, 4) and the subject of the present chapter. Empedocles and Anaxagoras are mentioned by Aristotle, and appear as alchemists in the Turba philosophorum. *But the ascription of this theory of transmutation to Empedocles must be the work of a later writer; or perhaps Empedocles (like Callisthenes in III, i, 7) is a mistake for some other name. What is said of Anaxagoras, however, is based on Aristotle's criticism of his theory that everything contains within it 'seeds' or particles of everything else—e.g. flesh and bone are somehow already present in food, &c. It was, I think, Albert himself who sought to emphasize any similarity between this and the alchemical doctrine of 'occult' qualities in metals, because this enabled him to bring Aristotelian arguments to bear. Finally, it must be noted that this theory is not really 'opposed' to that of the preceding chapter: Callisthenes-Khalid also mentions it (see note 1 below).*

HERMES and Gilgil and Empedocles and almost all that group of alchemists seem to defend an opinion which is opposed to this. For they say that in any metal whatever there are several specific forms and natures, postulating one that is occult and one that is manifest, or one inside and another outside, or one in the depths and another on the surface—like

[7] I have omitted *non*, since Albert is stating a familiar alchemical theory—that metals *can* have a new specific form imposed on them.

those who speak of the 'latency' of forms, and say that 'all things contain all things', as Anaxagoras believed. For they say[1] that lead is gold inside and lead outside; but gold, on the other hand, is gold outside, on the surface, but inside, in the depths, it is lead. And copper and silver are related to each other in the same way, and so is almost any metal at all to any other. And this seems a strange statement.

For a *homeomerous* substance has the same specific form, inside and outside, occult and manifest, in the depths and on the surface. And it is established that metals are included in the [group][2] of *homeomerous* things. Thus what [these alchemists] say seems to be quite absurd. Furthermore, they say that they do not use the terms 'inside' and 'outside', and the rest, with reference to the situation of parts in the whole, but rather with reference to the properties and natures of 'dominants' and 'subordinates'; for a 'dominant' encloses and conceals whatever it dominates. And accordingly, they state exactly the thought of Anaxagoras—namely, that all metals are in all metals, and identification is made according to the 'dominant' one.

Moreover, we know that gold is not burnt by fire, but lead is, especially if sprinkled with sulphur; but if this statement of theirs were true then when fire is applied to lead, [the lead] ought to be burnt up, and the occult gold in it ought to be left. But we do not see this happen. And similarly, silver is protected by lead[3] from being burnt; but then, if the lead were completely consumed, the silver that was in the lead ought to be left, according to what they say—unless perhaps there is in any metal an infinite amount of every other metal, as Anaxagoras said. But in that case, none of them could be completely consumed by fire. But we have disproved this at the beginning of our *Physics*.[4] Besides, if we admit that this is true, it would never be possible to burn away the visible metal by

[1] Examples of this are numerous: *Book of the Three Words* (Manget, 1702, Vol. 2, pp. 189–90): 'This work inquires into the moist and cold, in which the hot and dry are occult, and this we need to know in order to make occult what is manifest, and make manifest what is occult.' More specific statements occur in Rhasis's *Book of Alums and Salts* (Steele, 1929, p. 31): 'What is occult in gold is manifest in silver, and what is manifest in gold is occult in silver' (p. 37): '[Copper] is manifest copper and occult silver' (p. 41): 'Since it is established that lead (*Saturn*) is one of the cold dry bodies, therefore its occult [nature] is undoubtedly gold (*sol*); because what is manifest in it is cold and dry, and what is occult in it is moist and warm.'

[2] *generatione*, error for *genere*. Metals are classified as *homeomerous* things in *Meteor.* IV, 10, 388 a 12.

[3] In refining silver by cupellation with lead.

[4] *Phys.* I, 4, 187 b 22 ff., where Aristotle refutes the theory of Anaxagoras.

fire, so that the occult [metal] could be freed and made manifest. And then the whole study of alchemy would be in vain. Therefore this statement is not in agreement with the scientific reasoning which we have established in all our books.

But perhaps they say this because of the close relationship among the metals, which [depends] on their materials. For lead contains superfluous watery moisture and has a sort of combustible fatness, and an earthiness that is not well blended with the Water, nor yet well purified. [And all this] is consistent with [the fact that] sometimes, through the industry of wise men, by means of fire, the superfluous watery moisture is extracted from it by evaporation, and all the fatty oiliness in it is burnt up, and the sulphurous earthiness in it is purified by sublimation, and the vapours are blended in some container that condenses earthy vapour with radical moisture into a good, firm mixture; and by the force of heat, the moisture is changed to a yellow colour,[5] and then it has the lustrous colour of gold. For this way of art is like the way of nature, as we shall explain later.

But even though this may be true, nevertheless it is no reason for saying that lead is gold 'in the depths'; because, granting that it is gold which thus [comes out] shining from lead, yet we already know that these transmutations completely destroy the lead. Therefore, since the specific form was that of lead, the specific form of gold was never simultaneously present in the same material. And this will appear all the more true, if what comes from the lead is not proved to be gold. Perhaps it is something like gold, but not [real] gold; because art alone cannot confer substantial form.

Besides, we have rarely or never found an alchemist, as we have said, who [could] perform the whole [process]. Instead, by means of the yellow *elixir* he produces the colour of gold, and by means of the white *elixir*, a colour similar to silver, attempting to make the colour remain fast in the fire and penetrate throughout the whole metal, just as a spiritual substance[6] is put into the material of a medicine. And by this sort of operation a yellow[7] colour can be induced, leaving the substance of the metal unchanged. So again, [it is clear that] there are not several forms of metals present in each other.

[5] From the description, here and in III, i, 10, this would seem to be litharge, an oxide of lead.

[6] 'Spirits' prepared by distillation.

[7] *flavus* in this one instance surely means 'yellow' (for which Albert usually says *citrinus*). Elsewhere *flavus* has been printed for *blavus*, 'blue'. See I, ii, 2, introductory note.

These, then, and the like, are the arguments against the statements of those who say that the specific form of any metal whatever is present in any other.

CHAPTER 9: WHETHER ONE FORM OF METAL CAN BE TRANSMUTED INTO ANOTHER, AS THE ALCHEMISTS SAY

The greater part of this chapter agrees closely, even verbatim *in places, with the Paneth manuscript entitled* Metals and Alchemy *(see Introduction: 'Date of Composition of the* Book of Minerals*').*

The quotations of Avicenna come from three different works: De congelatione *(Holmyard and Mandeville, 1927);* Ad Hasen regem epistola *(Zetzner 1613, Vol. 4); and* De anima in arte alchimiae *(Manget, 1702, Vol. 1). For notes on these see Appendix D, 10.*

ON the basis of all the foregoing [arguments], we are now able to consider the truth of the statement which some ascribe to Aristotle, although in truth it was made by Avicenna[1]—namely, 'Let practitioners of alchemy know that they cannot transmute one form of metal into another, but only make something similar, as when they colour a red [metal] with yellow, so that it may appear to be gold; or whiten it until it is similar to silver', or gold or whatever substance they want. As to the rest, that is, 'that the specific differences between metals may be removed by some clever method, I [Avicenna] do not believe it is possible. But it is not impossible to remove accidental properties, or to diminish the steps between them'—this is the opinion of Avicenna, which he expressed to Hasen,[2] a philosopher distinguished in natural and mathematical sciences.

But Avicenna in his [*Letter to Hasen on*] *Alchemy* says that he found [trivial] the counterarguments of those who, in their alchemical [books,]

[1] The quotation here is from *De congelatione* (pp. 54–55), although Albert seems to refer it to the *Letter to Hasen.*

[2] *Hastem*, for *Hasen*, whom Albert probably supposed to be the tenth-century Arabic author of a famous book on Optics. In the next paragraph he paraphrases part of the *Letter to Hasen* (p. 972): 'I have considered the books of those who uphold the art [of transmutation], and found them empty of the reasoning which is a portion of every art, and discovered that most of what is in them is nonsense. And I have examined the books of those who oppose it, and found their counterarguments feeble and their reasoning trivial, and not such as to destroy [belief in] the art.'

denied the transmutation of metals. And for this reason he himself adds that 'specific forms are not transmuted, unless perhaps they are first reduced to prime matter (*materia prima*)'[3]—the [indeterminate] matter of [all] metals—and then, with the help of art, developed into the specific form of the metal they want.

But then we must say that skilful alchemists proceed as skilful physicians do: for skilful physicians, by means of cleansing remedies clear out the corrupt or easily corruptible matter that is preventing good health—for good health is the end which the physician has in mind—and then, by strengthening nature, they aid the power of nature, directing it so as to bring about natural health. For thus undoubtedly health will be produced by nature, as the efficient cause; and also by art, as the means and instrument.[4] And we shall say that skilful alchemists proceed in entirely the same way in transmuting metals. For first, they cleanse thoroughly the material of quicksilver and sulphur, which, as we shall see, are present in metals. And when it is clean, they strengthen the elemental and celestial powers[5] in the material, according to the proportions of the mixture in the metal that they intend to produce. And then nature itself performs the work, and not art, except as the instrument, aiding and hastening the process, as we have said. And so they appear to produce and make real gold and real silver.

For whatever the elemental and celestial powers produce in natural vessels[6] they also produce in artificial vessels, provided the artificial [vessels] are formed just like the natural [ones]. And whatever nature produces by the heat of the sun and stars, art also produces by the heat of fire, provided the fire is tempered so as not to be stronger than the self-moving formative power in the metals; for there is a celestial power

[3] This is again from *De congelatione* (p. 55). But similar statements about *materia prima* occur in the *Letter to Hasen* (p. 980) and in *The Soul in the Art of Alchemy* (p. 635).

[4] *organice et instrumentaliter*. Cf. *The Soul in the Art of Alchemy* (p. 634):

The matchless skill of the Philosophical art does not, as the ignorant generally charge, seek to make gold and silver from nothing (*de novo*), because these are always formed by nature in the bowels of the earth. But the alchemist (*artifex*) acts only as the means and instrument (*organice at instrumentaliter*), calling forth the form of gold from matter already so-disposed, setting nature in motion, so that by the blending and gentle heating of art, it may be stirred and developed from potentiality to actuality.

[5] The 'elemental powers' are the matter. The 'celestial powers' can be strengthened by operating at chosen times: for instance, the *Book of the Three Words* (Manget, 1702, Vol. 2, p. 190) recommends: 'First, when the Sun enters Aries and is in his exaltation. Second, when the Sun is in Leo. Third, when the Sun is in Sagittarius.'

[6] *in vasis naturalibus*: these 'vessels' are, as III, i, 10 makes clear, the fissures and pores in the rock where ores are formed.

mixed with it in the beginning, which may be deflected towards one result or another by the help of art. For the celestial power is widespread, and its effects are determined by the powers of whatever it acts upon in mixtures. For this is the way we see the celestial powers acting in the whole of creation, especially in things produced from putrefaction.[7] For in these we see the powers of the stars influencing the powers in the material so as to produce something for which it is suitable. And alchemy also proceeds in this way, that is, destroying one substance by removing its specific form, and with the help of what is in the material producing the specific form of another [substance]. And this is because, of all the operations of alchemy, the best is that which begins in the same way as nature, for instance with the cleansing of sulphur by boiling and sublimation, and the cleansing of quicksilver, and the thorough mixing of these with the material of metal; for in these, by their powers, the specific form of every metal is induced.

But those who colour [metals] white with white, or yellow with yellow [colouring], leaving the specific form of the original metal unchanged in material—without doubt they are deceivers, and do not make real gold and real silver. And yet they nearly all follow this method, completely or partly. For this reason I have had tests made[8] on some alchemical gold, and likewise silver, that came into my possession; and it endured six or seven firings, but then, all at once, on further firing, it was consumed and lost and reduced to a sort of dross.

All this, then, is our account of the nature and specific form of metals in general.

CHAPTER 10: THE PLACES WHERE METALS ARE PRODUCED

Albert here makes plainer than in the parallel discussion on stones (I, i, 7–8) that place *is the 'mould' that determines the* form, *as well as the 'vessel' that contains the mineral. This is one of his most interesting chapters, because he incorporates in his explanation of ore genesis information obtained by talk with prospectors and miners, or by observations made during his own travels (see Introduction:*

[7] See I, i, 2, note 10.

[8] *ego esperiri feci.* Partington (1937, p. 12) suggested this translation, since he believed that Albert was not himself an adept skilled in chemical manipulations.

'Date of composition of the Book of Minerals'). *Some of these I have supplemented by references to the German mining expert, Georgius Agricola, who, although he lived some three hundred years later than Albert, described mining districts that Albert must have visited and a technology that was only beginning to be 'modernized' in 1556, when his* De re metallica *was published.*

Many of the mines that Albert saw must have been comparatively new, exploiting the minerals in the zones of weathering and secondary enrichment. Once these rich deposits had been worked out, mining of the poorer ores below the water table was hampered by difficulties with drainage.

Finally, it is of interest that Albert, while not denying the importance of 'heavenly influences', is here more concerned with local, physical processes, and insists that these can best be explained by comparison with alchemical operations—since 'Art is an imitation of nature'.

NOW we must add something about the places where metals are produced, since the place has a great effect on metals, as it does on stones, as we have already said.

We have seen pure gold formed in the sands of rivers in different countries, and in our own country both in the Rhine and the Elbe.[1] We know also that in our own country and that of the Slavs[2] gold is found formed in stones in two ways: the first way is that it seems to be incorporated with the whole stone,[3] and the stone has the character of *topasion* which is not transparent, or of golden *marchasita*; and [the gold] is extracted from the stone after roasting, [by crushing it] in a mill[4] made of

[1] Mining alluvial gold was described by Theophilus (probably in the twelfth century) in his *De diversis artibus*, III, 49 (translation by Hendrie, pp. 268–9):

OF GOLD SAND. There is another gold, which is called sandy (gold), which is found upon the banks of the Rhine in this manner. The sands are dug up in those places where there is an expectation of finding it, and are put upon wooden tables. Then water is frequently and carefully poured upon them and, the sand flowing away, a very fine gold remains, which is replaced in a small vessel separately. And when the vase is half full, quicksilver is placed in it and it is rubbed strongly with the hand until it is quite mixed together, and thus placed in a fine cloth, the quicksilver is squeezed from it; but what remains is placed in a crucible and melted.

This is a description of the amalgamation process. The gold is dissolved in the quicksilver, from which it is later separated by heating.

[2] Silesia during the latter half of the twelfth century was a 'frontier land' for German settlers, some of them miners who were attracted by the mineral wealth.

[3] This is a sulphide ore body—auriferous pyrite or chalcopyrite—as may be inferred from the statements that (1) it looked like *topasion* (II, ii, 18) or *marchasita* (II, ii, 11 and V, 6); and (2) the ore was roasted before the gold was extracted.

[4] Ore was crushed with millstones like those used for grinding grain. Stamp mills came into use only in the sixteenth century, according to Hoover (in Agricola, *De re metallica*, note on p. 281; and pictures on

large and very hard flintstones, and by burning it in the burning heat of a strong fire. Also we have seen gold formed in stone, not incorporated with the whole stone, but as a sort of vein[5] traversing all or part of the substance of the stone; and this is torn out of the stone by digging and purified by fire.

And we have found silver formed in four ways, and perhaps it is formed in still more ways in other countries. But these four ways we have found in Teutonia; for I myself have found it incorporated with the whole stone[6] from which it is separated by roasting, crushing, and fire, as has been explained for gold incorporated with stone. I myself have also found it as a sort of vein[7] extending throughout the substance of the stone; and this was somewhat purer, but still had some stony *calx* mixed with it. And it is found in earth as a sort of vein purer than any found in stone; for in the place called Freiberg—which means 'Free Mountain'[8]—it is sometimes found as soft as a firm mush[9]; and this is the purest and best kind of silver, having very little slag, as if it had been purified by the industry of nature.

Iron, too, is found incorporated with stones;[10] and it is also found in watery earth like grains of millet.[11] It has much slag, and is purified by

pp. 294, 296, showing mills of the type probably used in Albert's time).

[5] Native gold in quartz gangue; see description of a vein in III, ii, 6.

[6] This, too, is a sulphide ore, undoubtedly galena (lead sulphide), which may contain a good deal of silver. Such ore occurs at a number of places in the Rhine Highlands, where it was worked under the Roman occupation or even earlier. In the thirteenth century the Emperor Frederick II granted a loan on the 'Cologne Pits' near Ems; and the Lüderich mine, in the Berg district, is said to have been worked by Archbishop Conrad von Hochstaden to raise money for rebuilding Cologne Cathedral (Beyschlag *et al.*, pp. 702, 696). These may have been among the mines known to Albert.

[7] This was probably a network of veinlets characteristic of secondary enrichment, containing such minerals as argentite, pyrargyrite, &c.—which are, as Albert says, 'purer' in that they contain a higher percentage of silver than the argentiferous galena from which they are derived by leaching.

[8] *qui dicitur Vuriebeg, quod sonat liber mons.* The organization of the 'free companies' of miners, as it existed in the sixteenth century, is described by Agricola (*De re metallica*, Book IV). Silver had been discovered at Freiberg about 1170 (*op. cit.* pp. 5–6, footnote by Hoover citing Agricola's *De veteribus et novis metallis*).

[9] A mixture of soft lead and silver minerals formed by surface weathering of argentiferous galena. See further in IV, 5.

[10] Of the oxide ores, magnetite, which is black, 'looks like' iron, while hematite, goethite, and limonite, which are dark red to yellowish brown, were probably recognized by their 'rusty' appearance. Carbonate ore, siderite, is also brownish. Such deposits are widespread in the Rhine Highlands, the Harz, and the Swabian Alb. Many are of low grade, but were used locally in the small-scale operations of medieval times.

[11] Bog iron ore, a colloidal mixture of hydrous oxides of iron, probably formed by the agency of bacteria. It occurs in swamps, shallow lakes and rivers, especially in wetter parts of the north German coastal plain.

many strong hot fires, which force it to distil out of the substance of the earth or stone, with the very bowels of which it seems to be united.

Copper is also found in veins in stones; and that which is at the place called Goslar[12] is the purest and best, and is incorporated with the whole substance of the stone,[13] so that the whole stone is like golden *marchasita*; and that which is deeper down is better because it is purer.

Lead and tin are found incorporated with stones,[14] and quicksilver is found running out[15] in the same places.

And when the stones are fired, sulphur[16] oozes out, especially from stones containing copper, like those in the place called Goslar.

The natural scientist seeks to understand the cause of all these things; and, as we have said in the science of stones, the place produces things located in that place because of the properties of heaven poured into them by the rays of the stars. For as Ptolemy[17] says, in no place does any of the elements receive so much of the rays of all the stars as in Earth, because [Earth] is the invisible centre of the whole heavenly sphere; and the power of the rays is strongest where they all converge; and therefore Earth is productive of many wonderful things.

In order to know the cause of all the things that are produced, we must understand that real metal is not formed except by the natural sublimation of moisture and Earth, such as has been described above. For in such a place, where earthy and watery materials are first mixed together, much that is impure is mixed with the pure, but the impure is of no use in the formation of metal. And from the hollow places containing such a mixture the force of the rising fume opens out pores, large or small, many or few, according to the nature of the [surrounding] stone or earth;

[12] Goslar, the old imperial city at the north front of the Harz Mountains, owed its importance to silver mining which began in the tenth century (Agricola, *De re metallica*, p. 37 and Hoover's footnote citing *De veteribus et novis metallis*). Albert had certainly visited Goslar, and it is odd that he often speaks of the copper, but never of the silver, that was mined there.

[13] Chalcopyrite occurs at Goslar, along with pyrite, as well as ores of lead (containing silver) and of zinc.

[14] The lead ore is galena (see note 6 above). For tin, see IV, 4.

[15] Mercury is not common in Germany, occuring only in a few enriched silver veins. The great source of mercury, in medieval as in ancient times, was Spain, and it is possible that Albert took this information from the work of some Spanish alchemist, as well as the report that mercury can be extracted from a stone (cinnabar) in IV, 2.

[16] Sulphur is of course present in all sulphide ores, but when these are roasted the sulphur is oxidized and passes off as the acrid gas, sulphur dioxide. If Albert means *liquid* sulphur, this could only be obtained under reducing (rather than oxidizing) conditions. But see III, ii, 5, note 8.

[17] Ptolemy's *Tetrabiblos*, I, 2, 2.

and in these [pores] the rising fume or vapour spreads out for a long time and is concentrated and reflected; and since it contains the more subtle part of the mixed material it hardens in those channels, and is mixed together as vapour in the pores, and is converted into metal of the same kind as the vapour.

And evidence of this is that in all such veins the [outside][18] is smoky and ignoble; and if the metal is incorporated with the whole stone, the upper part is full of slag, and useless, while the inside is better and more noble. The reason for this is undoubtedly that [the part of] the material which is set on fire and burns and blazes ascends higher up and is incinerated, like a sort of slag and ashes;[19] and therefore it is found to be rather dry and friable and brittle. But that which is concentrated in the bowels of the stone is thoroughly mixed together and not burnt; and thus it is solidified by a gentle, slow heat, and afterwards hardened by the cold of the earth.

And if the surrounding place is compact and not porous, then the vapour makes one passage, or two, or more, according to its force and quantity; and according to the softness of the place, the vapour either makes a passage through it or fails to do so, fills it, and is converted into metal. For it has great power of penetration.

Evidence of this is that when hot metal is poured out on earth it penetrates by different ways into the earth. This is like the figure of the vessel[20] [Plate II]: the first place in which the metal is received is the circle ABC, and one vein full of metal from the vapour is the line CD, and another is the line AG, and in the same way it is formed along many lines.

But if the whole substance round about is filled with minute pores, then the material evaporates into the whole substance of the surrounding body and fills it; and being concentrated in all its pores, is converted into

[18] *interius*, probably an error for *exterius*, since the rest of the paragraph is undoubtedly a description of the weathered crust, called *Eisenhut* ('iron cap') by the German miners, which is found on the *outside* or *upper part* of an exposed sulphide ore body. It is composed of black or brownish residual iron oxides, other metals having been leached out and concentrated in the zone of secondary enrichment below. The untrained observer would not imagine that it had any connexion with valuable ores; so the fact that Albert considers it actually a part of the ore body, and includes it in his explanation of ore genesis, is good evidence that he had talked with miners and prospectors.

[19] Albert is thinking of smelting operations, where the impurities rise to the top as slag, and the metal collects below. The 'iron cap' is generally rough and porous, and does indeed look rather like scoria or slag.

[20] These figures are not in the printed texts, but they appear in a manuscript in the Bodleian Library (Ashmole 1471, fol. 33 v). See Plate II.

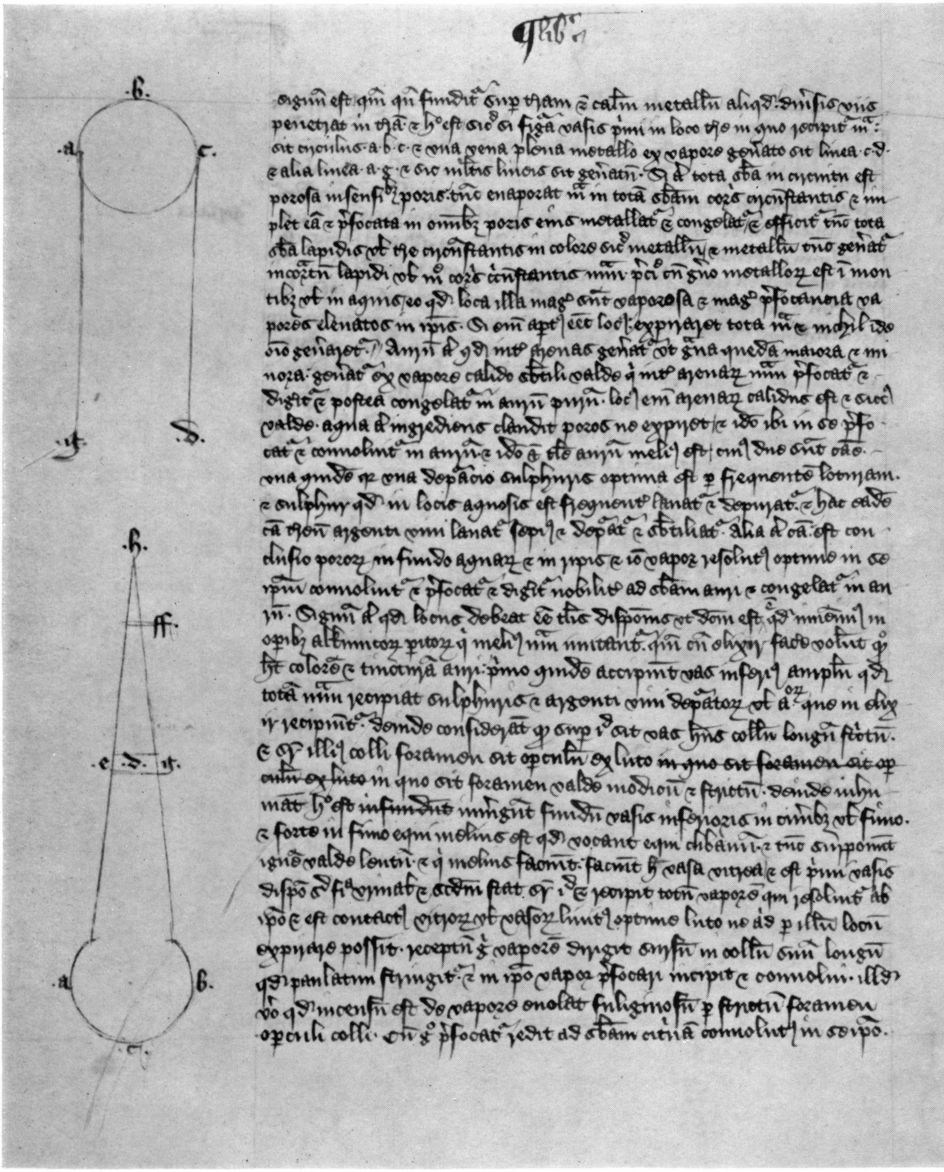
metal and hardens. And then the whole substance of the surrounding earth is coloured like metal, and then metal is formed incorporated with the surrounding stone or material. [This happens] especially if the formation of metals occurs in mountains or waters, because these places are more full of vapours and more active in concentrating the rising vapours. For if the place were wide open all the material would escape and nothing at all would be formed from it.

But gold which is formed in sands,[21] as a kind of grains, larger or smaller, is formed from a hot and very subtle vapour, concentrated and digested in the midst of the sandy material, and afterwards hardened into gold. For a sandy place is very hot and dry; but water getting in closes the pores so that [the vapour] can not escape; and thus it is concentrated upon itself and converted into gold. And therefore this kind of gold is better. And there are two reasons for this: one is that the best way of purifying Sulphur is by repeated washing, and the Sulphur in watery places is repeatedly washed and purified; and for the same reason the earthy Quicksilver is often washed and purified and rendered more subtle. Another reason is the closing of the pores underneath the water along the banks; and thus the dispersed vapour is well-compressed and condensed, and is digested nobly into the substance of gold, and hardens into gold.

Evidence that the place must be arranged as we have described it is to be found in the operations of those skilful alchemists who are the best imitators of nature. When they wish to make the *elixir* which is to have the colour and tincture of gold, first they take a lower vessel[22] big enough to hold the materials of well-purified sulphur and quicksilver or other things which they put into the *elixir*. Next they arrange it so that on the top of this there may be a vessel having a long, narrow neck; and over the opening of this neck is a cover of clay in which is a very small, narrow

[21] Albert assumes that alluvial gold is formed right where it is found. Does this mean that medieval prospectors did not know how to follow a 'pay streak' upstream to its source? or simply that they did not tell Albert all they knew? But the gold in great rivers like the Rhine and the Elbe comes from so far away that the connexion between source and placer is not obvious. The first printed book on mining (*Bergwerk- und Probierbüchlein*, Sisco and Smith, pp. 40–41), published soon after 1500, still speaks almost in Albert's words of 'gold generated in rivers' or 'born in streams'. Later in the sixteenth century Biringuccio (*Pirotechnia*, 1540, Smith and Gnudi, pp. 29, 31–32) realized the truth, that gold is merely transported by streams, after being loosened from the bed-rock by weathering; and Agricola (*De re metallica*, 1546, Hoover, p. 76) also gives this explanation, specifically refuting Albert.

[22] This apparatus is similar to that described in Avicenna's *Letter to Hasen* (Zetzner, Vol. 4, p. 974).



II. Figures in a manuscript of the *Book of Minerals* (Ashmole 1471 fol. 33v) opening. Next they *inhume*[23]—that is, they immerse the bottom of the lower vessel in ashes or dung, or better in [a pan of] horse-dung, which they call *equi clibanum*, and then they apply a very gentle fire. The better operators make these vessels of glass; and the character of the first vessel is like a urinal, and the second stands on top of it and receives all the vapour which rises from it. And the contact of the two glasses or vessels is well sealed with lute so that nothing can escape; and therefore it directs the vapour it receives upwards into its long, gradually tapering neck. And there the vapour begins to be concentrated and compressed; and what is burnt out of the vapour flies up like soot through the narrow opening of the cover on top of the neck. Therefore, since it is concentrated and compressed upon itself, it is converted into a yellow substance; and this, collected afterwards, tinges any metal you like to the colour of gold, or even to a more beautiful colour if it be the noble *elixir*, in which the maker has committed no mistake. The figure of the vessels is like this [Plate II]: the lower vessel is ABCD, the upper vessel EFG, and the cover H.

It will be the same in nature. And therefore it is clear why almost all formation of metal should be found diffused through veins and pores, which are like the neck of the place where the vapour[24] is concentrated and compressed. But the formation is easier in the substance of stone, and in stony places, because they are solidly enclosed on all sides.

This, then is our account of the places where metals are produced. Why it is that sometimes metal is found which is soft will be determined later on[25] better than here. And therefore we here conclude our account of the substantial cause of metals.

[23] *inhumatio*, literally 'burial'. Albert's condensed statement covers three slightly different procedures for 'burying': (1) in a pan of warm ashes raked out of the furnace; this would supply heat for a short time only, but would prevent the glass from breaking by sudden cooling; (2) in a pan of ashes which was then set over a low fire; this is essentially the sand-bath used today; (3) in a pan of horse-dung: in this case no fire was used, gentle heat being supplied by fermentation in the dung. In his *Plants* (VII, i, 1) Albert attributes the excellence of manure as a fertilizer (*laetamen*) to this sort of heat in it, adding, 'this is shown by the industry of alchemists, who advise that processes of ripening are best carried out in a pan of manure (*in clibano laetaminis*)'.

[24] *vas*, apparently an error for *vapour*, unless Albert's sentence is elliptical—'the *vapour* is compressed where the neck of the *vessel* is constricted'.

[25] See IV, 5.

TRACTATE ii

THE [ACCIDENTAL PROPERTIES] OF METALS

CHAPTER 1: THE SOLIDIFICATION AND LIQUEFACTION OF METALS

The title of this tractate is printed by Borgnet as De actionibus metallorum, *but it should be (as in the 1518 edition)* De accidentibus metallorum, *'on the accidental properties of metals', like the corresponding tractate (I, ii) on stones* De accidentibus lapidum; *and the present chapter begins with a statement about 'accidentals'.*

Fusion and solidification are here explained in terms of the constitution of metals, as set forth in III, i. Heating activates an intrinsic liquidity which Aristotle called Water, and the Arabs Quicksilver. Later chapters develop more fully the theory that the greater the amount of Quicksilver in a metal, the more easily it melts.

WE must now take note of whatever accidental properties occur spontaneously in metals, such as their being liquefiable and malleable, and their colours, tastes, and odours, and their ability to be consumed by fire, and whatever other such properties appear spontaneously in them.

But the liquefiability of metals is somewhat different from that of other things that become liquid, for such things become liquid and flow, and their parts separate from each other—as for example, wax, salt, and the like, whether they are liquefied by dry heat or by moist cold.[1] But in metals the moisture is not separated from the dryness, but is dissolved in it; and, being so dissolved, it moves about there as if it had been swallowed by the Earth and were moving about in its bowels. And on this account Hermes[2] said, 'The Mother of metal is Earth, that carries it in her belly'. And this is the reason why [molten] metal does not adhere to or moisten anything that touches it; because earthy dryness prevents it from moistening or adhering. But the moisture prevents the dryness from standing still.[3] Thus each acts upon, and is acted upon by, the other. But when the

[1] The words *liquefactio, liquabilitas,* &c. cover both melting by fire (like wax) and dissolving in water (like salt).

[2] Quotation from the *Emerald Table* (see Appendix D, 7), which Arnold of Saxony (Stange, p. 42) refers to Hermes's *Book of Alchemy*.

[3] That is, it rolls about in globules, as stated in the description of molten metal in III, 1, 2.

metal is rather poorly mixed, because neither one is contained in the other, then the earthy part is burned up in the fire and the moisture evaporates and does not quench the earthiness, defending it from the fire; and the earthiness does not hold fast the moisture, preventing it from evaporating. Such a metal in liquefying gives off much [smoke],[4] and is bad-smelling because of the bad smell of the Sulphur; and it leaves much slag and dross, because of the burning of its Earth. But if [its constituents] were very pure and perfectly mixed, the moisture would not evaporate perceptibly, and the Earth in it would not burn; and therefore it would give off very little smoke, and that not bad-smelling, and like gold, it would have almost no dross.

But the solidification [of metals] is less different [from that of other substances] than their liquefaction [is]. For their solidification is [caused] by the pressure of the cold acting within the dryness; and the moisture—[no matter] whether it is pure and radical moisture, or impure and superfluous, whether well- or ill-mixed—is compressed in exactly the same way, and is hidden in the interior and held fast, so that it cannot enter into the patches of dry earth. And the same [is true of] those metals that are not liquefiable by dry heat, but only softened, like [iron].[5] For softening comes about only through the dissolving of the moisture so that it begins to move about within the dryness in the bowels of which it is contained.

But metals that have what Aristotle calls a 'stuttering'[6] mixture, like tin—the more they are liquefied the drier and more brittle they [become], because their moist parts fly away and what is left is dry and not well stuck together, and therefore it breaks more quickly.[7] It is called a 'stuttering' mixture because the mixing attains the proper proportion in some parts and not in others; but of real union, so to speak, there is very little. [It is] just like a man who stutters, being able to say some words and not others. And because [such metals] are not completely mixed, therefore when they are liquefied they easily evaporate; since the parts, being poorly attached, let go of each other, and then the moisture does not protect the dryness from catching fire, and the dryness does not keep the moisture from running away and evaporating.

[4] *frigidum* ('cold') must be an error for *fumum*, 'smoke' or 'fumes', as in the statement about gold just below.

[5] *frigidum* again, here an error for *ferrum*, 'iron' (as in the 1518 edition). Before the invention of an efficient blast furnace, iron could not be fused completely. See IV, 8.

[6] See IV, 4, introductory note.

[7] Tin in copper alloys hardens them, and too much tin makes them brittle. But Albert's notions about tin are not entirely correct. See IV, 4.

Evidence of what we have said is that solid lead and tin, if left lying for a while, become scaly outside and greyish, or perhaps black after a long time.[8] This happens, undoubtedly, for two reasons: one [reason] is that when the moisture is forced by cold into the inside, it leaves the outside earthy and dry, and this produces a greyish colour. The second [reason] is that the small amount of moisture that is on the outside evaporates because of the heat of the surrounding Air, and this again leaves greyish Earth that colours the surface.

And this is the reason, too, why lead cannot be welded to lead[9] when the edges of two [pieces] are liquefied by a white-hot iron, unless the hard surface is scraped beforehand to remove the dry Earth that keeps [the edges] from sticking together; because the sticking of one to the other is [accomplished] by the power of the moisture, which flows [from one] into the other, and not by the power of the dryness, which remains fixed. But even then they will not stick together unless, after scraping, they are rubbed with soap or something else unctuous and fatty. And this is because the Quicksilver in the lead contains unctuous moisture, as has often been said; and therefore it will not adhere to a surface except through having something in common (*symbolum*) with its nature.[10] But copper sticks iron together, and molten silver is best of all, for sticking metals together. And the reason is that the Quicksilver in these [metals] is good and subtle and pure, and it sticks things together because of its viscous moisture. For, being such as it is, because it is related to, and has something in common with, their nature, it penetrates into the things that are to be joined and at once holds them firmly.

This, then, is our account of the liquefiability and solidification of metals. For we have discussed the nature of liquefiable things in general in the *Meteorology*.[11]

[8] Tin and lead tarnish dark grey when exposed to air.

[9] Lead can be welded to lead, but usually is soldered with a lead-tin alloy having a lower melting-point than lead. Albert does not mention the solder (probably not realizing that it had a different composition from pure lead), but he does mention two other essentials—that the surfaces to be joined must be clean, and that something like soap or tallow is used (to reduce any oxide that may be formed).

[10] *per aliquod habens symbolum in natura: Symbolum* is the 'common factor' by means of which a thing is able to be transmuted into, or unite with, another. Thus *The Soul in the Art of Alchemy* (Manget, 1702, Vol. 1, p. 636) says: 'A property common to all metals is that, since their material is closely related and has something in common (*et inter habentia symbolum*) in material and natural powers, it is easy to transmute them into each other.' See also III, ii, 6.

[11] *Meteor*, IV, 6, 382 b 28 ff.

CHAPTER 2: THE MALLEABILITY OF METALS

The word used here, ductilitas, *indicates a general 'workability' rather than the present-day technical term 'ductility', the capacity to be drawn into wire. Although wire-drawing was practised by medieval craftsmen, only hammering is mentioned here, so the best translation seems to be 'malleability'. Albert's explanation of this physical property of metals repeats what has been said in III, i, 3; but he now adds 'evidence' from the manufacture of gold- and silver-leaf; and finally makes the significant suggestion that one test of the genuineness of gold is its malleability.*

METALS seem to be the only things that are malleable, showing greater and better malleability than anything else. The cause of malleability is what has been said above: namely, moisture that is enclosed in dryness but not completely bound. For when this moisture is released by the expulsion of the chilling cold that binds it, then [the Earth] floats in [it] just as even iron and stones float [in Quicksilver],[1] and do not sink, because of the boiling motion and thickness of the metallic moisture. But even when the moisture is bound by chilling cold, nevertheless it is still present. And when the metal is hammered [the moisture] makes it yield to its surroundings, and by so yielding it is drawn out without losing its continuity. But metals differ very greatly in their capacity to be acted upon in this way. Gold is the most malleable of all; and after that, silver; then, very pure copper; and then iron; and lead and tin are much less [malleable].

Gold can be drawn out to the greatest extent, so that thin sheets are made, which are spun with silk or placed on pictures.[2] And it can be drawn out even further if silver is placed on the gold, in the proportion of six to one. For example, if on four marks of silver one-sixth [as much] gold is placed, or even less, then the gold is drawn out as much as the whole of the silver can be; so that [the gold] is no longer seen except as a colour on the silver. But if the thin sheets are melted, [the metal] does not appear to be gold at all, but entirely silver. But if gold is beaten by itself,

[1] *tunc tantum natat in terra quod etiam ferrum at lapides in ipso natat.* But *ipso* refers back to *humidum*, 'moisture', which in metals was supposed to be Quicksilver. The sense then seems to be that Earth floats in this moisture (as it would not do in Water), with an allusion to the oft-cited paradox that a large, heavy piece of iron will float in mercury, while a small bit of gold will sink (cf. Alexander Neckam, *De naturis rerum*, LV, Wright, 1863, p. 163).

[2] Making gold-leaf and tin foil is described by Theophilus, I, 24–26 (Hendrie, 1847, pp. 28–33); also leaf of combined gold and silver, for which he gives the proportions of one part of gold to twelve of silver (op. cit., pp. 334–7)

without being placed on silver, it cannot be drawn out so much,[3] because it cannot bear the blows of the hammers without being perforated; but silver placed upon it protects it from the blows. And the cause is certainly the subtle moisture which absorbs dryness; for this moisture yields not by separating from adjacent parts but by drawing them along with it; and thus yielding without losing its continuity, it is drawn out more and more. But some metals are less malleable, and this happens for one of two reasons: for either their moisture is too gross and impure, so that it is not so capable of expanding; or else they suffer from a 'stuttering'[4] mixture, so that when drawn out one part separates from the part near by, and is pulled away from it by the hammer blows.

And therefore this is a way of proving that an error has been made in the operation of alchemists;[5] for because of the great admixture of yellow or white substances with the Quicksilver in the compounding of what they call the *elixir*, dryness [enters][6] into the moisture in their metals, but they are not strongly united and thoroughly blended. And therefore the metals made by alchemists are very frequently broken when they are drawn out by hammering; unless the alchemists imitate nature successfully and accomplish the work of nature, as we have said before. For when metals are mixed together, for instance tin and copper, or any others, because of their 'stuttering' mixture they lose their malleability and break when beaten with a hammer. For they are not really blended but only put together,[7] and one enters into the other only in so far as to colour it.

This, then, is the cause of malleability.

CHAPTER 3: THE COLOUR OF METALS

This discussion of colours is a continuation of that in I, ii, 2–3 on the colours of stones, and is similarly based on Aristotle's theory of light and vision (The Soul, *II, 7, 418 a 26 ff. and* The Senses, *3, 439 a 13 ff.*)*: light is a sort of activity in a*

[3] This is not true. Gold can be beaten out thinner than silver, but the leaf is extremely fragile and 'so light that a breath will blow it away' (cf. Theophilus, op. cit. pp. 30–31).

[4] See IV, 4, introductory note.

[5] Pure gold is very soft and malleable. Testing alchemical gold by fire has been mentioned in III, i, 9.

[6] *intra*, error for *intrat*.

[7] *non permixta sed composita. Compositio* is a mere 'putting together'. Aristotle (*Gen. and Corr.* I, 10, 327 b 34 ff.) uses the illustration of wheat 'combined' with barley, where the two kinds of grain are 'mixed together' but each retains its own identity. *Permixtio* comes nearer to what we mean by chemical combination, where two things 'combine' to produce a single new thing.

transparent medium. We cannot see transparency—we see its 'limit' or 'boundary' at the surface of a coloured body. But Albert is trying to explain not only the colours but also the peculiar lustre of metals, so he speaks of 'transparency' as something almost 'glassy' within *metals, which is seen as metallic lustre. The colour changes resulting from exposure to air, treatment with sulphur, vinegar, &c., are mentioned again in Book IV, in the descriptions of individual metals, and notes on these will be found there.*

It is not difficult to reach a conclusion about the colours of metals, for three colours are found in them to a greater or lesser degree. One of these is common to all, and this is a shining lustre, like light incorporated in a coloured body. The second, which is white, is possessed by several metals to a greater or lesser degree: the whitest is silver; then tin; third, lead; and last, iron. The third colour is yellow or reddish, and gold has this to the highest degree; after this, copper, but the colour of copper tends towards a brownish black.

But let us assume here what has been proved in *The Senses*[1]—that colour is the boundary of a limited transparency. Thus any body in which the condensed transparency is clear and pure has lustre incorporated, as it were, with its colour. For transparency when condensed [is bright][2] and lustrous, since its density retains the light, of which it is the appointed limit, just as potentiality receives the appropriate actuality. Therefore, a shining lustre will be common to all metals, because of the subtle, watery [material] which is limited by a boundary[3] and condensed in them. And the more subtle, pure, and dense the Water that any metal contains, the more shining and brilliant it will be when polished; because without polishing, one part casts a shadow on another, and more or less prevents it from shining. For this reason, gold has the brightest lustre of all; and next, silver; but iron, when very well purified, is said by the alchemists to contain something of silver[4] and to be very close to it; and therefore when it is polished it shines like a mirror.

[1] *The Senses*, 3, 439 a 28.

[2] *niter*, error for *nitet*.

[3] 'Limited' in the sense of having a *surface* that reflects; but also in the sense of being 'solid', since Aristotle (*Gen. and Corr.* II, 2, 329 b 29) defines a solid as determined by its own boundary (*terminatum*), in contrast to a liquid, which has no boundary of its own, but takes the shape of its container. In the following discussion of reflections *terminatus* recurs with this double meaning.

[4] Pure iron is silvery white and quite malleable and ductile—in these respects it might be said to be 'very close to silver', though its metallurgy is very different.

A mirror[5] is caused by moisture which is solidified and is capable of taking a good polish; and it receives images because it is moist, and holds and retains them because it is solid (*terminatum*); for it would not retain them in this way, if the moisture were not incorporated [in it] and limited by a boundary. This is why Air does not retain such images, although it receives them; because Air exists as a spirit [that is, a vapour or gas], and receives such things in the manner of a spirit; and having no boundary, it does not focus them into one place and shape, as is necessary for reproducing them, but acts only as a medium through which the images pass, and not as a limiting boundary that gives them being.

The white colour in metals is caused by moisture bound by an earthiness that is [clean],[6] subtle, and well-digested; for this is extremely white, like the appearance of quicklime (*calx*). This is present in nearly all metals. But whenever metals contain an earthiness that is dirty and impure, or burnt Earth, they become either greyish, like clay, or else black, like burnt Earth, as is seen in soot. Lead, therefore, always tends towards a greyish colour, because its earthiness is dirty though not burnt. And tin is not so greyish as lead, because it is not so dirty. But silver always shines with whiteness because its earthiness is [clean],[7] subtle, and well-digested. But iron, because the earthiness in it is burnt, is sooty and black.

And for the same reason, [iron] is always subject to rust; and the cause of this is merely that it contains burnt Earth; for what putrefaction is to moist [things],[8] rust is to iron. For when the moisture is removed, what is left is parched, dry, and burnt, and is reduced to ashes. Evidence of this is that iron is especially affected by rust if something burning[9] is thrown upon it—such as salt, sulphur, orpiment, or the like. But silver does not turn to rust[10] but rather to an azure colour, because of the great transparency in it, which produces the sapphire-blue of good azure. And for this reason Hermes,[11] leader and father of alchemy, says that if thin plates

[5] Mirrors were generally made of polished metal, although even in the twelfth century Alexander Neckam (*De naturis rerum*, CLIV, Wright, p. 239) mentions mirrors of glass backed with *plumbum*, which was probaby tin.

[6] *lutulentum*, 'dirty', which is contrary to the sense of what follows: probably *lotum*, 'washed', 'clean'.

[7] *locum*, for *lotum*, 'washed'.

[8] *Meteor*, IV, i, 379 a 17 describes decay as a sort of drying.

[9] *adurens* in many cases signifies not only combustion but any chemical attack or reaction that changes the appearance of a thing.

[10] *rubiginem* is the red rust of iron. Silver does, of course, tarnish, but the coating (mostly sulphide) is dark.

[11] Arnold of Saxony (Stange, p. 44) cites Hermes *in libro alchymie* for this. The treatment with salt and vinegar is essentially that used since antiquity for making a white

of silver are smeared with salt of Ammon and vinegar, and suspended over an *alembic*—that is, a sort of vessel—then the silver plates change into the colour of azure. And then, if the plates are reduced to ash with sulphur, so as to become powder, and then stirred with vinegar and *zeruph*—that is, a kind of herb—the azure will be fermented and perfected.

But it is true that many things burn silver that do not burn gold, because [in silver] the earthiness and moisture are less well purified and blended [than in gold]. Therefore, if boiling or very hot sulphur is sprinkled on it, silver is blackened, because the earthiness in it is burned. And when silver is cooked with salt and [tartar][12] it is whitened and purified at once, because such penetrating [substances] attack the earthiness and separate the burnt part from it; and the remainder, which is purer, becomes whiter.

The yellow colour in metals is caused by the Sulphur, which colours them; for heat, violently cooking the moisture mixed with earthiness, converts it to a [yellow][13] or reddish colour, as is seen in the science of urines,[14] and in alchemical operations; and in red or reddish *lixivia*;[15] and in yellow bile; and likewise in honey and gall, which have been strongly digested by heat. If, then, both the earthy and the watery materials are very pure, the heat in them cannot separate them so as to burn them up, but only digests and alters their colour to a shining yellow, this is the cause of the colour of gold. And therefore [gold] is not burnt if sulphur is thrown upon it.

pigment from lead (see IV, 3, note 7) and a green pigment from copper (see IV, 6, note 10) But silver so treated would not give a blue pigment. Nevertheless, this recipe, with variations, is found in many old collections so it must have had some value (Hendrie, notes, pp. 80–81, 422–3; Merrifield, Vol. I, pp. 46–49, 136–7; Vol. II, 394–9); probably the silver contained some copper. The remainder of the recipe is even less intelligible, since heating silver, or any possible silver compound obtained by the above treatment, with sulphur would only produce black sulphides. It is possible that this has been confused with an entirely different recipe for making blue colours. If *zeruph* is really a plant, perhaps it is woad or indigo, which produce blue dyes. But in Arnold (loc. cit.) it is *zemp* (cf. II, ii, 20, *zemech*), so perhaps it is *zaffer*, originally the blue pigment from powdered lapiz lazuli, but also a dark blue glass containing cobalt, long used in the East for colouring glass and pottery glazes. *Zaffer* is said not to have been used in Europe before the fifteenth century (Singer, *et. al.*, *History of Technology*, Vol. II, pp. 301, 312), but it may have been mentioned by some Arab alchemist. If so, it is obvious that the recipe was transmitted without being understood.

12 *cartaco*, error for *tartaro* (ed. 1581) 'wine-stone' or argol, obtained from the crust formed in wine casks. Arnold of Saxony (Stange, p. 44) also gives this on the authority of Hermes's *Book of Alchemy*.

13 *circulum*, error for *citrinum* (eds. 1495, 1518).

14 Inspection of urines was an important method of diagnosis in medieval medicine.

15 For *lixivium*, see III, i, 4, introductory note.

But if the earthiness is impure and not well blended, then the heat that digests and blends it will burn it, and it will become yellow; but after a little while it will tend towards a sooty blackness, as is [the case] with copper. This is why all ancient images and vessels of copper are blackened. And sulphur thrown on hot copper burns it very violently; for [copper] contains earthiness that has been burnt yet is [still] capable of burning, as we have said; and this is not sufficiently well blended with the moisture.

So much, then, for our account of the colours of metals.

CHAPTER 4: THE TASTES AND ODOURS OF METALS

Tastes and odours are explained in terms of Aristotle's theories (The Soul, *II, 9–10, 421 a 7 ff. and* The Senses, *4–5, 440 b 27 ff.*). *Mining and metallurgy abounded in odours. It must be remembered that metals were not clearly distinguished from their ores; shining metallic sulphides like galena and chalcopyrite 'look like' metals, and were so regarded. The chemical reactions that take place during smelting and refining were not understood. Sulphide minerals give off an odour like rotten eggs (hydrogen sulphide) when attacked by acids, either during natural weathering or in alchemical operations. When roasted in air they produce sulphur dioxide, which, if not exactly a smell, is choking and irritating. There are also ores that yield poisonous fumes of chlorine or arsenic. Gold was a striking exception, because it usually occurs as native metal, and gives off no gases on fusion. The tastes are due to the formation of soluble metallic salts of various acids. All are disagreeable and more or less poisonous. The term* vapour *is used here, as in I, i, 8, for something invisible yet potent that passes from the metal cup into the wine, from ore minerals into ground water—or even into the lungs of the miners.*

THE tastes and odours of metals must be considered together, because odour is a sort of consequence of taste.[1] It is generally true of all metals that, because of the sulphurous substance they contain, their tastes have a certain sharpness. Although this is admittedly least evident in lead and tin, yet even in these it is proved by [the fact that] water that has been running or standing for a long time in pipes of lead or tin[2] becomes very

[1] The close physiological connexion between smelling and tasting is noted by Aristotle (*The Senses*, 4, 440 b 29).

[2] Pure tin is harmless, but the danger of lead-poisoning was recognized by the Romans (Vitruvius, *On Architecture*, VIII, *6*, 10) and by

irritating to the bowels or internal organs. About copper and [iron][3] there is no doubt, for these are hot, especially copper, which contains a burnt substance; and so [does] iron, to some extent. And this is why their odours have a certain sharpness.

Again, it is generally true that the tastes and odours of all metals are somewhat foul, because of that same sulphurous substance in them, of which we have spoken. But they are more or less foul according to the badness of the Sulphur in them. For in gold there is very little foul odour, since its Sulphur has absolutely no badness, because it is subtle, and is only unctuous enough to combine well, and is thoroughly blended, as we shall show later. Moreover, because it is so uniformly combined and compact, it gives off little vapour; and for the same reason, too, it has little odour or almost none. But silver contains Earth that is not [actually] burnt but is capable of being burnt; and therefore [silver] gives off more vapour and has more odour than gold, though much less than copper. And in comparison with copper, silver has a sweet taste and a sweet odour, though with a slight flavour of Sulphur. And gold is even sweeter, though it changes the taste [of things] only a little, almost imperceptibly. But [the taste and odour of] iron are earthy, and only slightly tinged with Sulphur; and those of lead and tin are very dull, because they contain so much Water.

But when metals are dissolved,[4] their tastes are considered to be more dependent on the vapour of their odours, since taste is a consequence of the combination itself, rather than of the constituents that are combined; because the constituents sometimes have entirely different tastes from the combination. And therefore, in some respects, the vapour and constitution of a metal can hardly be learned from its odour and taste.

Among all metals, copper is most active in giving off vapour; and after this, iron. And for this reason these metals completely spoil the taste of waters which are in contact with their ores. And so water coming out of the earth where there is much copper is extremely bitter and loathsome—as it is in the place called Goslar, where the water is made so bitter that nothing can live in it. And evidence of this is that if wine or any other

Avicenna, as quoted by Albert in a *digressio* on healthful and unhealthful waters in his *Meteora* (II, iii, 20): 'But ditch waters and waters carried in lead pipes are the worst, especially if they have been running for a long time in lead [pipes], because they absorb from lead a harshness which sometimes irritates the bowels.'

[3] *auro*, but the statement cannot apply to gold. I have assumed *ferro* from the context.

[4] *in metallis liquidis*, 'liquid metals' here means not *fused* but chemically *dissolved*.

liquid except water is poured into a brazen vessel, it is immediately spoilt, with such a loathsome bitter taste that it can hardly be drunk. But water is not immediately spoilt, so as to change its taste, because the natural coldness of Water prevents the formation of vapour. But if the water stands there for a long time, and especially deep down in the earth where heat is confined and continually causes the ores to give off vapour, then water, too, has its taste and odour spoilt.

There is, then, in comparison with all kinds of stones, a taste and odour peculiar to metals. Some stones, indeed, give off vapours and odours; but these are not really stones, but things like 'tears'[5] and gums, such as *kacabre* and *gagates* (jet), as we have said in the books on stones. But all the same there is a foul taste and a foul odour [characteristic] of metals; even though one [metal] is said to have a sweet or some other kind of odour, in comparison to another.

These odours and vapours are extremely dry. And therefore they are applied to watery eyes[6] and are very injurious to the chest.[7] Evidence of this is that when the miners go into the mines they cover their mouths and noses with two or three layers of cloth[8] so that their breathing may not be too much injured by the vapour—for this is where the greatest damage is done, as we have said.

So much, then, for our account of the tastes and odours of metals.

CHAPTER 5: THE ABILITY OR INABILITY OF METALS TO BE CONSUMED BY BURNING

The term used here is cremabilitas, *the ability to be cremated, completely consumed by burning. To us, 'burning' means oxidation, but Albert includes other chemical reactions that result in blackening or loss of metallic appearance. His*

[5] See II, ii, 17, *Succinus*; 9, *Kacabre*; 7, *Gagates*.

[6] This can hardly refer to *vapour* from smelting metals, chiefly sulphur dioxide, which is very irritating. By ellipsis, Albert here refers to something else produced from such vapours—undoubtedly zinc oxide (V, 8, *Tuchia*). Constantine (*De gradibus*, in *Opera*, p. 383) calls its *cadmia*, and says that 'mixed with eye-salves it cures moisture flowing from the eyes'.

[7] *praecordiis*, literally 'diaphragm', but often best translated 'heart' or 'lungs' in medical descriptions of symptoms associated with diseases of those organs.

[8] In this case the 'damage' was probably 'miner's pneumonia', caused by inhaling dust. Agricola (*De re metallica*, Hoover, 1912, p .6) says 'miners are sometimes killed by the pestilential air which they breathe; sometimes their lungs rot away'.

theory is that of Aristotle (Meteor, *IV, 9, 387 a 18 ff.*)*: burning is the conversion into vapour or smoke of the moisture in anything, leaving its dryness as ash. The 'three kinds of moisture' are distinguished by Aristotle* (Gen. and Corr. *II, 2, 330 a 13 ff.*) *as (1) 'foreign' moisture, dampness clinging to, or condensed on, the surface; this is easily removed by moderate heat; (2) 'foreign' moisture that is more deeply soaked into anything—such as the water in clay or dough, which disappears on baking; (3) 'radical' or 'intrinsic' moisture, which is* inherent *in a thing. Nowadays we do not call this last 'moisture' at all—it is, rather, the liquidity that appears on fusion.*

AMONG accidental properties of metals that are very indicative of their substance is the ability or inability to be consumed or burnt. And we must now learn the causes of this, and what differences there are in the natures of metals. We know that Water is not one of the things that can be consumed in this way; but things that [can be] have a very unctuous moisture mixed with earthy substance. And we know that Sulphur is extremely unctuous and earthy, but Quicksilver is watery with very subtle earthiness.

We know, therefore, that the ability of metals to be burnt is [due to] the Sulphur, and not to the Quicksilver by itself. Furthermore, we also know that in anything that contains very unctuous moisture mixed with earthiness, the moisture is of three kinds. One of these is extremely airy and fiery, adhering to the surface, as a consequence of the [upward] motion of those elements [Fire and Air], so that they always rise to the surface of things in which they are mixed and combined. The second, close beneath this, contains more wateriness floating about among the parts of the thing. The third has its moisture firmly rooted and immersed in the parts and bounded[1] in the combination; and therefore this is the only one that is not easily separated from the combination, unless the thing is totally destroyed. And therefore this must be the nature of Sulphur.

And for this reason the more skilful alchemists recommend that the [first] two kinds of moisture be removed from sulphur by means of penetrating solutions like vinegar, and sour milk, and goats' whey, and water of chickpeas and boys' urine;[2] and also by boiling and sublimation repeated several times in an alembic. For one of these [moistures] certainly does not withstand fire; and since it is able to be consumed when it is set on

[1] *terminata est*: 'solidified'—but the moisture is still present, even in solid metal, because it always reappears on heating.

[2] None of these reagents is really very strong: the 'mineral acids', hydrochloric, nitric, and sulphuric, which are concentrated by distillation, seem to have been unknown to Albert.

fire, it consumes the substance of the metal; and therefore it is not only useless for the purpose[3] but even harmful. And the second is very volatile and evaporates in the fire; and therefore this, too, is of no use for the purpose in the plans of alchemists. But the third remains deeply rooted and intrinsic, and so this is useful for the purpose.

And the same considerations must be applied to the Quicksilver, which is the other element in metals. For when this is pure, with its earthy substance well washed and subtle, and strongly bound by mixing with watery moisture; and likewise when its watery moisture is neither too much nor too little, but just the right amount for the combining power of the Earth in it—then each protects the other from the fire, as we have often said. For then the earthiness binds the moisture fast, and does not let it evaporate, and the moisture quenches the earthiness, and does not let it catch fire. But if the earthiness is dirty, or there is too much of it, or too little, in proportion to the moisture; or even if there is just the right amount, but it is not strongly bound in the mixture—then it catches fire and is consumed, and burns the substance of the metal. And likewise if the moisture has not been digested in a manner suitable for combining into metal, and is not well bound; or if there is too much or too little—then it must necessarily vanish by evaporation, and the substance of the metal will be left dry and ready to be consumed. It is according to all this that we must consider the ability of metals to be consumed. For a metal is able to be consumed when any one of these [conditions] is present, and the more so when several of them occur together.

Therefore gold that is pure and good because the condition of both its constituents—that is, of its Sulphur and Quicksilver—is so excellent, is least consumed; and whatever things consume other metals do not consume it, but only purify it—such as salt and brick dust, and sulphur, and arsenic, and the like.[4] Silver is somewhat inferior [to gold], because its Sulphur contains some wateriness, and so [does] its Quicksilver. And therefore when this wateriness evaporates, the silver at first begins to be blackened, and then to be burnt by burning substances, such as sulphur and [arsenic],[5] and other things that have been mentioned, and many more which alchemists use.

[3] 'for the purpose' of preventing the metal from burning.

[4] These reagents were used in parting gold from silver: see IV, 5, introductory note and IV, 7, note 14.

[5] *argentum*, 'silver' makes no sense here; I have assumed *arsenicum*, as in the account of gold above.

But copper is very much burnt, because it does not have its Sulphur well bound in the wateriness of its Quicksilver, and it has too much earthiness; and therefore it is very easily consumed by burning. And I myself have seen at Copper Mountain[6] that pieces of green wood[7] propped up against the copper ore[8] are at once consumed, because of the abundance of Sulphur and fattiness exuding from the copper ore. Iron is also burnt to a red colour, because earthiness predominates in it and this catches fire. In tin and lead the Quicksilver is not well cleansed of clayey, fatty substance, and also it is too watery; and therefore as the watery part evaporates in the fire, the clayey, unctuous substance in them is burnt.

This, then, is our account of the ability or inability of metals to be consumed by burning.

CHAPTER 6: THAT THERE IS A CYCLICAL PRODUCTION OF METALS FROM EACH OTHER

This chapter sums up Albert's conclusions about transmutation. He has already invoked Aristotle's theory of a cyclical, step-by-step transmutation of the elements (Gen. and Corr. *II, 4, 331 a 7 ff.*) *to explain the transformation of Water into stone (I, i, 9); he now extends it to account for the transformation of one metal into another. Albert does not doubt that this occurs in nature and is theoretically possible in the laboratory; but the alchemist can succeed only if he 'works with nature' (cf. III, i, 9–10), producing a perfect 'imitation of nature'. Albert implies elsewhere (III, i, 9) that complete success is seldom or never attained.*

[6] *in monte aeris*, evidently a translation of the German *Kupferberg*.

[7] *ligna viridia*. This seems a curious fuel for the purpose. Perhaps Albert means only to emphasize a remarkable fact—'even *green* wood caught fire'. But perhaps he had seen, without understanding it, the 'poling' of copper—green wood plunged into molten copper, supplying carbon dioxide to reduce any copper oxides that may form. If so, he must have confused two different stages in the smelting of copper, recalling only that green wood was used somehow.

[8] *ad lapidem aeris*—'the copper stone'. This is a different term from that used previously, 'copper incorporated with stone', and it refers, I believe, to a different ore—the Mansfeld copper shale or slate (*Kupferschiefer*), which began to be mined about the beginning of the thirteenth century (Beyschlag *et al.*, p. 1127). The copper sulphide is finely disseminated in a bituminous sediment. In Agricola's time it was the practice to roast it in heaps in the open air; once ignited by faggots, it continued to burn for days (*De re metallica*, Hoover, 1912, p. 279; picture on p. 278). This crude method, very likely in use in the thirteenth century, was effective because of the high bituminous content, so that 'the stones took fire'.

AN additional statement should now be made: one thing that is common to all metals is that their materials are closely related.[1] We know, from what has been determined in the science of *Generation and Corruption*, that among [things] having a common property in their material, powers, and potentialities, the transmutation of any one into another is easy. And this is the reason for the assertion of many philosophers—whose father is Hermes Trismegistus,[2] called the prophet of philosophers—that the production of the metals is cyclical, from each other, just as the production of the elements is cyclical. And this seems to me very true.

For when, in matter, the properties that are nearest together and farthest apart are still not separated by very much, as is clear from previous [chapters], the differences among them result from the parts of both [kinds of] materials—the well-purified and digested, and the impure and undigested. And so it happens that everything impure and undigested is purified and digested, if the natural powers of digestion prevail. Otherwise, it happens that everything that is digested suffers from imperfect cooking (*molynsis*), or from an admixture of undigested material, or perhaps insufficient heat to solidify it. Therefore it happens that the materials that are closest to the elements are transmuted into each other; and since such transmutation [of the elements] occurs, the metals must be capable of being transmuted into each other. And thus it happens that the production of metals is cyclical, from each other.

Experience shows that this [is the case], both in the operations of nature and in the techniques of art. As to natural processes, I have learned, by what I have seen with my own eyes, that a vein flowing from a single source was in one part pure gold, and in another silver having a stony *calx* mixed with it. And miners and smeltermen have told me that this very frequently happens; and therefore they are sorry when they have found gold, for the gold is near the source, and then the vein fails. Then I myself,[3] making a careful examination, found that the kind of vessel[4] in which the mineral was converted into gold differed from that in which it was converted into silver. For the vessel containing the gold was a very

[1] See III, ii, 1, note 10.

[2] See Appendix D, 7.

[3] Albert here describes the impoverishment of a vein on passing from one country rock to another. Unfortunately the locality is not given, but his description suggests the Rauris district in the Hohe Tauern, where quartz veins carry gold in gneiss and are locally enriched at the contact with slate; but in the slate they carry no gold, although galena ('silver') is still present (Beyschlag *et al.*, pp. 630–2).

[4] *vas*: the 'natural vessel' is the enclosing rock.

hard stone[5]—one of the kind from which fire is struck with steel—and it had the gold [pure][6] and not incorporated with the stone, but enclosed in a hollow within it, and there was a little burnt earth between the stony part and the gold. And the stone opened out with a passage into the silver vein, traversing a black stone that was not very hard but earthy; and the black stone was fissile, the kind of stone from which slates are made for building houses. This proves, however, that from a single place which was the vessel of the mineral matter both [gold and silver] evaporated, and a difference in the purification and digestion had been responsible for the difference in the kind of metal.

And what artisans have learned by experience is also the practice of alchemists who, if they work with nature, transform the specific form of one metal into another, in the way already described. Thus it is, then, not improbable that there is a cyclical production of metals from each other; and in this metals are unique, occupying a special position between elements and mixed bodies. But let it not escape us that in all things produced cyclically from each other, the transformation is easier between those that have more properties in common. And that is really why gold is made more easily from silver than from any other metal. For only its colour and weight need to be changed, and this is easily done; for if its substance is more compacted, its weight will be increased as its Water is decreased; and an increase in good, yellow Sulphur will result in a change of colour. And it is the same with other [metals], too.

This, then, is our account of the passive [or accidental] properties common to all metals.

[5] Quartz, the commonest gangue mineral in veins of native gold.

[6] *parum*, 'a little'. But Albert is contrasting 'pure' (native) gold with 'incorporated' gold (cf. III, i, 10, note 3) and presumably wrote *aurum purum*.

BOOK IV
THE METALS INDIVIDUALLY

A SINGLE TRACTATE

CHAPTER 1: THOSE THINGS THAT ARE, AS IT WERE, UNIVERSAL IN METALS, LIKE THEIR FATHER AND MOTHER, THAT IS, SULPHUR AND QUICKSILVER

Albert's descriptions of the seven metals are not, like his descriptions of stones (II, ii), based on any contemporary encyclopedia. Although Arnold of Saxony, Bartholomew of England, and Thomas of Cantimpré (see Appendix B, 11–13) all deal briefly with the metals, Albert's treatment differs considerably from theirs. He is trying to explain the properties of metals in terms of the Aristotelian doctrines set forth in Book III, and he often refers to his visits to mining districts, metal workshops, and alchemical laboratories (III, i, 1), as well as to his reading of alchemical books (some of which Arnold also quotes).

On the other hand, in all eight chapters of Book IV there is an unmistakable resemblance to the Paneth manuscript, Metals and Alchemy, *which is probably Albert's own first draft of this Book (see Introduction: 'Date of Composition of the* Book of Minerals*'). Although that manuscript is rather brief, it treats of the same topics, in the same order, and often in the same words. In a few places, where Borgnet's text is faulty, I have followed Paneth's readings.*

This first chapter deals mostly with sulphur. The speculations of the alchemists about the nature of sulphur were based on its unexpected behaviour on heating. Sulphur is polymorphic, with several different molecular structures. Native sulphur (orthorhombic α-sulphur) melts at 112.8° C. to a mobile straw-yellow liquid (λ-sulphur); this is 'watery', according to the alchemists. On crystallizing, it forms monoclinic β-sulphur; but if the liquid is further heated it thickens (becomes 'sticky', 'oily', or 'viscous') and changes to a dark red colour (μ-sulphur). This, by rapid chilling (e.g. by pouring into cold water) solidifies as a supercooled liquid, with a peculiar rubbery consistency; at room temperature it gradually inverts to α-sulphur. This is the basis of the distinction between 'live' and 'fused' sulphur. Liquid sulphur boils at 444.6° C., and the vapour, on contact with a cold surface, condenses directly to α-sulphur; thus sulphur was regarded as 'airy' or 'a spirit'. Sulphur also burns easily (hence it is 'fiery' or *'oily') with a small dull blue flame, giving off choking fumes of sulphur dioxide. This 'foul smell' was recognizably the same as that given off in roasting sulphide ores of copper, silver, or lead—a fact which undoubtedly led to the conclusion that metals contain sulphur. And the fact that native sulphur is found in volcanic regions, hot springs, and near burning coal seams, encouraged the belief in a 'hot, mineralizing vapour' underground.*

Crude sulphur was purified for alchemical work either by washing (since its specific gravity is much less than that of associated rock or earth), or by sublimation.

OUR plan now demands that we describe the metals individually, which could not be done until after we had determined the reasons for their natures and their accidental properties. For speculation proceeds from the general down to the particular elements, as has been determined at the beginning of the *Physics*.[1] In speaking, then, of the metals individually, we shall first touch upon those things that are, as it were, universal in metals, like their Father and Mother, as the writers on alchemy metaphorically say: for Sulphur is, so to speak, the Father and Quicksilver the Mother; or, to put it more accurately, we may say that in the constitution of metals Sulphur is like the substance of the male semen and Quicksilver like the menstrual fluid that is coagulated into the substance of the embryo.[2]

As to the substance and origin of SULPHUR, then, it is to be noted that since it liquefies by dry heat and congeals by cold, it must contain Water, as has been determined in the book on *Meteorology*.[3] But since it is brittle and can be pulverized by crushing, it must contain an earthy substance that is very dry. Since it is easily inflammable and sticky, it must contain oily and viscous [substances], the oily to make it inflammable and the viscous to make it sticky; and its flame is very smoky, with a colour almost sapphire-blue tinged with black. But from these [properties] we know that it is made up, as it were, of four substances, or at least three. For since it is active in penetration and attraction, as Avicenna[4] says in his [book on] medical simples, it must contain a fiery substance, and for this reason it is pronounced hot and dry in the fourth degree. And since it is

[1] See I, i, 1, note 6.

[2] This is expressed in Aristotelian terms, but also occurs in alchemical writings, e.g. the *Book of the Three Words* (Manget, 1702, Vol. 2, p. 190) draws a parallel between the growth of a child in the womb and the growth of metals in Quicksilver, each stage of development presided over by a different planet. See also I, i, 5, introductory note.

[3] See I, i, 3, note 3.

[4] *Canon of Medicine*, II, ii, 612.

easily inflammable, it must contain an airy substance. And since it is liquefied by dry heat, it must contain a moist watery substance. And since it can be pulverized and boiled dry, its substance must be earthy. And all these substances are so abundant in it that they are obvious and distinct in its active and passive properties.

But as we have said in the preceding [book],[5] it must have three [kinds of] moisture—two extrinsic and one intrinsic—and this need not be repeated here. But one observation must be added: its smoke indicates that the earthy substance in it is able to catch fire easily and be consumed; and its foul odour indicates that it is very poorly digested and not limited by a [firm] boundary; indeed, by violent heat, [it is destroyed],[6] instead of being digested and completed. And this incompleteness makes it capable of being a universal material of all the elements. But if it were perfected into one definite, completed form, then certainly it would not be capable of being changed into other things, unless this [completed form] were first removed. But as it is, because of its incompleteness, it is capable of being changed into everything, just like the seeds and so on, from which natural things are produced. And therefore wise nature provides abundant Sulphur in any place where metals are produced. And since Sulphur is hot, it will necessarily be active in opening up and solidifying any moisture that touches it. And since it is dry, it will be sharp, since heat and dryness are sharp. And therefore it will have the power of impressing its seal and form upon things, rather than of receiving [impressions]. And on this account it is given the position of Father and of male semen, by Hermes Trismegistus.

But it must be observed that whatever is hot and dry is joined with something moist and cold in one combination, and this combination is hermaphrodite,[7] as is seen in plants, which everywhere both fertilize and are fertilized.[8] But Sulphur is not really such a substance because it does not produce anything in its own substance, and it is not the 'Father' except [in the sense] that the male, out of his own substance, produces [offspring] in something else—that is, in menstrual blood—and that is the way Sulphur acts upon Quicksilver, but does not produce anything at all in itself.

[5] See III, ii, 5.

[6] *corruptam* supplied from Paneth (p. 35) and edition of 1518.

[7] A common alchemical figure, the androgyne, the two-sexed, the union of male (hot and dry) and female (cold and moist).

[8] This remark does not imply any understanding of the fertilization of plants; in fact rather the reverse, since for most European species the individual plant as a whole—e.g. an apple-tree—cannot be distinguished as male or female.

The colour [of sulphur] is yellow and sometimes white, or rather straw-coloured, that is, like the whiteness of wheat straw. The cause of this is heat, which accompanies the moisture and changes it to a yellow colour; and so sulphur seems to be what results [from this process] in the bowels of the earth. For when earthiness is mixed with much wateriness, and there is heat that cooks it—just as in the bodies of animals food is mixed with digestive juice, and its froth boiling up on the surface is changed into yellow bile—so it seems that Sulphur is like the froth of what is mixed together in the bowels of the earth. And that is why it is yellow, dry, and hot, although if it is more thoroughly cooked and more earthy it appears paler yellow, tending towards the white of straw.

Sulphur is divided into 'live' sulphur and 'fused' sulphur. 'Live' sulphur is just as it is taken out of the earth. That which is not 'live' but 'fused' has been melted afterwards. The only difference between them is in their accidental properties. And some is also found [with a colour] tending perhaps towards red or perhaps towards black; and this is because of burning heat that predominates in it.

So much, then, for what we have determined about the nature of Sulphur.

CHAPTER 2: THE NATURE OF QUICKSILVER

Quicksilver (argentum vivum), *or mercury, is liquid at ordinary temperatures. Its specific gravity (13.6) is greater than that of any metal then known except gold (19.3). Alchemists had learned in antiquity that it can be purified by distillation, and that its vapour is poisonous. One reason for regarding it as the 'Mother' of metals is its ability to form amalgams with other metals (except iron); small amounts of gold or silver can often be extracted from it, and this success fostered the faith that these metals were forming spontaneously in the mercury itself. Thus Albert speaks here (and also in IV, 5) of a 'lumpy' or 'mushy' stage, like a soft amalgam, in the formation of ore minerals.*

The chief mercury ore is bright red cinnabar, a sulphide from which the metal was extracted by heating in air in a distilling apparatus. Natural oxidation of the ore accomplishes the same thing, and globules of native mercury occur in some cinnabar deposits; if other metals are present, natural amalgams can form. Like sulphur (IV, 1) mercury was said to be of two kinds: Pliny (Nat. Hist. *XXXIII,* 41, *123) calls the native metal 'live' or 'quick' silver* (argentum vivum, *the* *name Albert always uses); but the metal obtained from cinnabar was supposed to be different, for Pliny called it 'a substitute' with the (Greek) name 'water silver'* (hydrargyrum, *from which comes our chemical symbol, Hg).*

QUICKSILVER contains two principal substances, according to all natural scientists. One of these is Water, the other, Earth, as has often been said. And its earthy [substance] contains some Sulphur, although there are some alchemical writers who say that its substance is entirely watery. And they say that this watery substance is thickened by the heat of Sulphur, but that, nevertheless, in itself it is nothing but Water. But this is quite impossible, for we have already determined, in the *Meteorology*[1] that Water by itself is not thickened, except by cold that changes it into Earth; but it is not at all capable of being boiled dry by heat. Moreover, we know from the principles of natural science that [Quicksilver] does not stick to anything that touches it, as Water does, because [Quicksilver] has subtle Earth in it. And it is so strongly combined that if it is sublimed by itself in a glass vessel with a long neck, it always remains the same, however often the sublimation [is repeated], without becoming drier or harder, unless there is an orifice by which it may escape.[2] And Quicksilver is to the material substance of metals as the menstrual fluid is to the embryo: out of it, by the force of the Sulphur that digests and burns it, all metals are produced. And when it begins to be changed into a specific form, at first it becomes lumpy, and then gradually it begins to solidify and be changed [into metal].

There are different [kinds of] quicksilver, since some is extracted from its own ores and is found 'live', and some is extracted by roasting from the stone in which it is produced, just as silver or gold is extracted from stone. And on account of its sharpness it is said to be a kind of poison. It is cold and moist to the second degree, and for this reason it causes loosening of the sinews and paralysis; and it kills lice and nits and other things that are produced from filth in the pores.[3]

Quicksilver sublimed with sulphur and salt of Ammon[4] is changed to a

[1] *Meteor*, IV, 3, 380 b 11.

[2] This remark would seem to have been displaced from below (see note 5)—'there is no change in weight, *unless some can escape*'.

[3] Lice were supposed to be spontaneously generated.

[4] This sentence confuses two different operations: (1) Combining mercury with sulphur would give the brilliant red sulphide, 'vermilion', valued as a pigment. This is the same as natural cinnabar, and, like it, can be decomposed, yielding liquid mercury, by heating in air. (2) Combining mercury with 'salt' (see V, 2, *Sal*) would produce white chlorides—such as calomel and corrosive sublimate—or perhaps ammonium salts. These

shining red powder, and if roasted in the fire again, it changes back to a moist, fluid substance. And perhaps that which is concentrated in the neck of the vessel—called an *alutel*—in which the sublimation is carried out is changed into something like stone, coloured like alabaster; and if this is afterwards roasted in the fire, it changes back again to quicksilver. But there are also different [kinds of] Quicksilver which appear more obviously in the metals [made from them] than in Quicksilver itself—such as dirty or pure, and other [kinds] which have been listed above.

And a remarkable thing about this material is that, however often it is sublimed by itself, there is never any powder left behind in the bottom of the vessel; and when it returns to the specific form of Quicksilver there is no loss, so to speak, in its weight.[5] And this undoubtedly happens because of the very firm combination of its earthy with its watery substance. For the viscous moisture holds the earthiness so firmly that, in evaporating, it takes it along with it into the neck of the *alutel*; and being concentrated there its spirit returns to the same specific form. But in the bottom [of the vessel] it does [not][6] harden, or change in colour, weight, taste, or odour. It is nevertheless volatile in the fire, and becomes incorporated with metals whenever it is mixed with them. And on this account Hermes calls it [a spirit][7] like Sulphur. But Avicenna[8] says that its whiteness is due to wateriness and subtle Earth, cooked together with Air which, taken up as a spirit, is present in its mixture.

All this has been said so that it may be understood that Quicksilver is nothing but the matter[9] in metals, since it undoubtedly suffers complete dissolution[10] by means of sharp waters, either natural or artificial. And after such dissolution it is capable of mixing with other substances and

are all poisonous, but have some uses in medicine. They can be decomposed, freeing metallic mercury, by heating in a closed vessel with sodium carbonate (see V, 7, *Nitrum*).

[5] Balances were in use in the Middle Ages, and many recipes give exact weights of ingredients. The failure to base chemical reasoning on such data as change of weight arose from the conviction that *qualitative* changes were more important than *quantitative* changes.

[6] *non* supplied from 1518 edition, as sense requires.

[7] *spiritum* supplied from Paneth, p. 35.

[8] Avicenna, *De congelatione* (Holmyard and Mandeville, 1927, pp. 51–52). But *Meteorology* (IV, 8, 385 b 5) also says that quicksilver contains Air, classifying it with viscous liquids like oil, pitch, and birdlime.

[9] That is, the female principle; Sulphur, as the male principle, supplies the *form* (see also I, i, 5).

[10] *mortificatur*, literally 'is killed'. *Mortificatio* is a technical term in alchemy, meaning complete disintegration. In the Hermetic writings it is sometimes coupled with the notion of resurrection, but there is no evidence that Albert held any such mystical views of chemical change.

imparts colour to them. And by the force and vapour of Sulphurit is congealed and brought to the hardness and specific form of the various metals. And therefore, since it is saturated by dryness and earthiness, it is held fast and cannot escape in the fire from the substance with which it is mixed.

This, then, is our account of Quicksilver.

CHAPTER 3: THE NATURE OF LEAD

Classical writers used plumbum nigrum, *'black' or 'dark lead' for lead, and* plumbum album, *'white' or 'pale lead' for tin (Pliny,* Nat. Hist. *XXXIV, 47, 156). But by the eleventh or twelfth century (e.g. in Theophilus)* plumbum *had come to mean only lead, and tin was called* stagnum *or* stannum. *Lead is bluish grey, with a bright metallic lustre only on very fresh surfaces, since it quickly tarnishes to a dull dark grey. Pure lead is heavy (specific gravity 11.3), soft and malleable, and melts at 327° C. Lead ores, however, often contain, or are associated with, other metals, which in smelting form alloys with the lead, making it seem lighter, harder, more brittle, or more fusible. One 'impurity' is commonly silver, so the alchemists' claim that silver can be made from lead had a real basis.*

Albert has little to say about ores of lead. His 'lead incorporated with stone' (III, i, 10, note 6) is the sulphide, galena, which is heavy, has a metallic lustre, silvery to steel-grey, and rather resembles a metal except for its brittleness. The metallurgy of lead was fairly simple: the ore was roasted and then smelted in furnaces using wood or charcoal; the temperature could be to some extent controlled by the use of bellows. In the roasting, sulphur was driven off (as fumes of sulphur dioxide) and the sulphide converted to sulphate and oxide of lead. These then reacted, at higher temperatures, with the remaining sulphide, to form more sulphur dioxide gas and metallic lead. If the temperatures were too high or the process took too long, much of the lead was oxidized to litharge, and reduction was effected by adding charcoal or green wood. As the mass began to fuse, stony materials rose to the top as a slag; this might be purposely augmented by adding limestone or siliceous rocks as a flux, in the hope of absorbing unwanted metals in the slag, while gold and silver (if present) would remain in solution in the lead. But ancient methods entailed a considerable loss of lead (and silver) in the slag.

IN the same way it is determined that LEAD has less material added to its Quicksilver than any other metal. And for this reason Aristotle and

Avicenna[1] say that molten lead undoubtedly seems to be Quicksilver. As to the constitution of lead, therefore, its substance is believed [to contain] a large amount of Quicksilver in proportion to its Sulphur; and perhaps only a little of the actual substance of Sulphur enters into the constitution of lead, but a great deal of its quality.[2] And this by its own heat cooks the material and changes it into the specific form of lead, just as a small amount of the substance of rennet curdles a large amount of milk.

The Quicksilver of lead is not of good quality, but watery and dirty; and therefore the wateriness easily evaporates in the fire, and an earthy powder is left, as a sort of ash remaining from the clayey substance of the lead. And since, as we have said, there is in lead a force of Sulphur, its vapour dries out the Quicksilver[3] just as the vapour of Sulphur does. For it is not possible that two substances should produce the same effect in the same way, except by means of the same thing which is in them [both]. We have already explained why lead has a greyish colour.

The effect of lead is cold and constricting, and it has a special power over sexual lust and nocturnal emissions, if a circle is made of it, two fingers wide, and worn around the loins and [anointed][5] with camphor. But care must be taken lest the lead, by its coldness contracting the material [below][6] too forcibly drive it upwards into the head, and cause madness or epilepsy; and care must also be taken lest it cause paralysis of the lower limbs, and unconsciousness. This, then, is the nature of lead in its constitution and effects.

And Hermes,[7] who has proved much about the transmutations of

[1] *De congelatione* of Avicenna, which was often attached to the *Meteorology* (Holmyard and Mandeville, p. 52): 'But lead, when liquefied, is undoubtedly Quicksilver; but it does not liquefy without first being heated.'

[2] The distinction between *quality* and *quantity* is thoroughly Aristotelian. The notion that a very minute *quantity* of something can impart its *quality* to a large amount of something else is illustrated here by rennet, and by other alchemical statements about the *elixir*, acting as a *ferment* (like yeast in dough) to transmute a large mass of base metal.

[3] The *Book of Alums and Salts* (Steele, 1929, p. 26) gives recipes for 'coagulating mercury by the odour of lead'—that is, making lead-mercury amalgam by exposing mercury to the vapour of molten lead. This immediately follows a recipe for 'coagulating mercury by the odour of sulphur'—that is, making cinnabar.

[4] See III, ii, 3.

[5] *pungatur* should be *perungatur* (Paneth, p. 36; and 1518 edition). This use of lead is mentioned by Pliny (*Nat. Hist.* XXXIV, 50, 166).

[6] *intimius*, the 1518 edition has *interius*; Paneth (p. 36) *inferius*, which makes better sense, in antithesis to the following *sursam ad caput*. Mere contact with lead would hardly be dangerous, but lead compounds taken internally are poisonous.

[7] Arnold of Saxony cites this from Hermes's *Book of Alchemy* (Stange, pp. 42–43); a recipe

metals, in his *Alchemy* reports that, if plates of lead are suspended over a vessel containing much strong vinegar, so that the vapour of the vinegar is continually in contact with the lead plates, the vapour will condense and destroy the substance of the lead, and change it into a powder that has a white colour and is called *cerusa*. But if vinegar is poured over the same lead plate, it becomes white and, on the other hand, the power of the vinegar is destroyed. The reason for this is surely that, although the substance of vinegar is dull on account of its coldness, it is nevertheless sharp in its action, because it is the remains of a sort of Fire that has arisen from it, just as ash is the remains of Fire in wood.[8] And by means of this sharpness, therefore, it penetrates into the substance of the lead, when the lead has been disintegrated,[9] and washes away the dirt from the congealed Quicksilver in it, and causes [the Quicksilver] to rise to the surface of the plate like grains of millet, which then grow whiter because they are more thoroughly purified.

Moreover, Hermes[10] also reports that lead, if roasted with something that burns it, such as sulphur and arsenic especially, produces a sublimate of a dark vermilion, that is, red colour, which [becomes][11] yellow if the fire is hotter and stronger. But if this substance is calcined with vinegar and dried out, it changes back to the white colour of *cerusa*. And the reason for this transmutation is that really it has Sulphur and Quicksilver, as we

similar in part to this is in the *Liber sacerdotum* (Berthelot, 1893, Vol. I, p. 217). The process is ancient (though now called the 'Dutch process'), mentioned by Theophrastus (Cayley and Richards, pp. 57, 187–91) and Pliny (*Nat. Hist.* XXXIV, 54, 175–6). Reaction between lead and vinegar forms lead acetate, which on exposure to air or water containing carbon dioxide is converted to the basic carbonate (*cerusa*), or 'white lead'. This was used as a pigment, and even as a cosmetic, although its poisonous nature was well known.

[8] This attempt at explanation is Albert's own. Wood ashes leached with water supplied lye ('pot ash', mostly potassium carbonate), the chemical properties of which were explained as 'heat' left over from the burning (*Meteor*, IV, 11, 389 b 3). Similarly, Albert suggests that vinegar retains 'heat' from its fermentation.

[9] *exterminatum*, that is, when it ceases to be *terminatum*, limited by its own boundary, solid, coherent.

[10] Hermes's *Book of Alchemy*, according to Arnold (Stange, p. 43); also, more briefly, in the *Liber sacerdotum* (Berthelot, op. cit., p. 204).

[11] *sit*, error for *fit* (ed. 1518; Arnold, loc. cit.). Lead forms a number of oxides which can be prepared by roasting metallic lead or 'white lead' (*cerusa*) in air. (The mention of sulphur and arsenic is irrelevant, reflecting some confusion between 'red lead' and other red minerals—cinnabar and realgar.) 'Red lead' contains more oxygen than yellow litharge, but the change of one into the other, or into an intermediate mixture, would probably depend more on the air supply than on the fire. Both oxides can, as Albert says, be changed into 'white lead' (*cerusa*) by treatment with vinegar.

have said, in the substance of which it is composed. For when sulphur is heated and cooled again, it becomes red. Evidence of this is [the fact] that manufacturers of *minium* (cinnabar) make it by subliming sulphur with quicksilver. But lead because it is dirtier [produces] a dark colour; but when the fire is made stronger, the original dirtiness is consumed and the colour grows lighter. And since Sulphur is burnt more than Quicksilver in a long-continued fire, the red colour due to the earthy burnt Sulphur becomes paler and is modified by the white of the Quicksilver that is still present; and the result is a yellow colour that is like white penetrating red and modifying its redness.

But nevertheless Hermes believes that if a still stronger fire is applied to all these, and they are strongly roasted in the fire, the whole substance of the Sulphur is consumed, and the force of the vinegar is destroyed by evaporation; and then, from the above-mentioned powders, the substance of the lead returns to what it was at first; but it is not of the same weight and purity, nor of the same quality, as at first.[12]

Nor must we omit to say that, as we have already stated, lead contains much wateriness and is poorly mixed; and therefore in the refining of other metals it protects them from the fire—as for example silver and gold are protected by lead when they are refined.[13] And hence some unskilful men say that lead has the ability to bring together things that are alike and

[12] It is not true that lead oxides or *cerusa* can be converted into metallic lead by further roasting, except in the presence of some reducing agent, which Albert does not mention. Probably charcoal was used, and Albert supposed this to be merely the fuel for heating the lead compounds. It is interesting that the change of weight here is noted, though it is not explained.

[13] Cupellation with lead is described by Theophilus (III, 49, Hendrie, pp. 316–17). I quote the procedure for recovering gold from scraps of gilt copper or silver:

> But if at any time you have broken copper or silver gilt vessels, . . . you can in this manner separate the gold. Take the bones of whatever animal you please, which (bones) you may have found in the street, and burn them, being cold, grind them finely, and mix with them a third part of beechwood ashes, and make cups as we have mentioned above in the purification of silver; you will dry these at the fire or in the sun. Then you carefully scrape the gold from the copper and you will fold this scraping in lead beaten thin, and one of these cups being placed in the embers before the furnace, and now become warm, you place in this fold of the lead with the scraping, and coals being heaped upon it you will blow it. And when it has become melted, in the same manner as silver is accustomed to be purified, sometimes by removing the embers and by adding lead, sometimes by recooking and warily blowing, you burn it, until, the copper being entirely absorbed, the gold may appear pure.

The object of cupellation is to oxidize all the lead, and with it the copper or other base metals present. The oxides are volatilized, blown away by the bellows or absorbed in the bone-ash crucible, leaving behind pure gold or silver; if both are present they form an alloy, and a further step is necessary to part the gold from the silver (see IV, 5, introductory note; IV, 7, note 14).

to separate things that are different.[14] And the reason for their mistake is that, when lead is fused together with gold or silver, the silver[15] runs together in one place, and the stones, if any are present, in another, and the lead in still another. But they are mistaken: for this bringing together and separation is due not to the lead but to the heat of Fire, as we have shown in the fourth book of *Meteorology*.[16] And lead in itself does not purify silver except by accident; for it is the heat of Fire, in itself, that purifies it, by bringing together pure substances and separating impure [ones], as has been said. But since silver is moist and Fire is dry, the heat of the Fire would be repelled by the silver if there were not something to unite them—that is, the lead; for as it becomes hot, its own moisture serves, as it were, to boil, digest, and purify the silver.

Lead is very heavy because its substance is clayey and moist, with the parts firmly compacted, although they are soft, since they are not well-digested, because of imperfect cooking (*molynsis*), as has been shown previously.

CHAPTER 4: THE NATURE AND PROPERTIES OF TIN

Tin was regarded in antiquity as a kind of lead (plumbum album *or* candidum). *Even in the Middle Ages, when it was recognized as a distinct metal, it still bore the name* (stagnum *or* stannum, *from which we get our chemical symbol Sn*) *of a low-melting, lead-silver mixture produced in smelting lead* (*Pliny*, Nat. Hist. *XXXIV*, 47, *159*).

Albert's account is rather unsatisfactory, and he probably knew very little about tin. One stumbling-block is Aristotle's curious statement (Gen. and Corr. *I, 10, 328 b 8–15*) *that tin 'stutters'* (*Greek,* psellizatai). *What Aristotle himself meant is not very clear: he says that in bronze the tin seems to disappear, and its only effect is to change the colour of the copper; so perhaps it 'hesitates' to combine, or 'fails' to impart its own qualities to the mixture. But Albert takes 'stuttering'* (*Latin* balbutiens) *to mean 'incapable of making a* good *mixture', and therefore* brittle. *This is not true. Of course, in some alloys (bronze, bell-metal, pewter) tin increases the hardness and brittleness of the copper or lead, and*

[14] One of these 'unskilful men' must have been Hermes, since Arnold quotes this from his *Book of Alchemy* (Stange, p. 43).

[15] We might expect 'silver *or gold*'. But cupellation was particularly used in extracting silver from lead ores; and even if gold were present, the alloy might appear silvery rather than golden.

[16] See III, i, 5, note 6.

Albert (perhaps misled by 'Hermes's Book of Alchemy'*—see note 5 below) may have reasoned that tin by itself would be even more brittle. But pure tin is very malleable; Theophilus (I, 26, Hendrie, pp. 30–33) gives directions for beating out tinfoil.*

But tin has other properties that might support Albert's conclusion. It has several crystalline modifications: above 100° C., it becomes less malleable, and cannot be annealed like copper. And below 18° C. ordinary 'white tin' changes after a while to 'grey tin', which is very brittle and crumbles to powder. This change ('tin disease' or 'tin pest') must have been observed in the cold climate of northern Europe; and this may be what Albert means when he says 'cast tin quickly decays', because tin suffers little from ordinary oxidation in air.

Albert does not describe tin mining, although this was active in central Europe and began to grow in importance about the end of the twelfth century (Beyschlag et al., *p. 428). Albert's contemporary, Matthew Paris, in his* History of the English *(in Madden, ed.,* Chronicles and Memorials of Great Britain and Ireland, *Vol. 44, Part 2, 1866, p. 453), says that German tin was 'discovered' in 1241 by a Cornishman who had fled to Germany, and that 'hitherto there were no tin mines anywhere in the world except in England, that is, Cornwall; and so the abundant supply caused the price to fall among the brokers'. German tin had certainly been 'discovered' earlier, so 1241 is probably the date when the Cornish mines began to feel the effect of foreign competition. The German tin industry was thriving in Albert's time and he must have heard talk of it, but I doubt if he had ever visited any workings. This can be inferred from his failure to mention the most important ore of tin, cassiterite, a brown or blackish mineral with no metallic lustre and nothing except its unusual weight to show that it is not a 'stone' but an ore mineral. It is resistant to weathering and collects in residual or alluvial deposits ('stream tin'), where it was mined like gold, by washing or panning, and then reduced to metal by heating with charcoal. If Albert had ever seen such an operation, we should expect him to mention it.*

We cannot, however, disregard his statement that he had seen something which he believed to be tin ore because he had been told so by 'men experienced in such matters' (III, i, 1). He calls this 'tin incorporated with stone' (III, i, 10)—in other words, a shining metallic sulphide. The only tin ore that would fit this description is stannite, which occurs in veins with cassiterite but is unlikely to have been sought out and mined separately while cassiterite was available. Albert's informants were probably confusing tin with some other metal, and what they showed Albert was most likely ore of antimony or bismuth. The sulphides of these (stibnite and bismuthinite) are silvery with a metallic lustre; and native *antimony and bismuth are sometimes found. Both metals are very brittle and impart this brittleness to alloys. Antimony (or stibnite) was known in antiquity as* stimmi *or* stibium *(from which comes our chemical symbol Sb). Pliny* (Nat. Hist. *XXXIII,* 34, *104) says that stibnite must not be roasted too much 'lest it turn into lead' (that is, metallic antimony). Bismuth did not attain an identity and a name until the sixteenth century. Agricola* (De re metallica, *Hoover, footnote, p. 110) called it* plumbum cinereum, *'ashy-grey lead', to distinguish it from lead and tin. He also recorded its German name,* bismut, *and said that the miners recognized it as an indicator of silver ore ('roof of silver'). Possibly metallic zinc was also mistaken for tin (see V, 8,* Tuchia, *note 1).*

WHAT is to be determined about TIN is almost the same as about lead. For these metals have specific forms that are very closely related, and there is little difference between them except that tin is whiter and purer. And the reason for this can only be the reason assigned by the philosophers before our time—that its [Quick]silver[1] is cleaner than that of lead, and perhaps it contains only a little Sulphur, and is cooked into the specific form of metal by the power and vapour of Sulphur rather than by much of the actual substance of Sulphur in its mixture.

It has a very 'stuttering' constitution; and the reason for this may be the complete dissolution of the Quicksilver by some kind of solvent vapour, or the effect of a solution of sharp water, which separates the parts. But I say vapours, not Water through which Quicksilver has passed after it received its specific form, but rather [vapours] which enter into the very substance of the Quicksilver. For such wateriness, once formed in it, is not very viscous; and it makes the earthy parts mixed with it become stiff, so that they do not mix well and stick together. For anything that is stiff and hardened on the surface does not mix well with anything else and is not capable of becoming continuously joined to anything near by. This, then, we must consider to be the cause of its 'stuttering' mixture. But since [tin] is itself 'stuttering', it makes all metals with which it is mixed 'stuttering', too, and takes away their malleability, as Hermes says; and when it is itself drawn out, it is quickly and easily broken.

This metal is also like lead in that neither of them is subject to rust;[2] but rather, if exposed to destructive substances, or even spontaneously, they develop a sort of dinginess and dirtiness; but lead [does so] more than

[1] *argentum* printed instead of *argentum vivum*, which is surely meant.

[2] *rubiginem*, derived from *ruber*, 'red', designates iron rust, as different from the dull greyish tarnish of lead or tin.

tin. They are also alike in that neither of them by itself gives out much sound [when struck]. The reason for the first [of these characteristics] is that [these metals] do not contain any hot, watery moisture, or else it is not very sharp, so as to destroy the earthy material in them and change it into rust. For rust is nothing but burnt earthiness. And the reason for the second [characteristic] is their softness and moisture; because anything soft and moist, if it is struck, yields by shrinking into itself, and therefore does not send back from its entire surface the air, which is the cause of sound, as is pointed out in the science of *The Soul*.[3] Tin, however, gives out more sound than lead. And since it has a dull sound, tin tempers things that have a sharp sound, such as copper, silver, and gold, and makes their note deeper. And therefore tin is mixed with copper in the melt for bells.[4]

As to what Hermes says in his *Alchemy*[5]—that tin, because of its excessive dryness, causes bodies with which it is mixed to be fragile and destroys their malleability—this is understood in the way already explained, namely, that by a sharp vapour or solution the earthy parts of it are dried out. Otherwise the statement would not be true, for we see that [tin] is softer than any other metal.

And they say that cast tin quickly decays, and that lead remains unchanged or even increases,[6] both in the open air and underground. And I believe this is probable, since it seems to agree with experience. The reason for this has already been assigned in *The Heavens*;[7] for the cause of the destruction of the elements is that they move into each other's [places]; and when the bond holding them is not strong, one element escapes from the other. Now it has already been stated that tin is poorly mixed, and this is the reason why it is damaged by Fire; and if it is removed from the place where it originated, it is destroyed more rapidly than other metals. But lead is very gross in its substance, and by absorbing dew and rain, it gradually

[3] *The Soul*, II, 8, 419 b 4 ff. gives Aristotle's theories about sound and hearing.

[4] For example, Theophilus (III, 85, Hendrie, pp. 360–1) specifies four parts (by weight) of copper and one of tin for bell-metal.

[5] Arnold of Saxony, quoting Hermes's *Book of Alchemy* (Stange, p. 45); also in *Liber sacerdotum* (Berthelot, 1893, Vol. I, p. 204).

[6] This is an old belief. Pliny (*Nat. Hist.* XXXIV, 49, 164–5) says that lead mines abandoned for a long time become 'more fertile' again—perhaps a report of a case where the walls of an old mine were found coated with secondary lead minerals deposited by water. And perhaps Albert refers also to lead pipes that have been covered by carbonates.

[7] *The Heavens*, II, 6, 288 b 15: each of the elements (Earth, Water, Air, Fire) has its own place and when out of its place strives to return to it. The elements held in compounds, such as plants or animals, on the dissolution of the compound at once escape back to their own places.

makes a mineral moisture which it converts into itself; and therefore, in the course of time, it sometimes increases.

Two [kinds of] tin are found, namely a harder and drier kind which comes from England or Britain, and a somewhat softer kind which is found more abundantly in parts of Germany.[8]

And now we have said enough about the nature of tin.

CHAPTER 5: THE NATURE AND CONSTITUTION OF SILVER

Silver (argentum) *is the most brilliant of the white metals; it is not oxidized in air or water, but tarnishes black if exposed to vapour or solutions containing sulphur. It is very malleable and ductile.*

*Albert's information about silver ores is evidently based on personal observation at Freiberg (see III, 1, 10) and perhaps elsewhere. The 'mushy' white material represents the uppermost zone of oxidized ores: secondary lead or zinc minerals, along with silver halides, such as cerargyrite ('horn silver'), very soft and waxy. Below the zone of oxidation is a zone of secondary enrichment: silver leached from above is carried downwards and redeposited, generally at the water table, where oxidation ceases, as sulphides and sulphosalts (argentite, pyrargyrite, proustite, &c.), and as native silver, which crystallizes in shapes like wires, 'strings', or sheets. Still further down is the unaltered original ore (argentiferous galena), which contains a far smaller percentage of silver. This sequence is reflected in the history of most mines. In the thirteenth century the Freiberg mines were still working comparatively shallow zones of oxidation and secondary enrichment. As these rich ores were worked out, and difficulties with drainage prevented deeper penetration below the water table, the Freiberg mines declined and were eclipsed by newer mines. Agricola, in the sixteenth century (*De natura fossilium, *Book VIII), said there was little native silver at Freiberg, but reports enormous masses of it taken from newer mines farther to the south-west in the Erzgebirge.*

Though argentiferous galena is not the richest ore, a great part of the world's silver has been produced from it. This is Albert's 'silver incorporated with stone', which was crushed, roasted, and smelted, giving off a 'foul odour' of

[8] Matthew Paris (loc. cit.) also says that German tin is the purest (*purissimum*). If such a difference really existed, it might be explained by the fact that the Germans were mining cassiterite (nearly pure tin), while the Cornish miners had 'gone underground' and were mining veins that contained stannite ('bell-metal ore'), which is partly copper.

sulphur dioxide. Some silver was lost in the slag, but most of it remained in solution in the molten lead, from which it was separated by careful remelting and finally by cupellation (see IV, 3, note 13).

'Burning' or blackening silver with sulphur played a part in two important technological processes: the parting of gold from silver, and the making of nigellum *or* niello. *In parting gold and silver, the added sulphur combined with the silver to form a black sulphide that was mechanically separable from the unaltered gold. In making* niello, *silver (along with copper or lead) was fused with sulphur, forming a black mixture of sulphides, which was applied like an enamel in engraved decorations on gold or silver. Theophilus (III, 70, Hendrie, pp. 316–19) gives the following directions for recovering gold from silver-gilt work; the resulting silver sulphide is to be cupelled to recover the silver, or else made into* niello:

When you have scraped the gold from silver, place this scraping in a small cup in which gold or silver is accustomed to be melted, and press a small linen cloth upon it, that nothing may by chance be abstracted from it by the wind of the bellows, and placing it before the furnace, melt it; and directly lay fragments of sulphur in it, according to the quantity of the scraping, and carefully stir it with a thin piece of charcoal until its fumes cease; and immediately pour it into an iron mould. Then gently beat it upon the anvil, lest by chance some of that black may fly from it which the sulphur has burnt, because it is itself silver. For the sulphur consumes nothing of the gold, but the silver only, which it thus separates from the gold, and which you will carefully keep. Again melt this gold in the same small cup as before, and add sulphur. This being stirred and poured out, break what has become black and keep it, and do this until the gold appear pure. Then gather together all that black, which you have carefully kept, upon the cup made from the bone and ash, and add lead, and so burn it that you may recover the silver. But if you wish to keep it for the service of niello, before you burn it add to it copper and lead, according to the measure mentioned above, and mix it with sulphur.

NEXT we shall speak of SILVER, because in colour it seems to belong with the metals already discussed. For since we do not understand the nature of a compound until we know of what and how many things and in what manner it is compounded, we must inquire into the nature of silver. And from what has already been said, we have ascertained that Quicksilver enters into the composition of silver, because silver has the same colour and, when liquefied, the same accidental [properties as Quicksilver]; for then it will not adhere to anything that touches it and it will roll about on a surface, but not spread out all over it, like water, oil, wine or any other liquid. These three [characteristics] we have seen to be present primarily in Quicksilver; and therefore if they are also present in liquefied silver, they must be due to the Quicksilver that enters into the composition of its substance. And since silver is extremely bright, with a shining whiteness, and is capable of taking a high polish, the proportion of Quicksilver it contains must be well digested and purified and mixed with extremely subtle material. And it also has [the characteristic] that, although its odour is foul, it is not so foul as [that of] other metals we have already discussed.

And we know from what has been said that both Sulphur and Quicksilver—and anything else at all which, because of its constitution, is moist and liquefiable by Fire—contains three [kinds of] moisture, just like living things, plants and animals. One [kind of] moisture is thick and undigested, rising to the surface like grease, fat, or oil; and it is this that makes things inflammable. And the second is like the phlegmatic humour[1] that moistens the parts of things, but does not contribute to reproduction or growth. And the third is the radical moisture saturating the essential parts of a thing; and because of this moisture the parts [of things][2] are firm, and grow, and are nourished. We have found that silver is hard and dry. And therefore it must have been thoroughly cleansed of the two superfluous [kinds of] moisture, and the subtlety of the third is responsible for its excellent mixture.

And when [the fire is] strongly blown, silver has a sulphurous odour; therefore it must have some of the substance and quality of Sulphur, for it is the heat of Sulphur that causes fermentation and digestion into the specific form of a metal. Of the substance of Sulphur, indeed, it has only a little, for the Sulphur does not even colour it;[3] but of the power and quality of Sulphur it has a great deal, since it is by the heat [of Sulphur] that the two [kinds of] moisture mentioned above have been consumed and the third well mixed with subtle, earthy material. For the heat and vapour of Sulphur, and especially of Sulphur that is well purified and sublimed, whiten things[4] very much, and by digestion make them subtle and mix them thoroughly and strongly; because even from the substance of Sulphur the two extraneous [kinds of] moisture have been removed by

[1] On *humours*, see III, i, 1, note 7, and III, ii, 5, introductory note.

[2] *raro*, should be *rerum*, as in the 1518 edition.

[3] See III, ii, 3 for colours of metals. The yellow colour of gold was supposed to be due to its Sulphur (see IV, 7).

[4] Fumes of burning sulphur (sulphur dioxide), often used for fumigation, have a strong bleaching effect. Constantine says (*Opera*, p. 386): 'If pink or red cloths or flowers are fumigated with sulphur the colour becomes white.' Albert makes a similar statement in his *Plants*, II, ii, 7.

the skill of nature, which is more certain and subtle than any art of the alchemists, and therefore has the most certain effect.

Having, then, the nature of Quicksilver, since it is a metal developed out of the purest Quicksilver by the heat of purified Sulphur into a shining specific form, therefore it must necessarily be white and have a high lustre. And, as has been said, it is well dried out and this is why it makes a ringing sound [when struck], which it would not [do] if it were soaked with superfluous moisture. And [the fact] that it is well digested gives it the power to act as it does; for it is found to be cold in effect, because of the abundance of Quicksilver in it; but because its moisture is so well digested and subtle, filings of it, even if ground up with other things or in mixtures, strengthen the breathing and [are effective for] palpitations of the heart.

But a remarkable thing which we have mentioned before is that the best kind of this metal is found in the earth as a soft, thick mush. The cause of this is surely the abundance of Quicksilver that was in those places; and when the third [kind of] moisture was separated, [going] into the composition of the silver, the other two were left in the dirty material round about. And this soft, lumpy, whiteness indicates that none of the superfluous, undigested moisture was taken up into the nature of the silver. And therefore, when this is placed in the fire it immediately evaporates into its natural moisture as it softens, and the moisture from the substance of the silver begins to grow firm, and when it is placed in the air and cooled, it congeals and is silver. And the litharge[5] from this moist silver is better than any other litharge for the white *elixir* in alchemy, because this litharge is from a moisture that has a tendency to [become] silver, and is potentially silver, just as fat is potentially an animal. And silver is purified in the fire with lead and then, by roasting, the lead evaporates and the dross is separated from the silver, as we have said above.

[But][6] when [silver] is found incorporated with stone, then it must be ground in a mill and crushed fine, both the stony substance and the silver. For when the parts are crushed fine and divided, one is more easily separated from another, and then the stony substance does not burn the silver.

But I must not pass over in silence the fact that sometimes in Teutonia

[5] Litharge is lead oxide, produced in cupellation; but the separation of metals was not perfect, and some silver also passed into the litharge. When the alchemists used this in the 'white elixir' and claimed (perhaps believed) that they had made silver, they were simply recovering silver that was already there.

[6] *artem*, error for *autem*, as in 1518 edition.

[silver] is found which is very firm and dry and almost pure; and this in our own time has occurred in two ways. One way it was found was as a column standing up under the earth, dried out and very tough and flexible. The other way it was found was extending under the earth like strings; and the quantity of this was as great as of that found in the form of a column. And the cause of these shapes was merely the differences in the places that acted as vessels in which the vapour was concentrated and converted into the material of silver. And the cause of its viscosity and capacity for being consumed in the fire was that, although the superfluous moisture had for the most part evaporated, yet some extrinsic moisture was still adhering to the substance of the silver, just as the extrinsic moisture of phlegm adheres to the members [in a living body], softening and loosening them; and when this is purified by fire, it makes the substance of the silver extremely pure.

But sulphur burns silver when it is sprinkled upon it in a molten condition;[7] and the blackening of the silver shows that it is burnt by the sulphur, as we have said above. For sulphur, because of its affinity[8] for the nature of metal, burns it; but it does not induce much burning in other things such as wood and stone, even if sprinkled upon them in a flaming condition.

This, then, is our account of the nature of silver.

CHAPTER 6: THE NATURE AND MIXTURE OF COPPER

There were two words for copper, aes *and* cuprum. Aes *included both copper and copper alloys, and in ancient writers* aes *usually meant bronze (copper-tin). But many old bronzes contain lead, and the Romans also had brass (copper-zinc), as*

[7] *liquefactum* might grammatically refer to either the silver or the sulphur, but probably the latter, as in the following sentence, where *inflammatum* certainly refers to the sulphur. Paneth (p. 42, footnote 1) says:

Experiments show that sprinkling sulphur on molten silver produces little effect, for most of the sulphur oxidizes and only a thin skin of sulphide forms on the silver, which is not very noticeable until after the melt has hardened. On the other hand, if solid silver is treated with molten sulphur, the surface at once turns black and forms a brittle crust of sulphide. This 'burning' of silver—in contrast to the effect on wood, stone, or (as later mentioned) gold—is so striking that there can be little doubt that this is the process referred to. The sulphur must be heated rapidly to well above its melting point—slowly melting it and applying at lower temperature is not nearly so effective.

[8] *propter affinitatem*. Note that 'affinity' was already a technical term in alchemy. See IV, 7, note 17.

as well other alloys, some of which had special names (Pliny, XXXIV, 1–5, 1–10; 20, 94–8). There was no special name for copper, though aes cyprium, *from the famous mines of Cyprus, was probably almost pure copper. By the time of Theophilus, at least,* cuprum *('from Cyprus') had come to mean copper; but Albert's contemporaries, Thomas of Cantimpré, Bartholomew of England, and Vincent of Beauvais, seem to take the two words as synonymous—* aes sive cuprum. *Albert generally uses* aes, *more rarely* cuprum. *In some passages* cuprum *seems to emphasize 'pure' copper, as in speaking of malleability (III, ii, 2) or a red colour (III, ii, 3); but this is not always so. In the present chapter, for instance,* aes *appears in the title, but in the recipe for green pigment* aes *is used at the beginning and* cuprum *later on. I have therefore not thought it practicable to distinguish the two words in translating.*

Copper is identified today by certain well-defined physical properties: it is a red metal, tough and malleable, with specific gravity about 8.9 and melting-point 1083° C. But all these properties are notably altered by admixture of other metals, either accidentally in smelting or purposely in making bronze or brass. Medieval craftsmen and alchemists regarded all such alloys as essentially the same metal, but with its qualities *changed. Albert, of course, explains these properties in terms of the Sulphur-Quicksilver theory, which was apparently confirmed by what he knew of copper ores. He describes again the 'iron cap' of weathered oxides (see III, i, 10, notes 18–19), the zone of secondary enrichment below it (where some gold was found), and the main ore body containing sulphides (pyrite and chalcopyrite, along with sphalerite, not yet recognized as an ore of zinc). According to his theory, the 'iron cap' is the excess 'earthy' or 'burnt' material, the sulphides are real metal 'incorporated with stone', and the gold is the final perfected stage of ore formation.*

The smelting of sulphide copper ores was probably the most complex metallurgical operation known in the Middle Ages. It involved at least four or five steps, some of which were repeated several times to get rid of impurities, though often with heavy loss of the copper itself. After crushing and concentration the ore was roasted to drive off part of the sulphur. The residue was mixed with a limestone flux and smelted; impurities such as iron and silica collected in the slag above a molten mass of copper sulphide, which was drawn off as matte. *The* matte *was black and unpromising in appearance, and had to be further oxidized in a furnace with a strong blast of air; the remaining sulphur was thus expelled as gas (sulphur dioxide); and metallic copper remained. There was danger of over-oxidation at this stage, and this was corrected by 'poling,' forcing green wood into the molten copper, to reduce any oxide that might be formed (which otherwise* *would make the copper too brittle). But even this copper was dark and rough, and had to be remelted before it assumed the appearance of 'pure' copper. Albert's reiterated statements that copper is 'black' and 'burnt' and 'contains too much Sulphur' show that he had seen something of this complex procedure.*

Pure copper was less useful than its alloys, of which brass was the most important in France and Germany, where zinc ores were more abundant than tin (see note 7 below). Albert's word for brass is aurichalcum *('gold-bronze'). A less useful alloy, made with arsenic, was silvery. Copper salts were used as green and blue pigments in painting (notes 10–13 below).*

METALS that are red in colour are different in their mixture from those already discussed, as we have shown when we were treating of the colours of metals. And iron has its own peculiar character, apart from the other metals. Let us therefore now discuss the constitution of COPPER, assuming what has already been demonstrated, that all metals are composed of Sulphur and Quicksilver. Let us assume, then, that the Quicksilver is good, not full of dross and dirt, but still not completely cleansed of extraneous moisture; and that the substance of the Sulphur is full of dross, burning hot and partly burnt, and in this condition it is mixed with the Quicksilver, both in substance and in quality.[1] Then undoubtedly it changes the Quicksilver to a red colour; and because neither [the Sulphur nor the Quicksilver] is sufficiently subtle, they cannot be well mixed. And this will make copper, which is not at all well mixed, since much dross is separated from it, and it evaporates greatly in the fire.

For when the Sulphur is partly burnt out, then some parts of the Quicksilver are better purified than others and the superfluous moisture in them is consumed; and in those parts it will appear to have veins of gold. But in other parts where it is less well digested it will be scaly and ignoble and earthy because it has been burnt. And we have found these differences clearly in the copper found in Teutonia at the place called Goslar.[2] And therefore this copper is reckoned better than any other, because it has veins of gold mixed with it. And it is not improbable that the Sulphur in that copper is mixed with a certain quantity of *arsenicum*;[3]

[1] See IV, 3, note 2.

[2] See III, i, 10, note 12. Modern reports on Goslar indicate only a minute amount of gold in the sulphide ores; but there may have been more in Albert's time, when the mine was working a zone of secondary enrichment now exhausted.

[3] Some copper ores (e.g. bournonite) contain arsenic and some are associated with arsenic minerals. But I doubt whether Albert means anything more than that arsenic, like sulphur, is 'burning hot'.

and for this reason the Sulphur of that metal is rendered more burning hot than that of other [metals].

Now, therefore, we understand the material of copper; it is a metal having rather more Quicksilver that it ought to have, which has been converted into a red form by mixture with burning Sulphur. Why the nature of Sulphur is burning hot has been satisfactorily explained earlier.[4]

And *arsenicum*,[5] when calcined, changes from red to black; but afterwards, if sublimed in an *aludel*—which is a covered vessel with a long neck, as we have often said—it again becomes white as snow. And if such calcination and sublimation are repeated a number of times it becomes extremely white and very sharp. And because of its sharpness, [*arsenicum*] added during the fusion of copper penetrates into it and changes it to a shining white. But if the copper stands for a long time on the fire, the *arsenicum* evaporates, and then the copper returns to its original colour, as is easily proved in [books on] alchemy.[6]

But those who carry on much work with copper in our region—that is, in Paris and Cologne and other places where I have been and seen this tested by experience—convert copper into brass (*aurichalcum*) by means of the powder of a stone called *calamina*.[7] And when this stone evaporates there still remains a dark lustre, approaching the appearance of gold. And to make it paler in colour, and so more like the yellow of gold, they mix in a little tin; but because of this, brass loses the malleability of copper. And those who wish to deceive and to produce a lustre like gold 'bind' the stone so that it may remain longer in the copper on the fire, and not evaporate from it so quickly. And the 'binding' [is done] with 'oil of glass'. They take fragments of glass, crushed and sprinkled into the crucible on the copper after the *calamina* is put in; and then the glass that has been put in floats on the top of the copper and does not allow the power of the stone to evaporate, but reflects the vapour of the stone down into the

[4] See IV, 1.

[5] See II, ii, 6, *Falcones* and V, 5, *Arsenicum*.

[6] This recipe is not in Hermes's *Book of Alchemy* as quoted by Arnold, but it is in the *Liber sacerdotum* (Berthelot, 1893, Vol. I, p. 214).

[7] *calamina* is the earthy weathering product (smithsonite, hemimorphite, &c.) formed from zinc ore (sphalerite). That used 'at Cologne and Paris' very likely came from the Moresnet district near Aachen. The earthy *calamina* was mixed with charcoal and finely divided copper and heated in a crucible until the zinc distilled out and united with the copper. The purpose of the 'oil of glass' was to form a slag, preventing the oxidation and escape of the volatile zinc. The colour of brass depends on its composition, being 'golden' with about 20 per cent. zinc; adding tin or silver would give a paler yellow, though we may doubt whether much silver was in fact used.

copper. And in this way the copper is thoroughly purified for a long time and the drossy material in it is burnt up. But after a while the oil of glass evaporates, and then the power of the stone evaporates, too; but the brass is made much more brilliant than it would have been without it. And anyone who wishes to make it still more like gold repeats these purifications by roasting with oil of glass several times, and in place of tin, puts in silver and mixes it with the brass. And it becomes such a brilliant yellow that many people believe it to be gold, though actually it is only a kind of copper.

But Hermes[8] says that if powdered tutty is mixed with molten copper—either white tutty or red—it changes the copper to the colour of gold. What tutty is will be explained in the following book,[9] where 'intermediates' are treated. But it is enough [to say] here that the burning heat of tutty consumes the earthiness and purges the superfluous moisture out of the copper; and so then it will be more beautiful. But the power of tutty, too, evaporates if it stands for a long time on the fire; and therefore, unless some remedy is used, the tutty will evaporate and the copper will regain its original colour.

Hermes[10] also says—and experience agrees—that if copper sprinkled with salt is placed over vinegar or the urine of a pure young boy, the power of the urine or vinegar will penetrate into the substance of the copper and change it to a green colour. Or, again, if copper alone is placed over pressed out [grapes from the vintage],[11] the mere vapour of wine will change it to a fine brilliant green colour. But orpiment or *arsenicum*, especially if burnt, brought into contact with this colour, destroys its greenness by thickening it, and turns it to a greyish, earthy colour that is almost opaque.[12]

[8] See note 6 above. This is really the same as the preceding recipe, except that the zinc is in the form of artificial zinc oxide (tutty, furnace calamine).

[9] See V, 8.

[10] Arnold quotes this, too (Stange, p. 43). The method itself is very old, being described by Theophrastus (Cayley and Richards, pp. 57, 191–3), Pliny (*Nat. Hist.* XXXIV, *26*, 110), and many medieval books on making pigments, &c.

[11] *ramos expressos*; but texts of 1495 and 1518 editions, and Paneth (p. 37) have *recemos expressos*; and Hermes (as quoted by Arnold, loc. cit.) more fully, *racemos vindemie expressos*, which is probably correct, since the use of fermenting marc is mentioned by Theophrastus and Pliny, and was no doubt also common in the wine-making districts of France and the Rhineland.

[12] These statements are also quoted by Arnold from Hermes (Stange, p. 43). Blue and green copper salts were much used as colours in painting. They are spoilt, however, by contact with pigments containing sulphur, such as yellow orpiment or red

The cause[13] [of these changes] is easily seen from what has been said. For salt is active in opening [things], and therefore opens the substance of the copper, especially if it has been beaten into thin plates; and then the sharp vapour of the vinegar or urine, derived from the excessive burning of the Sulphur [in it], burns the copper; and therefore the combined moisture and light earthiness that is burnt in it takes on a green colour, just like the hottest and worst yellow bile (*cholera*),[14] which medical men compare to copper rust [verdigris]. But since, in the first [case, that is, the making of brass], the vapour [of *calamina* or tutty] is not so sharp as the vapour of wine [combined with copper in making green pigments] it makes the red less intense, and therefore the brilliant colour of gold remains. But orpiment is intensely hot and therefore when it comes in contact with things coloured in this way [that is, copper greens], the slight amount of moisture present is burnt up; and what remains is earthy and opaque—in just the same way as yellow bile when it is burnt leaves a black ash [with the] accidental [properties] of black bile,[15] according to the experience of medicine.

So much, then, for our account of the nature and effects of copper.

CHAPTER 7: THE NATURE AND MIXTURE OF GOLD

Gold (aurum) *is a yellow metal, the heaviest then known (specific gravity 19.3), very soft, malleable, and ductile. It has always been highly valued for its rarity and beauty, but the alchemists were most deeply impressed by its apparent indestructibility: it does not tarnish in air or water, is not appreciably volatilized or oxidized in melting, and is not attacked by any chemical reagent then available. It was therefore regarded as the 'perfect' metal.*

realgar (*arsenicum*), because they react to form blackish copper sulphide.

[13] This explanation is rather confusing, and I have added a few words in the translation in an attempt to clarify it. The point is that a mild vapour (from *calamina*) reduces the redness of copper to yellow (brass); a sharper vapour (from vinegar, &c.) changes yellow to green; and a burning vapour (from arsenic minerals) changes green to black. Albert may be indebted to Hermes for this, since the *Book of the Priests* (*Liber sacerdotum*, Berthelot, 1893, Vol. 1, pp. 204–5) contains a somewhat similar statement about colours: yellow is a mixture of white and red, and green a mixture of yellow and black. But it is also in keeping with Aristotle's theory of colours discussed in I, ii, 2.

[14] See III, i, 1, note 7 on the *humours*.

[15] *cinerem melancholicum accidentalem calidissimae melancholiae*: there is something wrong with the text here. I have omitted *calidissimae*, 'very hot', because black bile (*melancholia*) was supposed to be cold.

Albert has already indicated (III, ii, 6) that this 'perfection' is reached by a natural transmutation of matter—a process, however, so easily deranged by impurities in the matter or by an unfavourable environment that it seldom reaches completion. This, he argues, is why gold is a rare metal, and why it is generally found 'pure' (as native gold), while other metals are found in ores that require treatment to remove impurities left in them by imperfect transmutation.

Albert is right in saying that the most important ore of gold is native gold. Its metallurgy is simple, since the gold has only to be freed from gangue minerals, earth, or sand. Crushing and washing were effective if the gold was fairly coarse; if it was very fine it was collected by amalgamation with mercury (see III, i, 10, note 1). Native gold almost always contains some silver (see V, 9, Electrum*) and the two metals were 'parted' in the final stage of refining (see note 14 below).*

To this we must add something about the nature of GOLD which, according to Hermes, is the only metal that is not 'diseased'[1] for neither of its constituent materials is imperfect or inharmoniously mixed. Although, like the other metals, it is made up of Sulphur and Quicksilver, its Sulphur is extremely bright and clean, purified by the most thorough washing, so that it contains absolutely no unctuousness capable of being consumed by fire, and no watery moisture or phlegm capable of evaporating; and perhaps it has been several times sublimed in hollow places beneath a solid surface, and digested by harmonious heat that carries out the process of ripening called *pepansis*.[2] And the earthy substance incorporated in the Sulphur is clean and extremely subtle, dispersed as vapour throughout the whole substance of the radical moisture of the Sulphur itself. Therefore the result is that the heat in this Sulphur is just right for combining, in no way departing from a harmonious mixture. And this acts as the male power in the constitution of gold.

And similarly its Quicksilver has two substances which are extremely clean, and the third substance[3] in it, which has been made subtle by heat, and is not merely finely divided matter but actually vapour, is the most subtle Earth that has been sublimed perhaps several times in hollows underground, by the influence of the vivifying heat of the sun and stars. And similarly the watery material, too, has been made subtle by the same method of oft-repeated sublimation. And since both[4] are present in this

[1] See III, i, 7. [2] See III, i, 3, note 7.

[3] Quicksilver was generally said to be composed of two elements, Earth and Water; but some authorities added Air, probably because mercury is easily distilled. See IV, 2, especially note 8.

[4] *vitrum*, 'glass'; but 1518 edition, *utriusque*; and Paneth (p. 38) *utrumque*.

state, [the mixture] becomes extremely subtle. For certainly these are mixed together by the effects of heat and of the arrangement of the place that concentrates and reflects the vapour back upon itself, so that the constituents are united in the mixture by a very strong bond.

But the Sulphur enters into the constitution of gold not merely as a quality but also as a substance; and since its substance is subtle, it penetrates everywhere throughout the Quicksilver, and in solidifying it also imparts colour; and since both have been made very subtle and changed into the form of the upper elements [Air and Fire], which in the nature of their transparency are like the perpetual body [Ether], both will have great transparency.[5] And when the numerous parts of the material are thickened they will pack firmly together; for this is [one] of the properties of a subtle substance, that on being packed together by thickening, it will have a very large number of parts in a very small space. And the transparency, being so compressed, causes the yellow colour; and the fine division [of the material] causes the very great solidity; and the packing together of many parts in a small space or place causes the weight, as is proved by what has been demonstrated by reasoning in *The Heavens*.[6]

And the result of this consolidation and harmonious mixing together is that gold has very little vapour, or none, and therefore almost no odour. For although odour is not essentially a smoky evaporation, nevertheless a strong odour frequently accompanies smoky evaporation. And so the result is that gold is the most indestructible of all metals, and it withstands the fire best because its mixture is the most firmly combined. For smoky evaporation sometimes indicates that bodies are being destroyed; and there is a little of this in silver and more in copper. And these facts supply the reason why some things burn silver that do not burn gold, such as sulphur, *arsenicum*, and certain other [things]. For the cause of such behaviour is the mixing, so that all its earthiness is within the moisture that protects it from the fire, and all its moisture is within the earthiness that keeps it from flying away by evaporation. This close union Plato[7] calls

[5] Gold, of course, can hardly be called 'transparent'; what is meant is its metallic lustre (see III, ii, 3).

[6] *The Heavens*, IV, 4, 311 a 15 ff. deals with heaviness and lightness. Albert in his own version (*The Heavens*, IV, ii, 5) emphasizes the notion that the more Air there is in anything, the lighter it is. Presumably he means that gold is so 'closely packed' that there is no room for Air in it.

[7] Perhaps *Timaeus* 56 B–C: the ultimate particles of the elements are so minute that many must be 'collected' or 'aggregated' together to make a perceptible amount of matter.

'an agreement' (*foedus*), and Empedocles[8] 'a gluing together of related things' (*collam germanorum*). And the harmonious mixture[9] of gold is the reason why it is warm and moist, and is prescribed for tremors of the heart and for black bile which causes melancholy, especially for [the disorder] that makes a man talk to himself when he is alone. It is prescribed for these afflictions either ground up with other things having the same power, or taken by itself as a powder.

Its solidity is the reason why it does not easily stain bodies that it touches, and therefore it is worn in rings and other ornaments. For silver stains a little and the other metals a great deal; and this happens because the unctuous moisture is not completely separated from them; and with this is mixed some burnt earthiness that stains like the soot of an unctuous body.

And the great purity of its material is the reason why [gold] is very rarely found mingled with any other body, but always, so to speak, pure; for if it were mixed with anything else, it could not retain such purity, and then it would degenerate into copper; and on the other hand it is very rarely found[10] incorporated with stones. And for this reason, again, it is frequently found as little grains of sand;[11] for anything of such great purity must occur only in small quantity, raised up out of the material and, as it were, evaporated; and therefore it is widely dispersed. But still there was recently found a nugget weighing a hundred marks.[12]

From all this it is clear, again, why these two metals, that is, gold and silver, have the special property of aiding and comforting the [human][13] constitution; and why they were adopted as material for coinage by the wise men of old times; for they are more durable and more noble than the other metals.

[8] See III, i, 3, note 5.

[9] *temperantia*. Albert's remarks about medicinal uses of gold are similar to those in Constantine's *Book of Degrees* (*Opera*, p. 348): 'Gold is more harmoniously mixed than the other metals. It has the property of curing stomach trouble, and strengthens those who are fearful and who have heart ailments. Galen asserts that it is good for melancholia and mange. When surgery is necessary, if it is done with gold instruments, this prevents rotting of the flesh.'

[10] I omit *nisi*, 'except (incorporated with stones)', as inconsistent with the facts

[11] *et grana arenularum*; but Paneth (p. 38) has *ut granula arenarum*.

[12] The old German mark (*marcha*), according to Hoover (*Agricola, De re metallica*, Appendix C, p. 617), was equivalent to 3609.6 Troy grains, or about one-half pound avoirdupois. This fifty-pound nugget was a remarkable find; but even larger ones have been recorded.

[13] *homines*: but editions of 1495 and 1518 and Paneth (p. 38) have *hominis*. I have also followed the Paneth manuscript in placing this clause before, rather than between, the other two clauses as printed.

The substances that purify gold are sharp and extremely dry, such as salt, especially sea salt, and the soot of substances that are unctuous but dry, and brick dust.[14] When gold is to be purified, an earthenware pot is made in the shape of a *cucurbita* or *scutella*,[15] and over this a similar one is placed, and they are cemented together with the stiff clay the alchemists call 'lute of wisdom' (*lutum sapientiae*). In the upper one there are many holes by which the vapour and smoke can escape. And next the gold is beaten out in thin, short sheets and arranged in the vessel in such a way that each layer of [gold] sheets has above and below it [a layer of] powder made of soot, salt, and finely ground brick mixed together. And it is cooked in a hot fire until it is extremely pure and the ignoble substances in it are consumed. The 'lute of wisdom' of which the pots are made is composed of ground-up pottery, remixed and baked; for such a vessel, when placed in the fire, does not shrink perceptibly in the fire. There are other ways of preparing 'lute of wisdom'[16] in alchemy, but let this, which is used by goldworkers, be sufficient. This, then, is the method of purifying gold, and nothing is burnt away in it except ignoble material. And for this reason Hermes aptly says in his *Alchemy*: 'Sulphur itself, because of a certain affinity[17] by which all metals are closely related to it, burns and reduces them all to ash, except only gold; for the pores [of gold] are tightly closed and cannot be opened'.[18]

At the present time the most abundant supply of gold comes from the

[14] This is the ancient 'cementation' process for parting gold from silver. The effective ingredients are the salt and brick dust. On strong heating the silver is attacked by the salt and converted to silver chloride, which is absorbed by the brick dust, leaving the gold unaltered. Another method of parting, by means of sulphur, is mentioned in IV, 5, introductory note.

[15] A *cucurbita* was 'gourd shaped'; a *scutella*, like a 'little shield', *i.e.* a flattish saucer.

[16] 'Lute of Wisdom' was a cement used for sealing a junction between a pot and its lid or an alembic. It was mostly plastic clay to which various ingredients were added to keep it from cracking during heating—egg-white, chopped dung, lint, or hair. But Albert (or his informant) seems to use the term also for the mixture of clay with a tempering of ground-up potsherds, used in making refractory crucibles.

[17] The first use of 'affinity' (*affinitas*) as a chemical term has sometimes been attributed to Albert, but it must go further back, for Arnold of Saxony also gives it as a quotation from Hermes: *Book of Alchemy* (Stange, p. 44); and it is in the *Liber sacerdotum* (Berthelot, 1893, Vol. I, p. 204). In any case, 'affinity' did not have the precise meaning that began to be attached to it in the eighteenth century, but seems to be merely an alternative translation for *symbolum* (cf. III, ii, 1, note 10), the 'something in common' that permits two things to react, combine, or be transmuted into each other.

[18] Cf. *Meteor.* IV, 9, 387 a 19: things are combustible only if they have 'pores' through which the Fire can enter.

kingdom of Bohemia; and recently in [Westphalia] in Teutonia, in the place called [Korbach],[19] gold has been found in a certain mountain; and this [gold] loses less during purification than any other kind. Yet it is valued at a lower price than any other kind, and the reason for this is surely only that it is new and its value has not yet been proved by the buyers.

It must be remembered, too, that gold is found of a sort of yellow-saffron colour, and becomes redder on cooking, because the material principle [Quicksilver], which is white, is consumed more than the formal principle [Sulphur], which is red.[20] And on this account alchemists wishing to make gold seek for the red *elixir*, which they call the 'medicine' and they seek to have four [properties][21] in it: it must impart colour, and be penetrating, and be indestructible in the fire, and be firmly consolidated. And this they call the 'Red of the Sun' (*sol*, gold). And in the *elixir* for silver they seek [the ability to impart] a white colour, to penetrate, to be fixed in the fire, and to be very subtle. And this they call the 'White of the Moon' (*luna*, silver). And on this account Hermes says: 'This[22] is the root on which all alchemists depend: the medicine of the Sun is red, that of the Moon is white.' And the shining white and saffron-red [*elixirs*] open up the gold, but a kind of cooking is needed so that it may absorb a [little][23] redness.

Everything said so far throws some light on the reason why most of the alchemists assert that, from every substance composed of the elements, they are able to extract three substances, namely, oil, glass, and gold.[24]

[19] *in Vuelvuale Teutoniae partibus in loco qui vocatur Turbeth*: in the 1518 edition *in Vuestvalie . . . Curbeck*, which may be correct, since mining (for metals as well as coal) was important in Westphalia, though I have found no record of any extensive gold mining. Westphalia, however, was a region of which Albert undoubtedly had considerable knowledge.

[20] The white is Quicksilver, female, supplying *matter*; the red, Sulphur, male, supplying *form* (cf. IV, 1–2). The reference may be to refining gold which originally contained some silver (see note 14 above), or to treating amalgam in which fine gold had been collected. In either case the 'white' is driven off, and the 'red' (gold) remains.

[21] Avicenna's *Letter to Hasen* (Zetzner, 1613, Vol. 4, p. 973) lists these same properties, adding that the *elixir* must also mix readily with other things in the liquid state.

[22] *qui*, which would seem to refer to Hermes, must be an error. Arnold of Saxony (Stange, p. 44) has *hec enim est radix*, &c., and the same appears in the text accompanying the *Emerald Table* published by Steele and Singer (p. 52).

[23] *medicum*; but (ed. 1518) *modicum* seems correct.

[24] This saying perhaps refers to assaying sulphides suspected of containing gold: First the sample is roasted, giving off fumes; this is the *oil* burning. Then a flux is added and the mass is fused; the slag that rises to the top is the *glass*. Finally, *gold* is left.

For it is clear from what has often been stated that there is a sort of fattiness in everything composed of the elements, which surrounds its parts; and since this is viscous, when the moisture of Water vanishes, [the fattiness] distils out of a substance set on fire and roasted; and by baking it is driven into the interior where it is protected longer from the fire. In every substance, too, there is a radical moisture mixed with subtle Earth, so that each holds fast to the other; and when this [mixture] is strongly heated, by subliming itself in the internal pores of the body when the external openings have been closed up by burning, it is divided, as it were, into two parts; the more gross and watery [part] floats about in the substance and by a very strong fire is fused into molten glass, and on cooling hardens into glass; but the purer [part], sublimed by heat, becomes saffron-yellow and is fused into molten gold, which hardens on cooling.

This is especially true of human hair, for this contains more of the mineral power, especially if it has been cut from the head. Why this is so is irrelevant here but is to be explained in the science of *Animals*.[25] Evidence of this is that in my own time a human skull was found and seen to have many bits of gold dust embedded between the teeth of the sutures in the top of the cranium.[26]

[25] This curious statement is not, so far as I can discover, elucidated in any of Albert's books on *Animals*, though these give Aristotle's theory about *hair*: that it is a 'residue', mostly of Earth and Water, extruded through the pores of the skin (*Generation of Animals*, V, 3, 782 a 30 ff.); that man has more hair on the head than on other parts of the body, because he has a large, moist brain and a skull with many sutures through which the superfluous moisture escapes (*Parts of Animals*, II, 14, 658 b 2 ff.). But in alchemy (for example, Avicenna's *Letter to Hasen*, Zetzner, 1613, Vol. 4, pp. 981–2) *hair* is recommended, along with eggs and blood, for making the *elixir*. One might imagine here the influence of magic, since all these things are symbolic of virility, fertility, life, &c.; but perhaps the alchemists were interested in them simply because sulphur and ammonia compounds could be extracted from them. On the other hand, these may be 'cover names' for secret ingredients. For instance, the *Liber sacerdotum* has a number of recipes that include hair, but once (Berthelot, 1893, Vol. I, p. 202) speaks of 'the golden stone (*lapis aureus*) which, according to another authority, is the same as the hair of living things (*capillus animancium*)' and Arnold quotes the same from Hermes's *Book of Alchemy* (Stange, p. 44). This must have been a mineral occurring in fine acicular or capillary crystals, a habit well known in millerite (nickel sulphide), but also found sometimes in marcasite and in stibnite; the latter was perhaps called 'golden stone' because it was used in parting gold from silver (cf. V, 6, note 1).

[26] Prehistoric human bones have been found in river gravels, and if any gold were present, tiny particles of it could easily be trapped in the sutures of a skull. But Albert, believing that all gold grows *in situ*, seems to suppose that the material in the sutures, which in life would have produced hair (see note 25 above), was here converted into gold.

For almost everywhere gold is found, as we have said, in the form of dust or grains.[27] And the reason for this is that the material is subtle, and it is driven out and sublimed. Evidence of this is that [gold] is found [that looks] like hardened droplets. For in the pores of the natural vessels the concentrated vapour is repeatedly doubled back upon itself and converted into fluid which takes [the form of] rounded drops. And if sometimes they are hollow, elongated, and [look] as if they were made up of smaller ones, this is because in the neck of the natural vessel the vapour is not converted or hardened all at once, but a bit at a time; and thus a second [drop] is added to the first, and sometimes a third to the other two, just as happens in the formation of hail.

This is our account, in general terms, of the nature of gold, according to natural science.

CHAPTER 8: THE NATURE AND MIXTURE OF IRON

Iron (ferrum) *is a silvery white metal, with specific gravity 7.9, very soft, malleable, and ductile. It oxidizes readily, forming a dark crust, or disintegrating as rust; for this reason it was thought to be full of 'dirt' and 'poorly mixed'.*

The most important iron ores are carbonate (siderite) or oxide ores (magnetite, hematite, goethite, limonite, &c.). After preliminary roasting, a flux was added and the ore was reheated with charcoal using as strong a draught as could be managed with bellows. The slag absorbed impurities (and also a good deal of iron) and the ore was reduced to metal. But the temperature was too low to obtain a clean separation, with a layer of slag floating on liquid iron. The two remained mixed in a pasty mass, which had to be removed from the furnace and hammered to break off and squeeze out the slag and consolidate the iron. Reheating and hammering were repeated until the iron was considered sufficiently pure. The product was a 'bloom' of wrought iron. Ordinarily the metal was never really molten, so cast iron could not be made; and even if it was accidentally produced, it was not of much use, being too brittle.

Steel (chalybs) *is iron containing a little carbon, and it was made successfully by empirical methods for centuries before its metallurgy was understood. Iron from the bloomery was rather pure, so carbon had to be added to it by further*

[27] Gold crystallizes in octahedra, commonly grouped in angular masses. But it is so soft that transported gold is usually worn into flattened scales (gold dust) or rounded lumps (nuggets), which Albert called 'droplets' because he thought they were formed by a distillation process.

heating in charcoal and hammering to mix the absorbed carbon into the iron. (The process was thus fundamentally different from the modern method, by which pig iron is first produced from a blast furnace using coke, so that the iron is high in carbon, and making steel requires removal rather than addition of carbon.) But in practice the smelting of iron ore and the conversion of the iron to steel might be carried out as a continuous process.

FINALLY, there must be some account of IRON. This is more ignoble than the other metals, which are liquefiable; and it cannot be liquefied like wax, but is liquefiable only in that it can be softened. And it is made up of Quicksilver that is very earthy, heavy, dirty, and impure, and of earthy, impure Sulphur that by its power converts the Quicksilver to the specific form of iron. And therefore iron is very scaly, and it rusts easily because of the burning of its Sulphur; and it makes a stain black as soot on anything that it touches. And perhaps the earthy substance of its Sulphur is like *atramentum*,[1] and that is why [iron] filings impart blackness to ink. And also it is not cleansed of unctuous moisture, and therefore it burns easily.

Evidence of this is that anything fatty applied to it, like soap or pitch, opens it up so that tin[2] poured over it penetrates into its substance. But after this penetration it becomes so brittle that it cannot be worked.

The burning of the earthy substance in it is proved by the great amount of slag that is separated from it; and especially by the fact that it is frequently found as black grains in earth.[3] And consequently it is clear why it is not liquefied like other metals, but only softened. For the cause of this is its earthiness. And thus Hermes[4] aptly says: 'The reason for the slow liquefaction of iron is that it has too much earthiness in its parts preventing its fusion'. But nevertheless, in a great fire, especially if sprinkled with sand and sulphur, it is distilled and purified. Because of its great hardness it has come to be used for making instruments such as hammers and anvils, by means of which the other metals are beaten out. And because of its dryness, sharp edges of it are strong, and therefore it is suitable for cutting and piercing things that have to be cut and pierced.

[1] See V, 3, note 4.

[2] Apparently a reference to tin-plating, which Pliny (*Nat. Hist.* XXXIV, *48*, 162) says was invented by the Gauls for coating bronze or copper vessels. I do not know why tin-plated iron should be unusually brittle, and suspect that Albert is merely reiterating what he has already said about tin (IV, 4).

[3] Bog iron ore: see III, i, 10, note 11.

[4] From Hermes's *Book of Alchemy*, as quoted by Arnold of Saxony (Stange, p. 43).

Hermes also says of it that Quicksilver, which makes it almost as white as silver, penetrates its substance, on cooking with sulphur and tartar, that is, [wine-]stone.[5] Sulphur, because of its burning force, and because of its incomplete state[6] is called by Hermes the 'never-sleeping' (*pervigil*) and the 'waylayer' (*insidiator*)[7] of all metals. Quicksilver, however, does not remain long in [iron] over the fire, but escapes from it, just as it does from the other metals, with which it mixes easily because it has a natural similarity to them, unless by great skill it is fixed and held fast. And because of its fugitive moisture, Hermes calls [Quicksilver] the 'runaway slave' (*servus fugitivus*).[8]

Since, as explained above, [iron] is dry and burnt, it is effective in soothing weakness of the spleen and stomach; and therefore those who have such ills are ordered to drink wine and water in which white hot iron has been quenched.[9]

STEEL is not a different specific form of metal from iron: it is merely the more subtle and watery part of iron extracted by distillation; and therefore it is harder and firmer [than iron], because of the force of the fire and the fine division of its parts, which become harder when heated. And it is whiter because more earthiness has been removed from it. But when it gets too hard, it breaks and shatters at a blow, because it is too much dried out. But different kinds of water[10] produce different degrees of hardening. For this reason smiths search out special waters for quenching the iron from which they make swords. For when iron is made white hot

[5] *vivi*; but editions of 1495 and 1518 have *vini*. 'Wine-stone' came from the crust in old wine casks and was a source of potassium carbonate. This sentence, too, is quoted by Arnold from Hermes (*loc. cit.*), but the meaning is obscure; perhaps it is part of a recipe for cleaning the surface of iron before plating or tempering.

[6] I omit *argentum vivum* here, as obviously imported from the following sentence.

[7] These are 'cover names' indicating that sulphur is always ready to attack metals. Arnold (Stange, p. 44) quotes the saying from Hermes's *Book of Alchemy*; it is also in the *Book of the Priests* (Berthelot, 1893, Vol. 1, p. 202).

[8] This also may be from Hermes's *Book of Alchemy*, though not quoted by Arnold. It is found in other alchemical books, e.g. *Book of Alums and Salts* attributed to Rhasis (Steele, 1929, p. 25).

[9] Constantine, *Book of Degrees* (*Opera*, p. 377) says that this treatment is recommended by Dioscorides and Galen.

[10] The notion that the quenching water affects the quality of the steel is very old (Pliny, *Nat. Hist.* XXXIV, *41*, 144). Although the natural waters of different regions do undoubtedly differ, it is much more probable that regions famous for their steel owed their success not so much to their water as to their local iron ores, which happened to contain small amounts of manganese, nickel, chromium, &c. But 'artificial' waters were concocted for the same purpose (see II, iii, 2, note 10).

and plunged into water it is hardened because the heat flees from the cold of the water into the interior of the iron and burns up the moist material in it; and as [the moisture] is consumed, the steel becomes harder and harder.

Let this, then, be all that we have to say about iron, and about the other metals, either individually or collectively.

BOOK V

MINERALS THAT SEEM TO BE INTERMEDIATE BETWEEN STONES AND METALS

A SINGLE TRACTATE

CHAPTER 1: THE GENERAL PROPERTIES OF INTERMEDIATES

In this final book, Albert deals with 'intermediates' (media)*—minerals that are neither stones nor metals but 'something in between'. This classification seems to be his own, and he begins by defending it against the fourfold classification of Avicenna, since his own scheme is nearer to Aristotle's science, which defines 'intermediates' in terms of 'extremes'. We may detect here a groping after the notion of* chemical composition*: the statement that 'intermediates are understood by their extremes' means, in the language of today, that compounds are understood by isolating and identifying their constituent elements. But such chemical analysis was beyond the power of alchemy.*

Yet the media *are important reagents in alchemy because, as Albert argues, being 'neither the one thing nor the other', they may be influenced by laboratory treatment more readily than substances in which the specific* form *is fully developed. All these minerals were known and used in antiquity; but there is no continuous tradition here, as for the descriptions of 'stones' (II, ii). Albert drew his information from a number of books on medicine and alchemy.*

In this fifth book on minerals there still remains the investigation of the nature of those things that seem to be intermediate in nature between stones and metals. For although Avicenna[1] has divided mineral bodies into four groups—stones, fusibles [that is, metals], sulphurs, and salts—yet it seems to us that Sulphur is in itself more [a part] of minerals than Quicksilver; for it becomes part of the material, [changing] one thing into the other.[2]

[1] *De congelatione* (Holmyard and Mandeville, 1927, p. 49): 'These mineral bodies are divided into four kinds—stones, fusibles, sulphurs, and salts.'

[2] The point seems to be that Sulphur is present not only in metals (as explained in Books III–IV) but also in other minerals. This is correct, since *atramentum* and *alumen* (V, 3–4) are sulphates, and *marchasita* (V, 6) sulphide minerals.

In speaking of intermediates, therefore, let us discuss first the nature of intermediates in general, and afterwards touch briefly on some of them individually, and with this we shall fulfil our intention in this book.

Everything, then, which in some ways shares the passive [properties] of stones and in other ways those of metals, we call an intermediate. For it is a property of stone not to be fused, and a property of metal, depending on its material, to be fused by dry heat. Hence stones belong to the group of dry things and of Earth, but metals to the group of moist things and of Water. Intermediates, therefore, are those things that in some respects are earthy and in others watery; and those that are [closer][3] to Earth solidify by dry heat; but others are closer to Water, and from these Water is distilled by dry heat—for instance [rock salt].[4] Furthermore, intermediates are any substances that fuse by dry heat and afterwards tend to solidify not only by cold but even on the fire, if boiled dry. For they would not fuse unless they were to some extent watery, but they would not solidify by boiling unless they were to some extent earthy, as may be gathered from the teaching of the *Meteorology*.[5] Moreover, an intermediate is anything that is composed of both [stony or earthy and watery or metallic] substances, even though it does not fuse in dry heat. Thus all slags that are smelted out with the stony parts of ore minerals are intermediates. And so is all *marchasita*,[6] which, like stones, does not fuse in the fire; but nevertheless its very colour and weight show its metallic nature. And also all crumbling substances, which in solutions are very effective in hardening and contracting things, have something of an intermediate material—such as all kinds of *alumen*.[7] And also all kinds of *atramentum*[8] seem to be intermediates, since something stony is found in their substance.

These intermediates have been produced by the mixture, in a vaporous condition, of the material of stone and the material of fusibles or metals. For a moist humour having something of the nature of Quicksilver is mixed with much Sulphur; and the humours and vapours and the other materials are combined by nature into some kind of intermediate. For wise and diligent nature, fulfilling the potentialities of all matter, does not pass from one extreme to the other, according to Aristotle,[9] without completing all intermediate [stages]. Therefore [nature] has made many

[3] *interiora*: but in 1518 edition *viciniora* as in the following clause, '*nearer* to Water'.

[4] *gemma*: in 1518 edition *sal gemma*: see V, 2, note 3.

[5] *Meteor*, IV, 6, 383 a 14 ff.

[6] Metallic sulphides (V, 6).

[7] Alum minerals (V, 4).

[8] Vitriols, natural sulphates (V, 3).

[9] References in notes 11 and 14 below.

things intermediate between infusible stones and fusible metals, that she might demonstrate harmony in everything and show her own desire for the good, so that everything that is possible in all kinds of matter might reach completion.

But the nature of intermediates is especially noteworthy in the transmutation of metals. For on these substances depends most of the science of those who endeavour to convert one [metal] into another. The intermediates are, as it were, the raw material, and, as we have shown above, anyone who makes a proper attempt to convert one metal into another must first reduce it to prime [matter][10]—that is, very close to the generic character of metal. Then, according to its aptitude, with the help of the powers acting on it, it easily takes on the nature and true specific form of the metal that is wanted.

The scientific reasoning that has been demonstrated in the *Physics*[11] shows that there is no motion[12] from one extreme to the other except through an intermediate [stage]. But it is a property of all [intermediates][13] that their specific forms seem to be incomplete; and therefore they are capable of being converted into anything at all; for an intermediate, strictly speaking, possesses only in an unformed state that nature which in the extremes is distinct and perfect, as will be explained in the science of *The Senses*.[14] The extremes are in some manner present in the intermediate but only in confused forms. And for this reason the extremes are brought out, by skill or by nature, from the intermediates, when the power of one extreme is concentrated over the other.

Let such be our account of intermediates in general. It is unnecessary to say more, because the intermediates are understood through their extremes.

[10] *ad naturam primam*, probably should read *ad materiam primam*. See III, i, 9, note 3.

[11] *Phys.* I, 5, 188 b 22 ff.: all intermediates are made up of extremes (all colours, for instance, of white and black, &c.); and V, 1, 224 b 29 ff. (even more explicitly): change may move from one extreme (or contrary) to the other, or may begin with an intermediate, in which case the intermediate is in a sense opposed (as a contrary) to either extreme.

[12] motion here means change. See I, i, 5, note 2.

[13] *metallorum*, but the context plainly requires *mediorum*

[14] *The Senses*, 6, 445 b 24 ff.

CHAPTER 2: THE NATURE, FORMS, AND KINDS OF SALT

Albert's classification of salt (sal) *is similar to that of Constantine of Africa in the* Book of Degrees (Opera, *p. 387*)*: 'There are four kinds of salt. There is salt made in salterns, that is, common salt. There is also* sal gemma. *And there is* sal indicum, *which is blackish in colour, but clear and hard. And there is another kind called* nauticum, *which solidifies from well-water.' All these were probably 'common salt' (sodium chloride) and the apparent differences were due to impurities or to different methods of preparation.*

Sal ammoniacum *or* armoniacum (*which Constantine mentions later*) *was also originally sodium chloride, brought from the Egyptian desert near the oracle of Jupiter Ammon. But the Arabs, by about the tenth century, began to use this name for ammonium chloride* (*which is still known as* sal ammoniac). *This is much less common, as a natural mineral, than sodium chloride, though it occurs in some volcanic regions. The alchemists' interest in it grew as they learned to prepare it from organic materials such as urine. It is not always possible to tell which kind of salt is meant; for instance, in the* Book of Alums and Salts (*Steele, 1929, p. 16*), 'sal ammoniacus, *noblest of all, not fleeing in the fire*', *is presumably the old 'salt of Ammon', sodium chloride, but the* sal ammoniacus (*op. cit., pp. 18–19*) *that is 'subtle, penetrating, a fugitive spirit' must be the volatile ammonium salt, especially since it is said to be obtained 'from dung and animal fluids'.*

LET us now speak of each of the intermediates individually.

And the first of these is SALT, of which we already know in general, from the science of *Meteorology*,[1] that it is made of gross, earthy material, burnt and afterwards mixed with watery moisture. That is why all salt tends to dissolve in cold Water and moist Air.

There are many different kinds of salt. There is sea salt (*sal marinum*) or that which is extracted from salt water. And there is rock salt (*sal gemma*)[2] which is like transparent crystal and is found in great abundance in Hungary, and is composed of an earthy mixture and therefore easily crushed to powder. It is not made of earthiness alone, however, but also contains a watery substance that has been hardened by cold and union

[1] *Meteor.* II, 3, 356 b 4 ff. See Appendix A, 4.

[2] *Sal gemma*, 'gem salt', is halite which occurs in almost colourless transparent masses or as large cubic crystals. But Albert can hardly have been very familiar with the natural occurrence: see note 9 below.

with the Earth; this is why it is transparent, and also why it liquefies in hot moist [Air],[3] and Water distils from it, leaving its earthy material behind. Again, there is the salt called *sal naphticum*,[4] which is black from the *naphtha* it contains; but when it is distilled the *naphtha* liquefies and separates from it, and then it becomes white. And again, there is [Indian] salt,[5] which is black in itself from the intense burning of the Earth in it. Furthermore there is salt of Ammon (*sal ammoniacum*), which is clearer and almost transparent.

And perhaps there are other kinds of salt beside these, found in different lands. For sea salt in the Mediterranean near Italy is of one kind, and that in the Northern Ocean near Flanders and Germany is of another kind. For that of the Mediterranean is produced at low tide where the tide ebbs, or in pits where the sun's heat reaches the bottom; and this is in coarse grains like snow mixed with hail. But that of the Northern Ocean [is produced] by boiling earthy materials from the sea bottom. There are salt springs, too, in different parts of Teutonia, and their waters are boiled into good salt as fine as flour. Salt is also made from urine, especially that of boys, by the alchemical operations of sublimation and distillation.[6]

But whatever the method of production of salt in general, it is nevertheless all one in nature, being composed of something earthy which is moistened and mixed with something burnt. And because it has been mixed with moisture, it is white after being burnt. And the more it is burnt, whether by boiling dry or by roasting, the whiter it becomes and the more bitter. For the taste of salt is mixed with bitterness, as will be shown in the science of *The Senses*.[7]

[3] Salt exposed to air may become moist and sticky, but this is not due to distillation of moisture from within, but to absorption of moisture from the air. Pure sodium chloride does not take up much water in this way, but salt made from sea water (including 'fossil salt' in sediments) commonly contains other salts of calcium and magnesium, which are strongly hygroscopic.

[4] *sal naphticum* (Constantine's *sal nauticum*) is named from its association with *naphtha*, liquid petroleum. Oil geologists now recognize a common relation between salt domes and structures containing petroleum; and salt springs or wells often occur with oil seepage.

[5] *sal radicum* seems to be an error for *sal indicum* in the 1518 edition and in Constantine (loc. cit.). Halite occurs in many colours, including black and dark blue. But if *sal radicum*, 'salt of roots', is correct, it may refer to salt made by burning twigs or roots; Pliny (*Nat. Hist.* XXXI, *39*, 82) mentions salt made in Germany, Gaul, and Spain by throwing brine on burning wood. This product would contain charcoal, some potash salts from the wood ash, as well as whatever salt was in the brine.

[6] Probably ammonium chloride, though it is not clear that Albert realized that it was really different from the other salt mentioned.

[7] *The Senses*, 4, 442 a 17–20: all tastes are a mixture of sweet and bitter, and 'salt is almost

Because of its earthiness all salt is found [to be] styptic, and because of its dryness it is itself drying, and prevents putrefaction. Because it is, at the same time, both hot and dry, it is cleansing, and because it has a penetrating sharpe taste, it seasons food. The crystalline kind is especially active in consuming gross vapours, but any of the hotter [kinds] is able to dissolve hardened humours in mixed bodies. And all salt has this [property] more or less.

In the same way, because of its dryness, together with the irregular arrangement of its pores[9]—an irregularity due to burning, which has deranged the order of the pores—salt is one of the many kinds of things that can be broken into little pieces.

CHAPTER 3: THE NATURE AND SUBSTANCE OF ATRAMENTUM

This chapter deals with a whole group of minerals, neither clearly differentiated nor accurately named in the Middle Ages. They are all products of the weathering of sulphide ores, mostly of iron and copper. Alkadidis (*Arabic* qalqadis, *from Greek* chalcitis) *was a white or yellowish crust of oxidation products, mostly sulphates.* Assurie (*Arabic* al-suri, *from Greek* sory), *was red oxide of iron.* Alkofol *is evidently the same word as our* alcohol, *originally meaning 'finely divided' or 'subtle'; but here it seems to be an error for* colcothar (*Arabic* qalqatar), *also known as* crocus Martis, *'yellow of Mars' (yellow iron oxides). The nameless blackish-grey material with a glint like gold dust is what the Greeks called* misy, *with still undecomposed bits of pyrite or other sulphide minerals (Cf. Pliny,* Nat. Hist. *XXXIV,* 29–31, *117–22; and Avicenna,* De congelatione, *Holmyard and Mandeville, footnote, p. 37). But the substance to which* atramentum *was more strictly applied was* alacantum (*Arabic* qalqant, *from Greek* chalcanthon), *which included hydrous sulphates of both*

the same as bitter'. Crude salt, especially sea salt, commonly contains magnesium salts that are bitter.

[8] Cf. Constantine, *Opera*, p. 387: 'All salt is hot and dry in the fourth degree, but not equally so, for some is hotter and drier than others. But salt universally preserves bodies and keeps them from decaying. . . . It dissolves and dries up gross, hardened humours.'

[9] *Meteor.* IV, 9, 386 a 9–18 and 387 a 2–5: fissility is due to pores arranged in rows (as in the grain of wood); things which are not fissile lack this alignment of pores and so break irregularly or crumble. But this explanation does not really apply here, because halite has an excellent cubic cleavage (mentioned by Pliny, *Nat. Hist.* XXXI, 39, 79). We should expect Albert to know this if he had ever seen large masses of natural halite (note 2 above).

copper (chalcanthite, 'blue vitriol') and iron (melanterite, which is green). The name copperas, *still used for the latter, shows how persistently the iron and copper minerals have been confused.*

Being very soluble, these sulphates are carried in ground or surface waters, from which they can be crystallized by evaporation. They were also prepared 'artificially' by leaching the half-decomposed sulphides in water, concentrating the solution by boiling, and setting it aside to crystallize (Pliny, Nat. Hist. *XXXIV,* 32, *123–5; Agricola,* De re metallica, *Hoover, pp. 572–5).*

THE nature of ATRAMENTUM is peculiar to itself, a *homeomerous*[1] mineral substance that can be dissolved by boiling in water, mixed with a stony substance that is not dissolved at all, even by strong boiling. The original kind of *atramentum* is undoubtedly liquid, and it has solidified of its own accord. But all *atramentum*, according to its kind, is characterized by having a foul taste,[2] and in being styptic and very irritating; and therefore when it is applied to things it thickens and hardens them.

There are several forms: one kind is white, which the Arabs call *alkadidis*; one red, which they call *assurie*; and one yellow, which they call *alkofol* [*colcothar?*]; and there is a green one which they call *alkacantum*; and a greyish one tinged with black which is almost stony. The green [kind], which some people call vitriol (*vitreolum*)[3] and classify as a sort of ink,[4] is more firmly solidified than the yellow, and has thicker outside coatings.[5] And the most efficacious among the greyish [kinds] of *atramentum* is that showing a sort of golden glint, as if there were gold dust sprinkled through it and dimly gleaming.

It is plain that almost all kinds of *atramentum* are made of Earth and Water. At first they were liquid and afterwards solid, and still they can be redissolved, by heat and moisture. Their [colour][6] depends to a greater or lesser degree on the fine division of the earthy material in them and the

[1] See I, i, 1, note 8.

[2] All descriptions of these minerals emphasize the rancid, vile, or nauseous taste and smell. The decomposition of the sulphides released hydrogen sulphide, which smells like rotten eggs. The sulphates have a disagreeable metallic taste, and taken internally act as emetics. (Cf. II, ii, 11, *Medius*.)

[3] *vitreolum*, 'glassy', refers to the transparent crystals, which Pliny calls 'glassy berries like grapes', when crystallized on strings in a vat (*Nat. Hist.* XXXIV, *32*, 123).

[4] *Atramentum* is 'shoemakers' black'; the iron sulphate combines with tannin to form a black colour that was used for dyeing tanned leather or making ink (for which oak galls supplied the tannin).

[5] *tunicas*. Crystals of chalcanthite and melanterite kept in dry air lose some of their water of crystallization and become coated with a white powder.

[6] *calorem*, 'heat'; but it should be *colorem*, since the context recapitulates the theory of *colour* given in I, ii, 2.

thorough cooking of the moisture, and on the larger or smaller amount of Air that is mixed in when the Earth was being cooked in the Water.

[*Atramentum*] is thus an intermediate between stones and metals because it has the constitution of stone and sometimes the lustre of metals.

CHAPTER 4: THE NATURE AND KINDS OF ALUM

Alumen *included a number of minerals, mostly hydrous sulphates containing aluminium; but precise identification is impossible, because the* alumen *found in nature was impure, probably contaminated by, and to some extent confused with, other sulphates, some of which (vitriols,* atramenta*) have been described in the preceding chapter (V, 3). Some of these minerals occur in fibrous or plumose forms, the* schiston *or* trichitis *of Pliny (*Nat. Hist. *XXXV, 52, 186). Kalinite and alunogen are white, or tinged with grey, yellow, or red; halotrichite is yellow. The most 'earthy' or 'stony' kind was probably aluminite, found in* alunschiefer *(alum shale or slate) in central Germany.*

Alum minerals, like vitriols, are very soluble in water, so that they can be prepared by leaching alum deposits and boiling to produce a saturated solution (Albert's 'moist' or 'liquid alum'), which is then allowed to crystallize. Alum was used in medicine, and was very important in the dye industry, which Albert does not mention.

ALUM is of an earthy constitution. Its Earth is of a kind that is gross and solidified by moisture; it lacks Quicksilver among its ingredients and yet somehow approaches that [substance]. And it seems to have been hardened by some force which, although not that of Sulphur, yet has some relationship to Sulphur. Alum is most commonly white in colour, and when it is roasted by dry heat a kind of Water distils from it, almost as it does from rock salt.[1]

[The kinds] most frequently occurring and most useful are three, namely: the long and cleavable kind, which appears feathery on the cleavage surface and has a colour like silver; and second, that which is dry and round, like a soft stone; in its silvery lustre and whiteness this is little inferior to the preceding, but it is less efficacious than that is; and some people call this 'round alum';[2] and the third is dry and, as it were, stony,

[1] See V, 2, note 3.

[2] When alum is heated, it melts and swells, giving off water of crystallization, and on cooling solidifies into a rounded porous mass, 'round alum' (Pliny's *strongyle* (*Nat. Hist.* XXXV, 52, 187), or 'burnt alum', which is less astringent than other kinds.

with a colour tinged with yellow. All three can easily be reduced to powder. The first two are hot and dry, very active in drying and causing contraction. The third is not [so efficacious as] a styptic, although it is stony. Water which has been used to wash the first kind, when it is well aged, and has been repeatedly strained through it, becomes excessively effective in consolidating and hardening all sorts of bodies. On this account the alchemists make use of it in the liquid they call 'virgin's milk' (*lac virginis*) which we have mentioned elsewhere and shall mention further.[3] It is said that there is found a 'moist alum' and that it is like unctuous *bitumen*,[4] very easily consumed by fire; and in this property and in being unctuous, it is very like Sulphur, but lacks its odour. And this form of alum some people call *naphtha*.

CHAPTER 5: THE NATURE AND KINDS OF ARSENICUM

Arsenicum *includes two arsenic sulphides, yellow orpiment and red realgar, which on heating in air change to the oxide, white arsenic. This chapter is a duplication of II, ii, 6,* Falcones, *where notes will be found.*

ALTHOUGH ARSENICUM sometimes [occurs as] a kind of stone, which we have mentioned in the second book on minerals, nevertheless, since several kinds of it are found, it ought to be better treated here. It is undoubtedly of an earthy nature, burnt, and having something of the unctuous character of Sulphur, for it is related to Sulphur. The moisture of Sulphur is very active in penetrating metals because it is related to them, and it burns them; and since *arsenicum* is even sharper, it is even more effective in burning them. It is friable, hot and dry, but more hot than dry; and thus it is very active in causing disintegration and eating things away.

Three kinds are found, namely white; and yellow, which is commoner

[3] Already mentioned in II, iii, 2, and also in Albert's *The Senses*, ii, 2.

[4] *bitumen* is asphalt, a solid or semi-solid residue of petroleum, and *naphtha* is the light fraction, sometimes produced by natural distillation processes. But this has nothing to do with alum. Possibly the only connexion is the mere juxtaposition of the two in Pliny (*Nat. Hist.* XXXV, *51*, 178–82, *bitumen*; *52*, 183–90, *alumen*) and Isidore (*Etym.* XVI, *2*, 1, *bitumen*; 2, *alumen*), whence they were copied together, as one item, into some compilation that Albert used. But possibly Albert accepted the connexion because he knew of some pyritic coal or oil shale, in which weathering had produced alum minerals.

as well as more friable and paler, than the others, and is called orpiment; and red. The best kind is that which is saturated with the red, but has streaks of other [colours]. And perhaps many other kinds are found, according to differences in the material.

CHAPTER 6: THE NATURE AND MIXTURE OF MARCHASITA

This group of minerals has already been dealt with in II, ii, 11, Marchasita; *see also 14,* Perithe, *19,* Virites, *but this chapter gives the clearest statement of Albert's belief that* marchasita *is a sort of 'unfinished' metal: it has already attained such properties as colour, lustre, and weight, but has not yet reached the* specific form, *which implies such distinctive metallic properties as fusibility and malleability.* Marchasitae *'look like' ores, but they always disappointed prospectors or assayers, who were unable to extract any metal from them by the methods then is use. Most of them were sulphides, although the native metals arsenic, antimony, and bismuth may have been included, since these are brittle, and seem to 'evaporate' in the fire. Albert's only criterion for recognizing different kinds was colour, so identifications are very uncertain, but the following are possibilities: 'golden', pyrite; 'silvery', marcasite; 'tinny' or 'leaden,' arsenopyrite, cobaltite, smaltite, stibnite, bismuthinite. When these were heated in an open furnace, sulphur or arsenic would be driven off as disagreeable fumes, and the residue would be an earthy* calx *of metallic oxides.*

MARCHASITA we have already mentioned in the second book on this science, but a more detailed discussion must be inserted here, since in truth *marchasita* has the nature of both stone and metal; and therefore it is neither the one nor the other, but more truly an intermediate. For it has the earthy substance of stone, which cannot be liquefied by dry heat, and it is reduced to a *calx* in a strong fire, as stone is. But it has the weight and lustre of metal, and is very heavy. And yet no metal is ever smelted from it, but rather [the metal] evaporates in the fire, and then the stone is converted to a *calx*. The reason for this, indeed, is that the metal in it has not completely attained its specific form. For if golden *marchasita* had the specific form of gold perfectly developed, the gold would not evaporate, but would be smelted out of it. Therefore it has the material and the colour of metal, but not the specific form; and thus it vanishes by evaporation when assayed by strong heating.

Marchasitae are of as many kinds as there are species of metals: For it is golden and silvery; the golden kind is rare but the silvery one is often found; the tinny and leaden kinds are also rare. But whatever the kind of *marchasita*, it has something in its nature and constitution beyond the nature of stone and belonging to the metal it resembles in colour. And yet it is hard and heavy—its hardness due to the hardness and baking and roasting of the stone, its weight due to the impurities not yet purged out of it.

The natural scientists of antiquity call this stone *adestrum*, which means 'stone of light' (*lapis luminis*) because of the aid that it brings to the sight,[1] especially the golden *marchasita*. Its natural quality is hot and dry, and its effect is to cause contraction, heating, ripening, and opening; and these effects are strong. It is said that, suspended from children's necks, it makes them fearless.

In alchemy, this stone is the principal food with which Quicksilver is fed[2], for [making] the White *elixir* from the silvery, and the Red *elixir* from the golden *marchasita*.

CHAPTER 7: THE NATURE OF NITRUM

This is a duplication of II, ii, 12, Nitrum. *The name* nitrum *was used for a number of different substances, probably least often for what we call nitre or saltpetre. It included borax (Arabic* baurac, tincar), *but most of it was some form*

[1] Stibnite (sulphide of antimony) was used as a cosmetic for the eyes. Constantine (*Opera*, p. 381) recommends it for this and other purposes, calling it 'hot and dry in the fourth degree'. Stibnite, however, is not 'golden', but steely or silvery grey with a brilliant metallic lustre. Perhaps the epithet refers to the well-known use of stibnite in parting gold from silver: on fusion with antimony sulphide the silver combines with the sulphur, while the freed antimony, along with the gold, forms a metallic button in the bottom of the crucible. The button is removed and roasted to oxidize and drive off the antimony, leaving pure gold. This method is first clearly described in the *Bergwerk- und Probierbchülein*, published about 1500, so it seems to have been in use in the fifteenth century. But if it was really mentioned in any work current in Albert's time, it must have been in 'veiled language' and he did not understand it. Or perhaps his subsequent remarks refer again to pyrite.

[2] 'Feeding' quicksilver is described in the *Book of Alums and Salts* (Steele, 1929, p. 26: *Cibatio mercurii cum corporibus*) as dissolving gold or silver in an amalgam that could be used for gilding or silvering other metals. But 'feeding' with *pyrite* seems to indicate the amalgamation method for extracting small amounts of gold or silver from pyritic ores. The crushed mineral was stirred with mercury, in which any free gold or silver would dissolve. After filtering off, the mercury was distilled away, leaving the precious metals. The alchemists believed that the mercury, 'fed' on pyrite, had spontaneously produced the gold or silver.

of sodium carbonate—natron or trona—or caustic soda. Not only was the name used loosely, but the substances themselves were impure, frequently containing salt, calcite, or gypsum. Thus all old descriptions of nitrum *and its uses in medicine and technology seem to the chemist of today to abound in inconsistencies. For example, Constantine,* (Opera, *p. 384) mentions its value for cleansing (borax and 'washing soda'), as a disinfectant, especially for the eyes and ears (boracic acid), and for stomach troubles (bicarbonate of soda).*

Nitrum *from Armenia (also mentioned by Constantine) was probably borax; Armenia, however, was not the source, but merely a place on the caravan route by which the Arabs brought borax from Central Asia. African* nitrum *came from Egypt, collected from natural deposits of trona and natron, or 'manufactured' like salt, by leaching alkali soils and evaporating the solution. In Teutonia, mineral springs such as those of Carlsbad and Selters contain sodium carbonate, but the mineral Albert saw at Goslar was probably not* nitrum *(see note 7 below).*

NITRUM is named from the island of Nitrea[1] where it was first found. The Arabs call it *baurac* (borax).[2] It is a kind of salt, darker than rock salt, yet nevertheless transparent; but it is in thin plates.[3] It can be roasted in the fire, and, after losing all its superfluous watery substance, the more it is burnt the drier it becomes; and then the salt itself will be sharper.[4]

The forms [of *nitrum*] are distinguished according to the place where they originate. Three kinds are found among us, namely, those of Armenia, and Africa, and Teutonia. [The last] is found abundantly in the place called Goslar: for as rain falls upon the mountain[5] which is full of copper ores, and the rain water percolates through the mountain, when, at a distance of a hundred paces,[6] it reaches the excavation made by the miners, then the water seems to be converted into *nitrum*. The natives believe this is rock salt, but I myself have proved, by sight and touch, that it is *nitrum*. And it occurs in the hollow of the mountain in the same manner and shape as the icicles that form on roofs from the water dripping off them in freezing weather;[7] this is not in plates, but round.

[1] Isidore (*Etym.* XVI, 2, 7) mentions *Nitria*, but he does not call it an island, merely 'a town or region in Egypt'. It was probably the place later called Wadi Nitrum, north-west of Cairo.

[2] See also *tinchar* (V, 9, note 1).

[3] Probably trona; but perhaps borax, or even salt with good cleavage.

[4] On heating, trona or natron gives off water of crystallization and then carbon dioxide, and is converted into caustic soda.

[5] The Rammelsberg, which rises abruptly just south of the town of Goslar. The mine openings are high up on the mountainside.

[6] Evidently not the depth of a shaft but the thickness of the mountain above the mine.

[7] Zinc sulphate, 'white vitriol', now called 'goslarite' from this locality. In the sixteenth

The African *nitrum* is, in comparison with the other forms of *nitrum*, as *nitrum* is to salt. All 'foam of *nitrum*' (*spuma nitri*), sometimes called 'flower of *nitrum*' (*flos nitri*)[8] is more subtle in substance and power than *nitrum* itself. The best 'foam' is that approaching the colour of marble, and it is very friable. All nitrum is hot and dry, and therefore its effect is to cause splitting,[9] cleansing, peeling of the skin, and corrosion; the African kind, especially, is sharper than the others.

CHAPTER 8: THE NATURE OF TUTTY

Tutty (tuchia) *is zinc oxide, obtained as 'furnace calamine' during either the making of brass with* calamina (*see IV, 6*) *or the smelting of copper ores with which zinc ore was accidentally mixed. Such mixture was likely, since at many places in Germany (including Goslar) pyrite, chalcopyrite, galena, and sphalerite occur together. Sphalerite is zinc sulphide, but it is dark brown or blackish, with none of the 'metallic look' of the other associated sulphides. Its old name, 'blende' (from German, to 'blind' or 'deceive'), records the fact that attempts to get a metal from it were unsuccessful. This was because zinc has a low boiling-point (918° C.) and during the smelting it distilled off, was reoxidized, and deposited in the upper part of the furnace, or in flues or chambers built above the furnace to collect it. Zinc was not recognized as a metal, or given its name, until the sixteenth century (Agricola,* De re metallica, *Hoover, footnote, p. 409).*

The different kinds of tutty differed only in purity. That swept up from the floor of the collecting chamber was mixed with soot and dirt, from which it could be at least partly freed by washing. The red and yellow kinds were contaminated with oxides of iron or lead. Re-subliming any of these produced pure, white, zinc oxide. All these were known in antiquity, but the nomenclature has always been somewhat confused. Pliny (Nat. Hist. *XXXIV, 22–23, 100–5; 33, 128*) *used* cadmia *or* cadmea *both for the earthy ores of zinc (which Albert calls*

century Agricola (*De re metallica*, Hoover, footnote, p. 572) described it almost in Albert's words, as occurring 'at Goslar in the form of icicles' (that is, stalactites). It was formed by oxidation of the zinc ore (sphalerite, zinc sulphide) and deposited by ground water in the old workings.

[8] Either a natural efflorescence of soda minerals, or else caustic soda, as a fine impalpable powder.

[9] *inscissivum*. Bartholomew, in his description of *nitrum* (*De proprietatibus rerum*, XVI, 70) has *scissilis*, 'cleavable'; and this might have been miscopied by a scribe looking ahead to the following *lavativum, excoriativum, corrosivum*. But *inscissivum* may be correct: savage remedies, such as burning with caustic soda or quicklime, were resorted to in desperate cases.

calamina, *IV, 6), and for the furnace products; but he supplies additional names for the latter*—pompholyx *for the best and whitest kind, and* spodos *for what Albert calls* succudus.

TUTTY (*tuchia*), which is frequently used in the transmutation of metals, is an artificial, not a natural, compound. It is made from the smoke that rises upwards and solidifies by adhering to hard bodies, where copper is being purified from the stones and tin[1] which are in it. And a better kind is made by re-subliming this; and next [best] is that which during sublimation sinks to the bottom; this is [*cadmia*][2] which some people call *succudus*.[3]

There are many kinds of tutty, for it is white, and yellow with a tinge of red. When tutty is washed something like a black sediment of tutty sinks to the bottom, and this is sometimes called [Indian][4] tutty. The difference between tutty and *succudus* is what we have said—namely, that tutty is what is sublimed and *succudus* is what sinks to the bottom of the channel, and is not sublimed. The best kind is voltatile and white; next, the yellow; and next, the red. When it is fresher it is more efficacious than when it is old. All tutty is cold and dry; and that which has been washed is more powerful in its actions.[5]

CHAPTER 9: THE NATURE AND PROPERTIES OF ELECTRUM

Gold and silver form a continuous series of solid solutions, and native gold nearly always contains some silver. If the silver content is around 20–50 per cent. the alloy has a brilliant pale yellow colour, and was in early times regarded as a distinct metal, electrum. *A more logical place for this chapter would have been in*

[1] Probably not tin but zinc, since the copper ores of Germany are much more commonly associated with zinc than with tin ores. Metallic zinc may actually have been obtained occasionally by accident, if some fault in the smelting process produced a reducing instead of an oxidizing atmosphere in the furnace.

[2] *climia*, probably an error for *cadmia* or *calamina*.

[3] *succudus* may be derived from *succumbere*, 'to fall down'; or it may be a corruption of *spodos*.

[4] *Inda*: perhaps for *Indica*, since Constantine (*Opera*, pp. 370, 383) says that both *spodium* (Pliny's *spodos*, Albert's *succudus*) and *cadmia* came from India; but his descriptions do not sound like tutty.

[5] Tutty was used for 'transmuting' copper to brass (IV, 6), and in medicine was prescribed for various purposes, some of them the same as those for which zinc oxide is used today—as powder or ointment for sores, pimples, and skin diseases.

Book IV, since Albert himself understands that electrum is a mixture of two 'real' metals, and not an 'intermediate' in the sense in which he defines that term in V, 1.

MANY of the ancients placed ELECTRUM not among the intermediates but among the metals. The Arabs call it *tinchar* and some people have also called it the 'binder of gold' (*capistrum auri*).[1] Its colour is that of a mixture of gold and silver, and thus there are two kinds of this metal, for there is an artificial [kind] made by mixing together silver and [gold];[2] but the other kind is a natural mineral, which the ancients declared to be the best of all metals. I do not know why, unless because they attributed to it this effect: if poison is put into a drink in a vessel made of such electrum[3] [the cup] emits a sound like that of *nitrum*[4] when vinegar is poured on it. Since electrum has the colour of gold and silver mixed, no doubt it has the properties and nature of both [these metals].

In this way, then, [ends] our account of mixed bodies that are *homeomerous*, but not organized or alive.[5] For, on the basis of what has been said, anything else that has not been mentioned here can also be readily understood.

[1] This sentence is confused and appears to be an over-abbreviated reference to the soldering of gold. *Tinchar* is borax, used as a flux; but the solder itself would be a gold-silver alloy with a melting-point lower than that of gold. So in this sense the alloy might be called the 'binder of gold'.

[2] *nitro*, 'soda', but 1518 edition reads *auro*, as sense requires.

[3] That is, the *natural* electrum, which was the only kind that had this property, according to Pliny, the original authority for this tale (*Nat. Hist.* XXXIII, *23*, 81).

[4] *nitrum* here is certainly sodium carbonate which effervesces with acids.

[5] *non complexionatis neque animatis* (cf. I, i, 1, note 2). Plants and animals are treated in great detail in a series of works, which come after the *Book of Minerals* in Albert's course on natural history.

APPENDIX A

ARISTOTLE

Life and Writings

ARISTOTLE (384–322 B.C.) was born at Stageira in Thrace. His father, Nichomachus, was physician at the royal court of Macedonia, and Aristotle was brought up in that country. At about eighteen he went to Athens for further education and was associated with the Academy until Plato's death in 346. The next few years he spent in Ionia, chiefly at Assos and Mytilene; and then, in 343, returned to Macedonia as tutor to the young son of King Philip II, Alexander (356–323). After Alexander became king and embarked on his brief career of world conquest Aristotle went back to Athens and founded his own school, the Lyceum. This was very successful until 323, the year of Alexander's death. But then anti-Macedonian feeling in Greece forced Aristotle to leave Athens. He turned over the Lyceum to his friend and colleague, Theophrastus (see Appendix B, 1) and retired to Euboea, where he died the next year.

Aristotle is known to have written philosophical dialogues, perhaps modelled on those of Plato, but little of these survives. What has come down to us seems to be a collection of teaching materials—treatises, lectures, notes on researches, &c.—preserved by a strange series of chances, and edited and 'published' only in the first century B.C. These were not finished literary productions to begin with, and they pose peculiarly difficult problems for scholars who have tried to determine the authenticity of each one and its relation to the development of Aristotle's thought. These problems are, for the most part, irrelevant here, since the schoolmen of Albert's time accepted without much question anything that came to them bearing the great name of Aristotle.

Neither is it relevant here to attempt a summary of Aristotle's philosophy. The works mentioned below are those on natural science with which Albert concerned himself, according to his own statement (*Phys.* I, i, 4); and the points selected for mention are those that seem to be important for the argument of the *Book of Minerals*. English versions of these are available in the Oxford translation of *The Works of Aristotle* (edited under the direction of W. D. Ross), and in the Loeb Classical Library, accompanied by the Greek texts.

1. The *Physics* (Latin *Physica* or *De physico auditu*) has little in common with the science bearing that name today. As Cornford says, in his General Introduction to the Loeb Library translation: '*Lectures on Nature*, the alternative title found in editions of the Greek text, is more enlightening. But *Principles of Natural Philosophy* (as the term would have been understood in the eighteenth and earlier nineteenth centuries) would be better still.'

The *Physics* stood first in the traditional order of Aristotle's scientific works, and Aristotle himself seems to have regarded its subject matter as fundamental for all the other sciences. It opens with the statement (I, 1, 184 a 10 ff.) that although the study of nature must begin with concrete, particular instances, its object is the discovery of abstract, general principles which 'explain' the observed phenomena; and we are satisfied that we understand a thing when we know its 'causes'. The English word 'cause' is an inadequate translation of the Greek *aitia* (*causa* in Latin). *Aitia* is that which underlies, or is responsible for, or is the essence of, anything. Thus Aristotle says (II, 3, 194 b 16 ff.) that the question How? or Why? may be answered in four ways, 'explaining' a thing in terms of: (1) the *matter* of which it is made (material *aitia*); (2) the process or agent by which it is made (efficient *aitia*); (3) the inherent nature or *form*, which makes it what it is (formal *aitia*); and (4) the end or purpose for which it was made (final *aitia*). Historians of philosophy refer to these as the 'four causes'. The *final cause*—that for the sake of which a thing exists—is understandable if we think of an artifact (a saw is made 'for the purpose of' sawing), or of an animal (which is provided with certain organs 'in order to' live a certain kind of life, &c.); but it is not always easy to distinguish from the *formal*, or even the *efficient*, *cause*. And Aristotle admits (II, 7, 198 a 25 ff.) that these three often seem to coalesce; but they are different from the *material cause*. The fundamental distinction, perhaps, is that between *form* and *matter*; though the natural scientist must still try to take into account the action or motion involved, and the purposiveness of nature.

Nature (*physis*) includes all things that move or change. Later physicists speak of *matter* and *motion*; but Aristotle in the *Physics* does not treat matter and motion as of equal importance. He assumes a material 'substrate' our of which all things are made, but his detailed discussions of the properties of matter are found in *The Heavens*, *Generation and Corruption*, and *Meteorology*. The *Physics* deals at length with motion, and with such problems as arise in connexion with the study of motion—continuity, infinity, place, time, void, &c. Aristotle distinguishes three kinds of motion: local, quantitative, and qualitative (V, 1, 225 b 5 ff.). Thus beside locomotion, change of place, we have motion in the sense of change in amount or size, and change from one condition to another.

In discussing motion Aristotle made some statements that were to cause much trouble for his later followers: for example (VI, 1, 241 b 24 ff.), anything that is in motion must be kept in motion by something (a mover); and (VII, 2, 243 a 3 ff.) the mover must be in contact with the thing moved. But these principles are essential to his view of the universe, which is developed in Book VIII (and also in *The Heavens*.) The universe is eternal and eternally in motion. But every motion requires a mover, and, since there cannot be an infinite series of moved movers, there must be at last an *unmoved mover*, setting all the rest in motion (VIII, 5, 256 a 4 ff.) by causing a rotation of the outermost sphere of the heavens (VIII, 8, 265 a 8 ff.; 9, 265, b ff.), but itself having no magnitude, parts, or position (VIII, 10, 267 b 8 ff.). This unmoved mover, outside all place and time, is beyond the scope of natural science (*physica*), and is further considered in the *Metaphysics* (XII, vii, 7, 1072 b 15 ff.) as pure self-thinking thought, that is, God.

2. *The Heavens* (*De caelo, De celo et mundo*), however, has little to say about the unmoved mover. In fact, Aristotle's various accounts of the heavenly motions are somewhat inconsistent, and it is possible (as Guthrie suggests in his Introduction to the Loeb Library translation) that *The Heavens* records an earlier stage in Aristotle's thinking, when he hesitated between the Platonic doctrine that the Cosmos is a living creature, and its motions are 'self-caused', and his own view that the motions are 'natural', inherent in different kinds of matter.

Be this as it may, the theme of 'natural motions' and 'natural places' dominates the argument of *The Heavens*. The cosmos is represented as a vast though finite system of concentric spheres, the outer ones composed of a special kind of matter—the 'first body', or Ether (*aither*)—unchanging and imperishable (I, 3, 270 b 1 ff.). The natural place of Ether is 'above' the other four 'elements'; it is neither 'light' nor 'heavy', and its natural motion is circular (I, 2, 269 a 30 ff.). Ether is the matter of the heavenly bodies (II, 7, 289 a 11 ff.), which are carried around on concentric spheres (II, 8, 289 b 30 ff.). In *The Heavens* Aristotle merely alludes to this machinery, but in the *Metaphysics* (XII, viii, 4, 1073 a 26 ff.) he gives details (based on the work of Eudoxus and Calippus). The scheme requires forty-nine spheres, each in contact with, and transmitting motion to, the next within, in order to account for the courses of the fixed stars, planets, sun, and moon.

The inner spheres, below the moon, are made up of the four other 'simple bodies' or 'elements', Fire, Air, Water, and Earth. These differ from Ether in that they are not unchanging and imperishable, being continually destroyed and re-created from each other (III, 6, 304 b 23 ff.; also *Generation and Corruption*). Their natural motions are in straight lines, either 'downwards' towards the centre of the universe or 'upwards' towards its circumference, since they are inherently 'heavy' or 'light' (IV, 1, 307 b 28 ff.). Accordingly, when in their natural places, Fire, the lightest, is at the top, next to the lunar sphere; below this is Air, then Water; and Earth, the heaviest, is at the bottom or centre. In this way Aristotle accounts for the distribution of atmosphere, sea, and land, and for the fact that the earth is a sphere 'at rest' in the centre of the whole system (II, 14, 296 b 7 ff.).

3. *Generation and Corruption*, or *Coming-to-be and Passing-away* (*De generatione et corruptione*), deals further with the elements. Aristotle examines and

rejects theories about the nature of matter offered by his predecessors, including Leucippus and Democritus, who spoke of 'atoms moving in the void' (I, 8, 325 a 23 ff.). For Aristotle the universe is a *plenum* and every material thing is, at least in theory, infinitely divisible. He again discusses change (as defined in the *Physics*)—local, qualitative, and quantitative; yet in any specific case the coming-to-be of one thing (for instance, a fire) is a part of the same process as the passing-away of something else (fuel). Thus *matter* is *potentiality* that assumes *actuality* only in *form*; and material substances are both matter and form (I, 4, 320 a 2; 5, 322 a 28; 7, 324 b 5 ff.).

These changes in form (including what we call chemical change) come about by 'mixing', a reciprocal relation in which the potential ability-to-act (Latin *actio*) and the potential capacity-to-be acted-upon (*passio*) are equally important. The substances so reacting must be in contact with each other (I, 6, 322 b 22 ff.); and the reaction takes place through their 'contrary' properties (I, 7, 324 a 3 ff.) The simplest forms of matter must therefore be defined in terms of 'contraries', which are the *hot* and the *cold* (said to be *active* qualities), and the *moist* and the *dry* (*passive* qualities). But since the same thing cannot be both hot and cold, or both moist and dry, the possible pairings of qualities give only the four 'elements': dry-hot, Fire; hot-moist, Air; moist-cold, Water; cold-dry, Earth (II, 3, 330 a 30 ff.).

These are not chemical elements in the modern sense, since they are continually being transmuted into each other (II, 4, 331 a 7 ff.). Transmutation is easiest between two elements that have one quality in common. For example, Water (cold-moist) by reacting with the 'contrary' of cold, which is hot, becomes Air (hot-moist); and this explains the boiling away of liquid into vapour. More difficult, though possible, is the reaction of two qualities in succession, as when Water (cold-moist) changes into Fire (hot-dry).

Since the elements are arranged (as explained in *The Heavens*) in concentric spheres according to their 'lightness' or 'heaviness', and these transformations are for ever going on between adjacent spheres, the elements are always changing their places in a perpetual cycle. This is the cause of many natural phenomena (described in the *Meteorology*). But the transmutations themselves must have a cause, and this (*efficient cause*) is the annual movement of the sun along the ecliptic circle (II, 10, 336 a 15 ff.); seasonal changes in heat and moisture effect the transmutation of the elements; and the resulting changes in the atmosphere, sea, and land surface control the life cycles of plants and animals.

4. The *Meteorology* (Greek *Meteorologica*, Latin *Meteora*, or *De meteoris*) falls into two distinct parts, Books I–III and Book IV, which were probably written as two separate treatises. Some scholars have doubted whether this is Aristotle's own work (especially Book IV); but if not, it was composed by a close follower

of Aristotle, thoroughly familiar with the *Physics*, *The Heavens*, and *Generation and Corruption*. The title *Meteorology* is misleading in English, and even in Greek is not strictly accurate: *meteors* means 'things high up in the air', and such phenomena (meteorology in the present-day sense) form only part of the subject matter, even in Books I–III, to which the title may really belong.

The first three books take up again the elements and their natural places, introducing another aspect of their transmutation (I, 4, 341 b 6 ff.), the two 'exhalations' drawn up by the heat of the sun from the surface of sea and land; one is moist and vaporous, the other dry and smoky. The former mingles with the Air; the latter, being hotter and lighter, rises into the sphere of Fire—a region hot and dry and potentially inflammable, where are produced all those 'lights in the sky' supposed to belong to the sublunary world—meteors and shooting stars, the aurora borealis, comets, and the Milky Way (I, 4, 341 b 24–8, 346 b 15).

In the sphere of Air the moist vapour cools, condenses, and produces clouds and rain, dew, hoar frost, hail, and snow (I, 9, 346 b 16–12, 349 a 12). Haloes, sun-dogs, and rainbows result from the reflection of light on mist and cloud (III, 2, 371 b 18–6, 378 b 6). Winds (II, 4, 359 b 27–6, 365 a 14) are caused by the dry exhalation; when it is trapped in masses of cooling air, forced downwards and ignited, tornadoes and thunderstorms occur; and the Fire in it appears as lightning (II, 9, 369 a 10–III, 1, 371 b 18).

In the spheres of Water and Earth the two exhalations account for many phenomena now classified as geological. The origin of springs and rivers (I, 13, 349 b 3–351 a 18) is partly rainfall and partly condensation of vapour in the earth. The sea (I, 14, 351 a 19–II, 3, 359 b 26) is fed by rivers, but its saltness comes from the dry exhalation: this contains a sort of 'burnt earthiness' that mingles with the moist exhalation in the Air and falls as brackish rain that 'salts' the sea. Earthquakes, tidal waves, volcanic eruptions (II, 7, 365 a 14–9, 369 a 9) occur where excessive amounts of the dry exhalation burst out violently from underground. And finally, the exhalations are responsible for the formation of minerals, the dry smoke producing infusible earths and stones, the moist vapour all kinds of metals. This short passage at the very end of Book III (6, 378 a 12–378 b 6) is the only attempt to explain minerals, and the implication that it will be elaborated elsewhere is not followed up, at least in any of Aristotle's extant writings.

Book IV has been called the 'chemical treatise'. It reconsiders the four 'elements', Earth, Water, Air, and Fire in terms of their *qualities*—hot or cold (active) and moist or dry (passive)—in order to explain such processes as putrefaction (IV, 1, 379 a 1 ff.), 'cooking' (heating in various ways), hardening, softening, drying, melting, and solidification (IV, 2, 379 b 10–7, 384 b 23). There is also discussion of the relation between the elemental constitution of different substances and their physical properties, such as plasticity, malleability, fissility, inflammability, &c. (IV, 8, 384 b 24–9, 388 a 9). Most of the substances mentioned are considered to be relatively simple 'mixtures' of elements: Aristotle's term is *homeomerous* (IV, 8, 384 b 31 ff.; 12, 390 b 2 ff.) for things that seem to be 'homogeneous' or 'uniform' throughout, like oil, stone, metal, wood, bark, blood, bone, &c. In living things the *homeomerous* parts are what we call tissues, which are further combined into the *anhomeomerous* (non-uniform) parts (organs), like flower, hand, eye, &c. These are to be further considered in the works on plants and animals.

5. *The Soul* (*De anima*) is the first of the biological treatises. This position may seem strange if we accept its modern designation as a 'Treatise on Psychology', but it is logical enough within the frame of Aristotle's philosophy. The Greek word *psyche* (Latin *anima*) is difficult to translate, since the English word 'soul' has acquired theological associations that are not in Aristotle. In this work *psyche* is 'life' or 'vital principle'—that which distinguishes living from dead matter. Therefore a discussion of it is a necessary introduction to the 'life sciences'.

Matter, as already stated, is potentiality, actualized in *form*. And for any living thing, its *form* is, first of all, its 'aliveness', that is, its *soul* (II, 1, 412 a 3 ff.). The soul is the cause of all vital activities of the organism (II, 4, 415 b 9 ff.). But such activities range from very simple to very complex (III, 9, 432 a 22 ff.): plants are capable only of nutrition, growth, and reproduction; animals, of course, also have these functions, but they are capable, as well, of sensation, desire, and movement; and man, beside all these lower faculties, has what we call 'mind'—he is able to think, remember, and imagine. Later commentators speak of three souls—vegetative (or nutritive), sensitive (or appetitive), and rational (or intellectual), but for Aristotle these seem to be merely different aspects of 'being alive'.

The treatise has little to say about nutrition, growth, and reproduction (these are dealt with elsewhere), but it discusses at some length sensation—the five senses, sight, hearing, smell, taste, and touch (II, 7, 418 a 26–12, 424 b 18): how sense data are combined in perceiving a thing as a whole (III, 3, 425 b 12 ff.); thinking and imagination (III, 3, 427 a 17–7, 431 b 19); and how the soul moves the body through impulse and desire (III, 9, 432 b 8–11, 434 a 21). It closes with the characteristic reminder that living things are endowed with these faculties in order to survive, and for their own well-being (III, 12, 434 a 22–end).

6. The group of short treatises known to medieval scholars as the *Parva naturalia*, or 'little works on nature', is usually placed next after *The Soul*, as a

sort of appendix, continuing and expanding the account of the relations of soul and body. The scope of these works may be sufficiently indicated here by simply listing their titles.

The Senses, or *Sense and the Objects of Sense* (*De sensu,* or *De sensu et sensibilibus*).

Memory and Recollection (*De memoria et reminiscentia*).

Three that are often grouped together as one work: *Sleep and Waking* (*De somno et vigilia*); *Dreams* (*De somniis*); and *Prophecy in Sleep* (*De divinatione per somnia*).

Another group of three often combined in one: *Length and Shortness of Life* (*De longitudine et brevitate vitae*); *Youth and Age* (*De juventute et senectute*); and *Life and Death* (*De morte et vita*).

With these may be placed a short treatise on *Respiration* or *Breathing* (*De inspiratione et expiratione*).

7. The treatise on *Plants* (*De plantis,* or *De vegetabilibus*) is not Aristotle's own work, at least in its present form. It has been ascribed to the historian, Nicholas of Damascus, who was a friend of Herod the Great in the first century B.C.; but Nicholas may have been revising or commenting on a work of Aristotle now lost. The treatise discusses the life (soul) of plants, their place in the order of nature, the characteristics of different species, and their classification; and also says something about their physiology and ecology.

Most famous of all Aristotle's scientific writings are those on animals, which comprise three long works and two very short ones:

8. The *History of Animals,* or *Researches on Animals* (*Historia animalium*), describes the anatomy, behaviour, and breeding habits of animals. More than 500 species are mentioned, testifying to the vast amount of work done by Aristotle and his pupils in this field. Some of the information, derived from books or folk-lore, is patently incorrect; but a large part seems to be based on observation, and in some cases dissection of specimens. Here Aristotle gives many details, some of which were later discredited, forgotten, and then rediscovered by modern biologists.

Great interest attaches also to Aristotle's comprehensive classification of animals which, although nowhere tabulated in full, plainly underlies his discussion, in both this and the following works. The two major groups are (1) animals 'with blood' (that is, with *red* blood, corresponding to vertebrates) and (2) those 'without (red) blood' (invertebrates). The first group is subdivided into (a) viviparous (man and below him other mammals) and (b) oviparous (birds, reptiles, amphibians, fishes). In the second group (invertebrates) he distinguished insects, crustaceans, shellfish, and 'soft-bodied' cephalopods, &c.; and below these, things like sea-cucumbers and sponges, 'intermediate' between animals and plants. This scheme, despite some mistakes, shows a remarkable grasp of the relationships of living things. To Aristotle, of course, this is not an 'evolutionary' order, but a natural hierarchy expressing the higher or lower activities of soul.

9. *Parts of Animals* (*De partibus animalium*) is not, as the title may suggest, a study of anatomy but rather of physiology. The 'parts' are classified as (1) *homeomerous* parts or tissues (fat, blood, marrow, flesh, bone, &c.); these are combinations of elements, and are in turn combined into (2) *anhomeomerous* parts or organs (eye, ear, stomach, kidney, &c.). But Aristotle's emphasis is on the *causes*, especially the *final cause*—that is, the purpose which each part serves in the life of the animal (I, 5, 645 b 15 ff.), reiterating his belief in the design and wisdom of nature.

10. *Generation of Animals* (*De generatione animalium*) deals with reproduction and heredity. In the higher animals the offspring receives something from both parents, being formed by the union of semen from the male and menstrual blood from the female. Both these fluids are 'residues', that is materials not used up in the normal growth and repair of the body (I, 18, 725 a 11 ff.; 19, 726 b 31 ff.). After sexual intercourse the semen (like rennet in milk) 'sets' the menstrual fluid in the form of an embryo in the womb (II, 3, 737 a 8 ff.). The female is passive, supplying only matter (*material cause*), from which the embryo is made, while the male is active, supplying semen (*efficient cause*) in which is the form (*formal cause*), the soul of the offspring (II, 4, 738 b 20). Aristotle compares the role of the male to that of the artisan, who has 'in his soul' the *form* of whatever he is producing by the movements of his hands and tools (I, 2, 730 b 20 ff.).

But in lower animals the roles of the two sexes are not so distinct; and for some of these Aristotle, being unable with the means at his disposal to unravel their life histories, has to accept the theory of spontaneous generation: this he says can occur where there is some kind of matter that has in it the potentiality of life (mud, water, slime, decaying organic materials). If this is acted upon by gentle heat (from the sun or from fermentation or putrefaction), animals are created, such as certain shellfish, worms, or insects (III, 11, 762 a 8 ff.).

11. The two short works are the *Movement of Animals* (*De motu animalium*) and the *Progression of Animals* (*De progressu animalium*). The former takes up again the problem of how the soul moves the body; the latter pays more attention to the mechanism—how many feet an animal has, how the legs bend, how the limbs are used in walking, running, swimming, or flying, &c.

The Transmission of Aristotle's Scientific Works

The channels by which Aristotle's science reached the medieval scholars of Europe were many and in some cases devious. Cultivated Romans knew Greek and some of them read Aristotle—for instance, the elder Pliny (first century A.D.) in collecting materials for his *Natural History*. But they did not make translations of Aristotle. Therefore, during the long ages when Latin was the language of learning in most of Europe, Aristotle's works ceased to be read, except for some of the books on logic, which had been put into Latin in the sixth century. It was not until the twelfth century that the others began to reappear in Latin translations, some made from the Greek and some from the Arabic (Wingate, 1931).

The early translations from the Greek were probably made in southern Italy or Sicily, where Greek was still spoken; but most of them are of unknown authorship, except for *Meteorologica* (Book IV), which was translated about 1156 by Henricus Aristippus, an official at the court of William I in Sicily.

The translations from the Arabic had a more complex history, beginning in the east with the translation of many Greek scientific works into Syriac, and later from Syriac into Arabic. In the ninth century a group of scholars in Baghdad, some of whom worked from Greek manuscripts, was producing the Arabic versions of Aristotle that subsequently inspired the commentaries of Avicenna (980–1037) and Averroes (1126–98). These versions were carried by the Arabs to Spain. And in the twelfth century, as the 'Moors' were gradually driven out, Spain, with its polyglot population, became another centre for the transmission of Arabic learning to the rest of Europe. So far as the works of Aristotle are concerned, the two most important translators were Gerard of Cremona (1114–87) and Michael Scot (*c.* 1175–1235). Gerard of Cremona was the leader of a great school of translators at Toledo, who produced Latin texts of the *Physics, The Heavens, Generation and Corruption*, and *Meteorologica* (Books I–III); and the pseudo-Aristotelian *Properties of the Elements*. Michael Scot also worked at Toledo, and later in Sicily, where he was astrologer at the court of Frederick II. His translations included new versions of some of the works already mentioned, as well as *The Soul*, the *Animals* (as one long work in nineteen books), and some of the commentaries of Averroes.

Thus by the early years of the thirteenth century Latin texts were available of all, or nearly all, Aristotle's scientific works, most of them in more than one translation. But as the century went on scholars became dissatisfied with these texts (Roger Bacon's complaints are well known). The task of providing new and better translations, direct from the Greek, was undertaken (some say at the instigation of Thomas Aquinas) by William of Moerbecke (1215–96), a Flemish Dominican who went to Thebes before 1260, was at the Papal Curia about 1265–76, and returned to Greece as Archbishop of Corinth about 1277.

Most of the Greek-Latin texts of Aristotle current in the latter part of the thirteenth century are attributed with more or less probability to him. Some were mere revisions of pre-existing versions from the Greek; others, especially those known only in versions from the Arabic, he translated anew from manuscripts obtained in Greece. He divided the long treatise on *Animals* into its three parts: *History of Animals*, ten books; *Parts of Animals*, four books; *Generation of Animals*, five books; and he added the two short treatises, the *Movement of Animals* and *Progression of Animals*, which were not in the Arabic version (though one or both may have existed in earlier translations from the Greek).

William also translated a few works of Greek commentators on Aristotle: Alexander of Aphrodisias (who lived in the late second–early third century A.D.), Themistius (fourth century) and Simplicius (sixth century).

These translations began to circulate soon after 1260. They gradually superseded earlier ones, and became the generally accepted texts of Aristotle until they were themselves superseded by the translations of Renaissance scholars.

Pseudo-Aristotelian Works

Among the writings ascribed to Aristotle by the Arabs, the Latin translators found several that were written long after his time and are quite un-Aristotelian in character. But these, too, were accepted as genuine by medieval readers, who believed that Aristotle, surely the wisest of all men, must have written something concerning every branch of human knowledge. I shall mention here only three of these, known as the *Secret of Secrets*, the *Properties of the Elements*, and the *Lapidary of Aristotle*.

12. The *Secret of Secrets* (*Secretum secretorum*, Steele, 1920) claims to be a treatise written by Aristotle for Alexander the Great, imparting the secrets of kingship and the lore of Hermes. The contents, which are differently arranged in different versions, include advice on the behaviour of a king, the wise selection of officers of government, the administration of justice, and the conduct of war, and the preservation of health by means of diet, baths, and medicines. Brief sections deal with the mysteries of astrology and alchemy.

The author is unknown, but he probably wrote in Syriac. An Arabic version was made about the beginning of the ninth century and the work continued to grow by accretion. It was several times translated into Latin and then into vernacular languages, and was widely read during the Middle Ages. One of the best Latin texts was edited and annotated by Roger Bacon (Steele, 1920).

Albert certainly knew the *Secret of Secrets*, and in the *Book of Minerals* he seems to allude to it in his remark about the influence of the stars on the 'inborn' aptitudes of children (II, iii, 3), and perhaps in his quotations from the *Emerald Table* (I, i, 3; see Appendix D, 7).

13. The *Properties of the Elements* (*De proprietatibus elementorum*, or *De causis et proprietatibus elementorum*, printed in the Works of Aristotle, *Aristotelis opera*, Venice, 1496) is obviously based in part on Aristotle; but it also introduced into medieval science additional topics for discussion: the role of the heavenly bodies in causing floods, droughts, and pestilences, and the role of the moon in causing the tides; the theory that the sea has continually migrated from place to place, and the evidence for and against such a theory; the source of underground heat in hot springs and volcanoes; and the questions of how and when hills and valleys were formed.

This was perhaps written in the tenth century. The author was not only a student of Aristotle but also something of an astrologer and geographer. The Latin translation from the Arabic was made by Gerard of Cremona.

Albert himself wrote a commentary on this work, which he cites in the *Book of Minerals* (II, iii, 4; see also Introduction: 'Albert's Scientific Writings' and 'Date of Composition of the *Book of Minerals*').

14. The *Lapidary of Aristotle*, or *Aristotle's Book of Stones* (*Lapidarium Aristotelis*, or *Liber Aristotelis de lapidibus*, Rose, 1875; Ruska, 1912) recounts a number of adventures of 'Alexander, my pupil' with precious or magical stones: Alexander found stones that called up demons or produced illusions, and other stones to counteract these; stones that caused horses to neigh and others that kept them from neighing (and used the latter in surprise attacks on his enemies), &c. These 'stones' are obviously fabulous—'talismans' or charms. But the *Lapidary of Aristotle* also describes many real minerals—gemstones, metals and their ores, and substances used in medicine and the arts.

The core of this work seems to have been a Syriac or Persian lapidary going back to the sixth or fifth century. It was translated into Arabic, perhaps at Baghdad in the ninth century, and subsequently reworked and enlarged, probably more than once. Latin translations were made from both Arabic and Hebrew versions; one of these, attributed to Gerard (presumably of Cremona), which existed in the thirteenth century, has since been lost (see notes on II, iii, 6).

Albert knew this work only by report and all his quotations from it are at second- or third-hand (see Introduction: 'Date of Composition of the *Book of Minerals*').

APPENDIX B

LAPIDARIES

Lapidaries before the Thirteenth Century

REFERENCES to precious stones as ornaments or amulets, and to mineral substances used in medicine or the arts, go far back in the writings of ancient Egypt and the Near East. But the European *lapidary*—a work dealing exclusively or chiefly with 'stones'—may be said to begin with the Greeks. Thereafter the tradition can be traced to the encyclopedists of the Middle Ages and on into the Renaissance, when the lapidaries began to be transformed into more or less scientific treatises on mineralogy, such as Georgius Agricola's *The Nature of Fossils* (*De natura fossilium*, 1546)—'fossils' at that time meaning all things 'dug up' out of the ground.

A complete history of lapidaries would fill a large book. All that is attempted here is to indicate briefly the works that can, in some sense, be considered sources for the 'lapidary tractate' (II, ii) in the *Book of Minerals*, though certainly Albert made little or no *direct* use of the earlier writings listed here (1–10). Good accounts of most of these are given by Thorndike (1923, Vols. I–II) and, in some cases, by the editors of editions listed in the Bibliography.

1. Theophrastus (*Theophrastos of Eresos*, *c.* 372–287 B.C.) was a pupil, friend, and colleague of Aristotle, whom he succeeded as head of the Lyceum after 322 B.C. Among his scientific writings is a little book *On Stones* (Cayley and Richards, 1956), perhaps part of a larger work, including a book on metals now lost. In it he discusses the properties of 'stones' in terms of the Peripatetic 'chemistry' of *Meteor.*, IV, and names as examples about fifty minerals and rocks, some of which are well described. Although the Greek text of this has survived, it does not seem to have been known to the Arabs, and its influence on medieval Latin lapidaries was only indirect, through quotations in Pliny (see 3 below).

2. Dioscorides (*Pedanios Dioskurides*, first century A.D.) wrote a Greek work *On Healing Substances* (Latin, *De materia medica*). This is perhaps better known as *The Herbal of Dioscorides* (Gunther, 1959), because most of the remedies mentioned were made from plants, and early manuscripts illustrated with drawings of plants became the models for medieval herbals, and even later, for botanical treatises. The fifth (and last) book, however, describes some mineral substances used in medicine. The treatise was translated into Latin at least as early as the sixth century, and another translation, from the Arabic, is attributed to Constantine of Africa (eleventh century—see 9 below). Works of this character,

which are essentially lists with no inherent structure or argument, are peculiarly liable to damage in transmission, successive editors or copyists adding, omitting, or rearranging material to suit themselves. By the thirteenth century some manuscripts under this name contained not only traditional medical recipes but also much about the magical powers of stones, drawn from entirely different sources. Thus the 'Diascorides' cited by Vincent of Beauvais contained some items from *Damigeron* (5 below); and Bartholomew of England used a 'Dyascorides' based partly on Marbod (10 below) and partly on Arabic sources.

3. Pliny (*Caius Plinius Secundus*, A.D. 23–79) wrote an elaborate *Natural History* (*Naturalis historia*, Loeb Classical Library) in thirty-seven books, of which the last five deal with minerals: Book XXXIII, precious metals; XXXIV, base metals; XXXV, earths; XXXVI, stones, building materials, &c; XXXVII, precious stones, gems, and other stones having remarkable properties. Pliny collected his 'facts' from a vast literature, most of which has perished; for example, in Book XXXVII (which is the most important for the history of lapidaries) he lists thirty-eight 'authorities', but Theophrastus's *On Stones* is the only one of them extant. Pliny credits many minerals with curative powers, evidently drawing on the same Greek medical works as were used by his contemporary, Dioscorides. He also recounts many magical powers of stones; these seem to belong to an eastern tradition, in books similar to *Damigeron* (5 below) and the *Lapidary of Aristotle* (8 below) that reached Europe much later. Pliny himself was scornful of such beliefs but his medieval readers were more credulous than he. The *Natural History*, being written in Latin, was accessible all through the Dark Ages and became the chief authority in its field: excerpts, paraphrases, and epitomes of it supplied a large part of the content of medieval bestiaries and herbals, as well as lapidaries.

4. Solinus (*Caius Julius Solinus*, third century) was another Latin writer immensely popular in the Middle Ages. His *Wonders of the World* (*Collectanea rerum memorabilium sive polyhistor*, Mommsen, 1864) was compiled almost entirely from earlier writers, especially Pliny. The material was rearranged on a geographical plan—for example, the accounts of minerals and precious stones are scattered throughout, under the countries where they are supposed to be found; but they were industriously collected together again by Isidore of Seville (6 below) and later writers of lapidaries.

5. Damigeron, or *The Powers of Stones* (*De virtutibus lapidum*, Abel, pp. 161–95; Evans, 1922, pp. 195–215) is a work having a very obscure history. If 'Damigeron' is the true name of the author, nothing further is known of him. The material seems to be derived from the Greek poem *Lithica* ascribed to

Orpheus and written perhaps in the fourth century. The Latin Damigeron, of about the fifth or sixth century, claims to be a translation made for the Emperor Tiberius by someone named Evax. So this version, as well as the poem of Marbod (10 below) based on it, is often cited as 'Evax' in later lapidaries. Damigeron (or Evax) gives few scientific facts about stones and emphasizes their magical powers, which are sometimes to be enhanced by engraving mysterious figures on the stone or mounting and wearing it in a certain way. This work is thus a link between the Plinian type of lapidary and the lapidaries dealing with *engraved* gems, of which Albert also gives a sample (II, iii, 5).

6. Isidore of Seville (*Isidorus Hispalensis, c.* 560–636), the great scholar of Visigothic Spain, in his encyclopedic *Etymologies* (*Etymologiarum sive originum libri XX*, Lindsay, 1911) attempted to cover the entire range of human knowledge, as extracted from the writers of classical antiquity and the Fathers of the Church. The title indicates his true interest—in words rather than in the study of nature. In Book XVI, on stones and metals, the descriptions are copied, some verbatim, from Pliny and Solinus, and the stones are rearranged in a somewhat arbitrary order based chiefly on colour. He did not know, or chose to ignore, such works as *Damigeron*, and his attitude towards magic stones reflects something of Pliny's scepticism, as well as the natural uneasiness of a Christian prelate about transmitting pagan beliefs: for instance, he groups together (*Etym.* XVI, *15*, 21) stones 'which the heathen use in certain superstitious practices'. Isidore was still considered a great authority even in the thirteenth century, and Albert occasionally quotes him.

7. 'Christian' lapidaries, commonly entitled *The Twelve Stones*, also reflect this uneasiness about pagan practices. Despite the attitude of the Church towards 'heathen superstitions', even devout Christians could not entirely shake off the old belief that precious stones possess some sort of supernatural powers or significance. This interest was to some extent legitimized by focusing attention on the stones mentioned in the Bible, especially the two (different) lists of 'twelve stones'—those in the breastplate of the High Priest (Exodus xxviii. 17–21; xxxix. 10–14) and those in the foundations of the New Jerusalem (Revelation xxi. 19–21). The former was the subject of a commentary by Epiphanius (*c.* 315–*c.* 402), Bishop of Constantia in Cyprus. This was translated from Greek into Latin at an early date (Dindorf, vol. iv, 1862; *versio antiqua*, pp. 141–224). Biblical commentators exercised their ingenuity not only in trying to identify the stones but also in assigning to them allegorical or mystical meanings. A good example of this type is printed among the writings ascribed to the English historian, Bede, as part of a *Commentary on the Apocalypse* (Migne, *Pat. Lat.* Vol. 93, cols. 197–202). This specialized sort of lapidary remained

separate from the tradition of secular lapidaries. But there are also works that list 'twelve stones' different from those in the Bible; and some that correlate them with the twelve Signs of the Zodiac (Thorndike, 1960). The latter should probably be classified as astrological lapidaries (see Appendix C, 4). Albert must have seen 'Christian' lapidaries, but he makes no special mention of the stones that appear in them; and his astrological lapidary (II, iii, 5) describes only the engraved figures, not the particular stones to be used.

8. The *Lapidary of Aristotle* (*Lapidarium Aristotelis*, or *Liber Aristotelis de lapidibus*, Rose, 1875; Ruska, 1912) is a pseudo-Aristotelian work (see Appendix A, 14). A few excerpts from this found their way into Arabic medical writings translated into Latin by Constantine of Africa (see 9 below). The whole work had certainly been translated by the thirteenth century, but Albert never succeeded in finding a complete copy of it (I, i, 1; II, iii, 6; III, i, 1). He quotes it several times, but evidently only at second- or third-hand (see Appendix C, 5; and notes on II, iii, 6).

9. Constantine of Africa (*Constantinus Afer*, or *Africanus*, *c.* 1015–1087), is said to have been born at Carthage and to have travelled widely in the East before settling down in Monte Cassino, where he spent his last years. He was the first important translator from Arabic into Latin, specializing in medical works. He has been accused (perhaps unjustly) of trying to claim these as his own writings, since he usually omitted the authors' names. Two that have been printed in his collected works are of interest here: the *Book of Degrees*, and the *Letter on Incantations* (*Opera*, Basel, 1536, pp 342–87; 317–20). The former (*Liber gradum*, or *de gradibus*) has been attributed to Ibn-al Jezzar, and also to Isaac the Jew, who wrote other books that Constantine translated. The *Book of Degrees* develops a theory of Galen that remedies can be classified in four 'degrees' of heat, cold, moisture, and dryness—a system that promised to be useful because physicians believed that a 'hot-dry' fever, for instance, could best be combated by a 'cold-moist' medicine. Among the drugs so classified are about thirty of mineral origin. This, then, is really a work on *materia medica*, in the tradition of Dioscorides, and not a lapidary. But it contained a few items from the *Lapidary of Aristotle*, which Albert quotes from Constantine. The other work, the *Letter on Incantations*, is supposed to have been written by Costa ben Luca (see Appendix C, 5). This, too, contains a few statements from the *Lapidary of Aristotle* that Albert quotes.

10. Marbod (Marbode, *Marbodus Redonensis*, 1035–1123) was a native of Angers and became Bishop of Rennes in 1096. His *Book of Stones or Gems* (*Liber lapidum seu de gemmis*, Migne, *Pat. Lat.* Vol. 171, cols. 1735–70) is written

in Latin hexameters and describes sixty stones and their properties. Marbod rarely (probably never) used Pliny directly, but took his descriptions partly from Solinus, partly from Isidore, adding medical and magical powers from *Damigeron* and a few fragments of the *Lapidary of Aristotle* (by way of Constantine's *Book of Degrees*); the poem is distinctly pagan in tone. There is also a 'Christian lapidary' that has been attributed to Marbod—*The Twelve Precious Stones in the Foundation of the Celestial City* (op. cit., cols. 1771–2), in rhymed Latin verse. But it was the secular *Book of Stones* that became the most widely read lapidary of the Middle Ages. Its popularity is attested by the large number of extant manuscripts, and also by the many paraphrases and imitations, in both prose and verse, in Latin and in vernacular languages. Marbod's name disappeared from many of these; and even when his work is quoted verbatim he is sometimes called 'Evax' (from his first line, 'Evax, King of the Arabs'), or simply *Lapidarius*. A large part of the 'lapidary tractate' (II, ii) in the *Book of Minerals* is derived from Marbod, although Albert never actually quotes him.

Lapidaries in Thirteenth-Century Encyclopedias

The authors discussed above have all contributed something to Albert's work; but he seems rarely to have made direct use of them. For the most part he relied on later compilations, such as appear in the encyclopedias of his contemporaries, Arnold of Saxony, Batholomew of England, Thomas of Cantimpré, and Vincent of Beauvais. These must now be considered:

11. Arnold of Saxony (*Arnoldus Saxo*) was probably the earliest of the four. Nothing is known of him except his name, *Saxo*, implying that he was born or lived in Lower Saxony, and his reference to himself as *clericus*, a member of the minor clergy. His book, *The Purposes of Natural Things* (*De finibus rerum naturalium*, Stange, 1905–6) is dated by Stange early in the thirteenth century. The third part of it deals with minerals and lists eighty-one stones. It is essentially a poor prose version of Marbod, in places so abbreviated as to be unintelligible unless one knows the original; to this is added some material from another source which Arnold does not name, but which can, in many instances, be identified as the 'Dyascorides' quoted by Bartholomew of England.

12. Bartholomew of England (*Bartholomaeus Anglicus, fl. c.* 1230–40) was a Franciscan. His reputation for learning was already established, and perhaps his encyclopedia, *The Properties of Things* (*De proprietatibus rerum*, Heidelberg, 1488), was already written, by 1230, when the General of the Franciscans requested his transfer from the French province to a teaching post at Magdeburg. *The Properties of Things* contains one book (XVI) on minerals and metals, compiled from many authorities whom Bartholomew names: Isidore of Seville,

Marbod (as *Lapidarius*), 'Dyascorides'; also Biblical commentators and medical writers, including Constantine of Africa and Avicenna. Bartholomew's habit (rather unusual for the time) of giving exact references is helpful for identifying unnamed citations in other writers.

13. Thomas of Cantimpré, or of Brabant (*Thomas Cantimpratensis*, or *Brabantinus*, *c.* 1201–*c.* 1270) was a member of the Order of Preachers, and was sub-prior and *lector* at the Dominican House in Louvain after 1246. He was acquainted with Albert, or at least had attended some of his lectures. His encyclopedia, *The Nature of Things* (*De natura rerum*) (British Museum MS. Egerton 1984; Evans, 1922, pp. 223–34), is supposed, from internal evidence, to have been written between 1228 and 1244. The book on stones bears a close resemblance to Arnold's, but makes more use of Biblical commentaries and identifies in the list the 'Twelve Stones' (of Exodus); it also cites the work of 'Thetel' on engraved gems (see Appendix C, 4).

14. Vincent of Beauvais (*Vincentius Bellovacensis*, *fl.* *c.* 1250–60) was also a Dominican and served as sub-prior at Beauvais about 1246. Later he was Royal Chaplain and tutor to the children of Louis XI. His encyclopedia, the *Great Mirror* (*Speculum majus*), is divided into three parts, the *Mirror of Nature* (*Speculum naturale*), the *Mirror of Doctrine* (*Speculum doctrinale*), and the *Mirror of History* (*Speculum historiale*). The *Speculum naturale* (Strasbourg, 1481), which deals with natural science, may have been finished by 1250, but this date is very uncertain. It includes one book (VIII) on metals and one (IX) on stones. In the latter Vincent cites many authorities—Vitruvius, Palladius, Pliny, and Solinus, as well as the more usual Isidore, Marbod (as *Lapidarius*), and 'Diascorides'; and he also cites his contemporaries, Arnold (by name) and Thomas (not named, but as the book *De naturis rerum*). Under the designation *Auctor* (author) he adds brief comments of his own.

Albert's Lapidary in the Book of Minerals

Useful accounts of these encyclopedias have been given by Thorndike (1923, Vol. II), but a detailed study would be necessary in order to answer all questions about their relations to each other and to Albert's works (on plants and animals as well as minerals). The conclusions stated here are based solely on examination and comparison of the portions dealing with stones and metals.

In considering Albert's immediate sources for the 'lapidary tractate' (II, ii) in the *Book of Minerals* I believe that Vincent of Beauvais can be ruled out entirely. Although his *Mirror of Nature* may have been completed around 1250 (see Introduction: 'Date of composition of the *Book of Minerals*'), the similarities between this and Albert's lapidary all seem to be Vincent's quotations of Arnold or Thomas or other sources that Albert used independently.

Bartholomew of England can also be ruled out. In fact, his lapidary in *The Properties of Things* seems to have no direct connexion with those in other contemporary encyclopedias: here, too, similarities show merely that Bartholomew was quoting (often more fully and more accurately) sources that others also used.

On the other hand, even the most superficial examination suggests that Albert's lapidary tractate is indebted to those of Arnold of Saxony and Thomas of Cantimpré (cf. Bormans, 1852; Rose, 1875; Aiken, 1947); and other parallels occur in the chapters on astrological sigils and on ligatures and suspensions (II, iii, 5–6). This is not surprising. Albert, as he himself tells us (III, i, 1), made a long search for the *Lapidary of Aristotle*, and no doubt consulted every lapidary he could lay hands on. But he never names either Arnold or Thomas. It may be that he did not know their names: Rose (1875, p. 335) reported that some manuscripts of their works are anonymous, and Thorndike (1923, Vol. II, pp. 396–398; 1963) lists a number of copies of *The Nature of Things* that lack Thomas's name or are attributed to someone else. But Thomas was a fellow Dominican, and claimed to be acquainted with Albert, and it is difficult to believe that Albert used his book without knowing who had written it. This, however, was a common usage of the time; many medieval writers pass along the sayings of famous 'authorities' like Aristotle, Hermes, or Evax, without giving the immediate contemporary source of their information, which may have been a paraphrase or epitome, the author being considered relatively unimportant.

If Albert used either of these contemporary lapidaries, he must have used both, since some of his stones are found in one but not in the other (at least in the texts I have seen), and a few are described partly in Thomas's phrases and partly in Arnold's. But the two are on the whole so similar as to point to a common source, and it is possible that Albert himself also used that source. The style of this part of the *Book of Minerals*, with its reiterated 'it is said' (*dicitur*, *fertur*), 'it is found by experience' (*expertum est*), 'some people say' (*quidam dicunt*), &c., indicates that he was comparing and summarizing information from several lapidaries. Arnold's and Thomas's cannot have been the only ones he used, because in some instances he names authorities that they omit.

Arnold says his lapidary is based on 'Aristotle and Aaron and Evax, King of the Arabs, and Diascorides'. This does not imply four separate works used independently; it was probably one manuscript, supposedly compiled by 'Diascorides' (see 2 above), and containing excerpts from Aristotle (that is, the *Lapidary of Aristotle*), Evax (Marbod, already reduced to a prose paraphrase), and Aaron (unidentified, but presumably a Jewish or Arabic work that supplied the items not in Marbod or the *Lapidary of Aristotle*). Thomas used the same source, but calls it merely 'Evax King of Arabia' (appropriately enough, since most of it came from Marbod). Bartholomew of England cites it, too, but uses only the name 'Dyascorides' (as the author of the whole collection); and he chooses mostly items that are not in Evax (that is, Marbod) whom he quotes directly.

Albert also lists 'Evax, King of the Arabs, Diascorides, Aaron' among his authorities at the beginning of the *Book of Minerals* (I, i, 1). He repeats 'Evax and Aaron and Diascorides' in introducng the subject of astrological sigils (II, iii, 4); this suggests that the lapidary of engraved gems (which is also in Arnold and Thomas) was a part of, or was bound up with, the manuscript that contained the alphabetical lapidary (II, ii). Finally, in the chapter on ligatures and suspensions (II, iii, 6) he again cites 'Aristotle and Diascorides', apparently the work that Arnold calls 'The *Lapidary of Aristotle*, translator Diascorides'. This chapter of Albert's closely resembles Arnold's and may be partly based on it; but Albert includes a few items from the *Lapidary of Aristotle* that are not in Arnold. Moreover, a number of Arnold's statements are also in Bartholomew, credited to 'Dyascorides'. So the material in Albert's final chapter on stones (II, iii, 6) seems to have been another part of a 'Diascorides' compilation that was known also to Bartholomew and Arnold. Albert no doubt valued it especially because it contained excerpts from the *Lapidary of Aristotle*.

APPENDIX C

ASTROLOGY AND MAGIC

ASTRONOMY is not only the oldest of the sciences; in the ancient world it was also a religion and a practical art. Scientific astronomy—the observation and recording of the motions of the heavenly bodies and the mathematical calculation of their courses—will not be discussed here. The astral religion, however, left its mark on Greek philosophy; and the practical art of predicting human fortunes from the stars was already widespread in the Roman Empire and was transmitted to medieval Europe through both Latin and Arabic channels. These influences are obvious in the *Book of Minerals*: the works mentioned or alluded to by Albert may conveniently be grouped under five headings: (1) Plato, (2) Ptolemy, (3) Hermes, (4) astrological sigils, (5) amulets.

1. Plato (427–347 B.C.), founder of the Academy at Athens, was influenced by the Pythagoreans, and in turn influenced a long line of thinkers beginning with Aristotle and including some of the Fathers of the Church, notably Augustine (A.D. 354–430). But the only one of Plato's own works that was read in western Europe during the Dark Ages was the *Timaeus*, in a Latin translation and commentary made by Chalcidius (Mullach, 1881, Vol. 2, pp. 149–258) in the fourth century. The *Timaeus* took a strong hold on men's imaginations: it deals with the themes of cosmic harmony, expressed in numerical ratios; of the ordering of chaos into cosmos by the Demiurge, who created the stars in their 'choric dance', and then entrusted to them, the 'young gods', the creation of all mortal things; and of the doctrine of man, the microcosm or 'little world', reflecting in his being the macrocosm or 'great world' of which he is a part. Plato did not teach astrology, as such, but the *Timaeus* might be held to support belief in the power of the stars over human lives; and later astrologers invoked the authority of Plato, as well as that of his pupil Aristotle (whose cosmology is discussed in Appendix A).

Albert, of course, knew the Chalcidius version of *Timaeus* (III, i, 6), and he also knew some of the Latin writers on Platonism, though the only one of these that he mentions in the *Book of Minerals* (II, 1, 2) is Apuleius of Madaura, who was frequently cited by Augustine in *The City of God*. Apuleius's own writings reveal an interest in magic as well as in philosophy; his most famous work is *The Golden Ass*, or *Metamorphoses*, a romance about a man transformed into an ass. Some of the Greek commentators on Aristotle were neo-Platonists, and their views are reflected in the Arabic commentaries: for instance, Avicenna's belief in angels as the intelligences that move the celestial spheres—a belief of which Albert strongly disapproves (II, i, 2–3). Neo-Platonist writings also have many connexions with 'Hermetic' books (see 3 below).

2. Ptolemy (*Claudius Ptolemaeus, fl. c.* A.D. 150) is famous as the author of the 'Great Work' on astronomy transmitted to Western science under its Arabic name, the *Almagest.* In the Middle Ages he was perhaps even more famous as an astrologer. His *Treatise in Four Books* (Greek *Tetrabiblos,* Latin *Quadripartitum*) is interesting even today as a 'rational' account of astrology. Ptolemy argues that the influences of the stars work through the *qualities* (heat, cold, moisture, dryness) which they impart to the atmosphere and the earth, causing winds, rains, floods, and droughts; their effect at any particular time and place depends on the positions of the planets in relation to each other and to the Signs of the Zodiac. On this basis he gives an account of weather, seasons, and climate that is in fair agreement with the facts in the eastern Mediterranean region (where he lived) and then goes on to claim equal validity for prognostications about 'major' events like earthquakes, pestilences, and wars, and about 'minor' events in the lifetime of any individual man or woman.

The Latin translation (*Quadripartitum*) was made from the Arabic by Plato of Tivoli before the middle of the twelfth century, and Albert cites it (II, i, 3; II, iii, 4), as well as the spurious *Hundred Aphorisms* (*Centiloquium,* Ashmand, 1822) which was translated even earlier. Medieval writers often confused Ptolemy the astronomer with the royal family that ruled Hellenistic Egypt, and called him 'king Ptolemy of Egypt', ascribing to him many other books on astrology; Albert alludes to some of these without giving their titles (see 4 below).

3. Hermes Trismegistus, 'Hermes thrice-greatest', is a name attached to a bewildering number of books on religious mysticism, astrology, magic, and even alchemy. The oldest of these, known as the *Hermetic corpus,* were written in Greek, probably at Alexandria in the early centuries of the Christian era. Hermes, however, was commonly identified with the Egyptian god, Thoth, whose teachings were said to have been handed down from the remotest antiquity; and this identification was accepted in the Middle Ages, so that Albert speaks of Hermes as the predecessor of Plato and other Greek philosophers. One book in the *Hermetic corpus, The Sacred Book of Hermes Trismegistus addressed to Asclepius* (Scott, *Hermetica,* Vol. I) is in Latin, evidently an early translation; this has been attributed (dubiously) to Apuleius of Madaura. It is strongly tinged with neo-Platonism. Albert cites it in his *Animals* (XXII, i, 5) and alludes to it in the *Book of Minerals* (II, i, 1), in speaking of the 'miraculous powers' of the soul.

Most of Albert's references, however, seem to represent a later stage of the

Hermetic tradition, transmitted through Arabic writers. These works are not easy to identify because 'sayings of Hermes' were endlessly repeated from one book to another. The *Universal Power(s)* (*De universali virtute*, cited in the *Book of Minerals*, II, i, 2, and in *The Nature of Places*, i, 5) is ascribed to 'Hermes and certain followers of his', but was undoubtedly written by a 'follower' whom Albert does not name. I have not identified this work, though it may still exist in manuscript. But it would seem to be connected with, or perhaps to be another version of, a treatise attributed to Hermes (or sometimes to Enoch) on *Fifteen Stars, Fifteen Stones, Fifteen Herbs, and Fifteen Images* (Latte, pp. 235–89). This is presumably of Greek origin, but the Latin text was translated from an Arabic epitome. It correlates the colours of stars with the planets and also with the four humours and the four elements: red with Mars, Fire, bile; livid or leaden, with Saturn, Earth, black bile; yellow with Jupiter, Air, blood; and white with Venus, Water, phlegm. Neither this list of colours nor the subsequent assignment of stones and images to particular stars corresponds very closely with the *Book of Minerals* (II, i, 2; iii, 5), so this work was not Albert's source; but it does probably represent a type of Hermetic treatise then well known.

Hermes was also said to have written books on astrological images (see 4 below) and on alchemy (see Appendix D, 7).

4. Astrological sigils, according to Albert (II, iii, 1), can be understood only by those skilled in astrology, necromancy, and magic; and it is therefore rather surprising to find him assuring his fellow Dominicans that this is 'good doctrine'. It is less surprising if we compare his views in the *Book of Minerals* with those of the *Mirror of Astronomy*, or astrology (*Speculum astronomiae*, Borgnet, Vol. X), which has also, though not unanimously, been ascribed to Albert (see Introduction: Albert's Scientific Writings). The *Mirror of Astronomy* (Ch. XI) says that images are 'abominable' if they are made or used with accompanying invocations or burning of incense to pagan gods or demons; less evil but still 'detestable' are images bearing 'characters' or inscriptions, especially in an unknown language, which may conceal something contrary to the True Faith. The only permissible images are those that derive their power solely from the heavenly bodies, through having been made at a time when the planets were in a configuration favourable to the intended purpose of the image. Such distinctions between 'black' and 'white' magic may seem tenuous today, but were apparently clear enough to the schoolmen (see Thorndike, 1923, Vol. II, pp. 549–92, 692–717).

The *Mirror of Astronomy* is a sort of 'annotated bibliography' of licit and illicit books (*in quo de libris licitis et illicitis pertractatur*). Of the illicit books the author says that it is a long time since he read them, that he regarded them with abhorrence, and can no longer remember the exact titles and contents of all of them; but those he does recall include several on rings, sigils, and images—in fact the very ones that Albert mentions in the *Book of Minerals.* Most of these have been identified in manuscript collections (Thorndike, 1947; Carmody, 1956).

Actually the only one of Albert's 'authorities' on this subject who is not mentioned in the *Mirror of Astronomy* is Geber of Seville (*Geber Hispalensis*). This is not Geber the alchemist, *Jabir ibn Hayyan* (see Appendix D, 3), but the twelfth-century astronomer, *Jabir ibn Afflah,* whose book criticizing the *Almagest* was translated into Latin by Gerard of Cremona. But Albert also refers (II, iii, 3–5) to the following:

Magor of Greece (*Magor Graecus*) and Germa of Babylon (*Germa Babylonensis*) are thought by Thorndike (1923, Vol. II, pp. 226–7, 718–9) to be the same as the *Toz Graecus* and *Germath Babylonensis,* who are also mentioned together in the *Mirror of Astronomy* (Ch. XI): Germa(th), also called Gergis, Gergic, &c., has not been identified with certainty: Carmody (p. 73) suggests *Jirjis ibn al-'Amid,* or perhaps *Georgius Antiochenus* (eleventh century). One of the books bearing this name concerns the *Images of the Seven Planets.* But *Toz* is certainly a variant of *Thoth,* that is, Hermes Trismegistus, and the *Mirror of Astronomy* (Ch. XI) notes a series of Hermetic books on the planets—Moon, Mercury, Venus, &c.—some of which contained several tractates on rings, images, characters, and incantations. Since these are all said to be very bad books, we can understand why Albert's later references to them (II, iii, 5) are so brief and vague.

Ptolemy, as already noted (2 above) was well known as an astrologer, and Albert paraphrases part of the *Tetrabiblos* (II, iii, 3); but he may be alluding also to spurious books of sigils, &c., that were likewise ascribed to Ptolemy.

Thebit ben Corat (*Thabit. B. Qurra*) worked at Baghdad in the ninth century. He wrote several books on mathematics and astronomy, and is also credited with one on magic tricks or illusions, which seems to be that mentioned by Albert as 'Hermes and Ptolemy and Thebit ben corat' (II, ii, 4), indicating that he knew it by the title recorded by Thorndike (1923, Vol. I, pp. 664–5; 1947, pp. 227–8) for the translation of Adelard of Bath: *Liber prestigiorum Thebidis secundum Ptolemaeum et Hermetem,* a compilation (presumably by Thebit) from some of the pseudo-Ptolemaic and Hermetic books already mentioned.

Another book on images (*De imaginibus,* Carmody, 1961) is ascribed sometimes to Thebit and sometimes to Aristotle, since Aristotle is quoted in the first sentence. But perhaps Albert's rather unenlightening mention of Aristotle on the aspects of Jupiter (II, iii, 5) is an allusion to one of the very worst books listed in the *Mirror of Astronomy* (Ch. XI), called *The Death of the Soul* (*Mors animae*).

Sahl ben Bisr, or *Zahel Benbriz,* or (as he is called in the *Mirror of Astronomy,* Chs. VIII, IX, X) *Zahel Israelita*, was a Jew who lived in the ninth century. Several of his works on interrogations and elections were translated into Latin, and also a short tract on engraved gems (manuscripts bear such names as Zael, Cheel, Cethel, Thetel, &c.): *Liber sigillorum filiorum Israel quem fecerunt in deserto*. This claims to preserve a tradition of the Children of Israel, who during their wandering in the desert received divine instruction as to the carving of gems (cf. Exodus xxviii. 9–30). But the figures described are distinctly pagan. One example may suffice: 'When you find on a stone a man holding in one hand a figure of a devil depicted with horns and wings, and in the other hand a serpent, and under his feet a lion, and above these figures stand the sun and moon, this stone should be mounted in lead, and it has the power of compelling demons to answer questions.' Thomas of Cantimpré (see Appendix B, 13) included this work of 'Thetel' in his encyclopedia (138r–140r), though he warned his readers not to put too much faith in such figures but rather to trust in God; and he added a prayer for sanctifying stones. Albert seems even more doubtful than Thomas whether this treatise, with its strange mixture of Biblical and heathenish elements, is really 'good doctrine'. He does not name Zahel, and makes only the barest allusion to 'the Children of Israel when they journeyed out of Egypt' (II, iii, 4).

Finally, there is another, more strictly astrological, lapidary which Albert does include in full (II, iii, 5); this was written by someone who had before him a set of *pictures* of the constellations. Such illustrated manuscripts have been described by Haskins (1924, pp. 285–8; 336–45, photographs in the Houghton Library of Harvard University). One of these is a thirteenth-century copy of a treatise by 'Nimrod the astronomer' (MS. Lat. VIII 22, Library of St. Mark's, Venice). According to Haskins, this is of Syrian-Greek origin, and was reworked, probably in Gaul, before the introduction of Arabic astronomy. It was apparently held in high regard, for the *Mirror of Astronomy* (Ch. II) mentions it even before Ptolemy. The constellations are shown in forty-three drawings which (like the drawings that accompany the *Herbal of Dioscorides*) suggest that a Byzantine prototype became the basis of a long-lived convention. Another, fourteenth-century, manuscript (Munich, cod. lat. 10268) is a copy of Michael Scot's *Introduction* to astrology (*Liber introductorius*); in this the drawings are more elaborate but the same convention is still discernible—for example, in representing Andromeda with hands bound to two stakes, or in combining in one drawing such groups as the Water Snake, Crow, and Cup, or the two Bears and the Dragon. These are, for the most part, the figures described in Albert's astrological lapidary.

The figures of the planets, on the other hand, are given in this lapidary according to a quite different convention, that of engraved gems of the classical period—Saturn as the old man with a scythe, Mercury with winged heels, &c.

Antique gems were preserved in royal and ecclesiastical treasuries, and were occasionally turned up on Roman sites, as Albert himself tells us (II, iii, 5); in fact, most medieval lapidaries of this type speak of such images as 'found' rather than 'made'. (Cf. notes on II, iii, 2).

This lapidary of engraved gems was apparently well known; in introducing it (II, iii, 4) Albert names as his authorities 'Evax and Aaron and Diascorides', meaning, I think, the 'Diascorides' manuscript in which he also found the alphabetical lapidary (II, ii: see Appendix B). It is certainly from the same source as the similar lists in the encyclopedias of Arnold of Saxony and Thomas of Cantimpré; and it has been found elsewhere: another specimen in Latin has been published by Evans (1922, pp. 239–46), and two in old French by Studer and Evans (1924, pp. 278–96). All these versions are corrupt; the names are distorted, the sequence confused, and figures from other sources are sometimes included. Albert's copy was evidently no better.

5. Amulets, used for 'ligatures and suspensions'—that is, binding to any part of the body or hanging round the neck—are not necessarily astrological, though Albert probably includes them (II, iii, 6) because he regards all powers of stones as heaven-sent. He names as his authorities for these Costa ben Luca, Aristotle, and Hermes.

Costa ben Luca (*Qusta ibn Luqa*, *c.* 820–915) worked mostly at Baghdad. He wrote on astronomy and philosophy, but Albert cites a work on *Physical Ligatures* (*De physicis ligaturis*), which has also been attributed to, and printed with, the writings of Galen and of Constantine of Africa (Constantine may have been the translator). In the latter's works (*Opera*, pp. 317–20) it is entitled *Letter to a son on incantations and adjurations*; other editions add 'and suspensions from the neck'. Albert paraphrases Costa ben Luca's argument for the efficacy of amulets, including the remarks of Socrates on what today might be called psychosomatic symptoms; and extracts a few quotations about stones. Costa ben Luca included many amulets made from plants and animals, and Albert mentions these elsewhere (II, i, 1).

'Aristotle' in this context, of course, means the pseudo-Aristotelian *Lapidary* (see Appendix B, 8), or at least the excerpts from it which, as Albert says at the end, were all he was able to recover. A large part of the chapter (II, iii, 6) closely resembles Arnold of Saxony's Chapter 8, on stones (*De lapidibus*), in the fourth part of his encyclopedia (Stange, pp. 85–87). Albert, in fact, is quoting, from Arnold or from Arnold's source, nearly everything except what comes from Costa ben Luca—not only the excerpts from 'Aristotle' but also those from 'Zeno's book on Nature'. But Arnold's chapter shows more clearly than Albert's that there were two different versions of the *Lapidary of Aristotle*. One is cited as 'Aristotle's *Lapidary*, translator Diascorides'; but the excerpts from it show that it was not really a translation but a compilation containing a few items from the *Lapidary of Aristotle* and a great many more that belong rather to the tradition of Marbod; this seems to be the 'Dyascorides' so often cited by Bartholomew of England. The other translation, which Arnold ascribes to Gerard (presumably of Cremona), is now lost; it contained information about the polarity of the magnet which is not found in any extant manuscript of the *Lapidary of Aristotle* (Rose, 1875; Ruska, 1912).

Hermes is not mentioned by Arnold in this chapter; but the whole fourth part of his encyclopedia is entitled *De virtute universali*. Albert, as we have seen (see 3 above), knew some Hermetic book with this title. Perhaps Hermes's name appeared in Arnold's source; or perhaps Albert himself added it, on recognizing the title or some of the contents of a book he knew independently.

APPENDIX D

ALCHEMY

The history of alchemy is difficult to trace because the basic documents, in Greek, Arabic, and Latin, are not always what they purport to be. Not only were old materials repeatedly reworked, but later writers often assumed earlier names already famous in order to lend their books greater authority. These problems cannot be dealt with here, but enough may be said to indicate the background of alchemical doctrines that were familiar in the thirteenth century, and to identify at least some of the works used by Albert in writing the *Book of Minerals*.

Alchemy seems to have originated in Hellenistic Alexandria, as an attempt to 'explain' technical processes (dyeing, glassmaking, metalworking, &c.) by theories drawn from Greek philosophy (Hopkins, 1934). Ancient arts, based on empirical methods developed through many centuries, began to seem mysterious to those who asked *why* the methods worked. Surviving documents from this period bear mostly Greek or Jewish names—Hermes, Plato, Democritus, Zosimus, Cleopatra; or Enoch, Moses and Aaron, and their sister Miriam. They preserve a strange mixture of practical recipes, laboratory directions, and mystical interpretations of chemical change.

Very little of the theoretical or mystical alchemy was transmitted directly, through early translation into Latin, to western Europe, where the earliest 'chemical' books are collections of recipes for making paints, cutting glass, working with metals, &c. such as the *Mappae clavicula* (Phillips, 1847). Later examples are Eraclius (or Heraclius), who wrote on similar subjects in Latin hexameters, *On the Colors and Arts of the Romans* (Merrifield, 1849, Vol. I); and a longer prose treatise by Theophilus *Upon Various Arts* (Hendrie, 1847; Dodwell, 1961) who explained not only painting and glassmaking but also the assembly of stained-glass windows, the making of gold and silver vessels for the church service, the casting of bells, and the construction of an organ. Such works, however, seem to have had little interest for the schoolmen, and are not quoted by the thirteenth-century encyclopedists. Albert himself gained at least some of his knowledge of technology by direct observation (III, i, 1; IV, 6).

Meanwhile the Arabic-speaking world had eagerly adopted Greek alchemy, elaborating the theories and adding to the factual content. And it was through translations from the Arabic that knowledge of alchemy began to spread in the twelfth and thirteenth centuries. Albert must have been well acquainted with this literature but his sources cannot always be identified. I will mention first a few works (1–4 below) which, although it is impossible to prove that Albert used them, were well known at the time and had a wide influence.

1. The *Conference of Philosophers* (*Turba philosophorum*, Ruska, 1931; Plessner, 1954) shows clearly the Arabic debt to Greek alchemy. It describes a meeting of Greek philosophers (their names strangely garbled) and attempts to link their cosmological teachings with alchemy. Little of this is really 'chemical', but some echo of it may have strengthened Albert's belief that Democritus, Empedocles, and Plato were alchemists (see 5 and 6 below.)

2. Morienus was, according to tradition, a Greek of Alexandria, and the teacher of the first Muslim alchemist, Khalid ibn Yazid Muawiya (d. 704), whose story is told in a work ascribed to Morienus, the *Book of the Composition of Alchemy* (*Liber de compositione alchimiae*, Manget, Vol. I). This was one of the first works of Arabic alchemy to reach the West, being translated into Latin by Robert of Chester before the middle of the twelfth century. If Albert did not know it, he certainly knew another, related, work ascribed to Khalid himself (see 8 below.)

3. Jabir, or Geber (*Jabir ibn Hayyan*, connected with the court of Harun al-Rashid at Baghdad in the eighth century) is credited by Holmyard (1957, pp. 66–80) with the formulation, though not necessarily the invention, of certain theories that reappear again and again in later alchemy: that volatile substances are 'spirits' and metals 'bodies'; that the planets influence the 'growth' of metal underground; and that transmutation may be effected by bringing about a 'balance' or 'harmony' between the 'external' or 'manifest' and the 'internal' or 'occult' natures of metals by means of an 'elixir'. He was acquainted with neo-Platonic notions of number, and tried to calculate by a 'magic square' the harmonious proportions for transmuting the metals.

The Arabic Jabirian *corpus* shows evidence of reworking and additions by other hands, probably about the tenth century. It was never completely translated into Latin. A fair sample of it is perhaps the *Book of Seventy* precepts or chapters (*Liber de septuaginta*, Berthelot, 1906, pp. 308–63), which reflects Jabir's ideas about metals, and also his interest in animal substances—eggs, hair, blood, and sperm—which enter into some of the recipes.

There are still other works, under the Latin name *Geber*, that were written in Spain and did not appear in Latin until about the beginning of the fourteenth century.

4. Rhasis, or Rhazes (*Abu Bakr ibn Zakariyya, al-Razi*, ninth century) was renowned as a physician. Some of his medical works were translated into Latin, as well as his *Book on Alums and Salts* (*Liber de aluminibus et salibus*, Steele, 1929,) sometimes called *On Spirits and Bodies* (*De spiritibus et corporibus*), or *Book of Secrets* (*Liber secretorum*). This is a sort of 'laboratory manual' dealing not only

with 'alums and salts' but also with metals, the making of alloys, and transmutation. The Latin version was made by Gerard of Cremona in the twelfth century, and it is extensively quoted by Albert's contemporary, Vincent of Beauvais (*Mirror of Nature*, Book VIII). But although many of its procedures are similar to those mentioned in the *Book of Minerals*, Albert is not really quoting Rhasis.

We now come to alchemists actually cited by Albert: (5) Democritus; (6) Plato; (7) Hermes; (8) Khalid ibn Yazid—as 'Callisthenes', (9) Avicenna, (10) Gilgil.

5. Democritus is a name that has been borne by more than one person. First, of course, by Democritus of Abdera (fifth century B.C.), one of the founders of the atomist philosophy. Whatever Albert knew of him came from Aristotle, who severely criticized his theories; and indeed Greek atomism played no part in the chemical speculations of the Middle Ages. Second, a Democritus who wrote books on magic (now lost), and who has been identified as Bolos of Mendes in Egypt (of perhaps the third or second century B.C.). Third, a Democritus (who may, however, be the same as Bolos-Democritus), author of a treatise *On things natural and mystical* (Steele, 1890; Stillman, pp. 153–61). Like other books on Greek alchemy this gives recipes for dyeing and for colouring metals to resemble gold and silver. But this is not the source of the statement that Albert (III, i, 4) attributes to Democritus—namely, that metals are made up of *calx* and *lixivium*—a theory which, according to Partington (1937, p. 10) is otherwise unknown in alchemy.

There are still other manuscripts, in Greek, Syriac, and Arabic, ascribed to Democritus. But probably Albert had merely seen some reference to Democritus in other alchemical works, though no doubt he supposed he was quoting Democritus of Abdera.

6. Plato (427–347 B.C.) certainly never wrote on alchemy, but here, as in astrology (see Appendix C, 1), his name was often invoked. In the *Timaeus* Alexandrian alchemists found the notion of 'prime matter' (*materia prima*) from which the four elements were created, and the suggestion that the elements can be transmuted into each other. Water is said to be the chief matter of all liquid or liquefiable things, including the fusible metals; gold is the most perfect metal, since the others contain fine Earth, which eventually appears as rust. Plato also taught that all evil, ugliness and disease are due to lack of harmony in the proportions of the constituent elements of bodies.

A number of alchemical books were later ascribed to Plato himself (D. W. Singer, 1946), some of which Albert may have known; but his references to Plato as an alchemist are too vague to be identified with any certainty.

7. Hermes (see also Appendix C, 3) was revered as the legendary founder of alchemy. But the Arabs realized that not all the books attributed to Hermes came from one hand, and recorded a tradition (quoted by Robert of Chester in the Preface to his translation of Morienus's *Composition of Alchemy*: see 2 above) that there were three 'philosophers' called Hermes: the first was Enoch, grandson of Adam; the second, Noah; the third, a King of Egypt after the Flood, who instructed mankind in many arts and sciences. Still others identified Hermes with the Egyptian god, Thoth.

Of Hermetic writings on alchemy, the *Emerald Table* (*Tabula smaragdina*) is perhaps the oldest, certainly the most famous and the most obscure. Though probably of Greek origin, it came into Latin from Arabic, and several different translations are known: one is embedded in the pseudo-Aristotle *Secret of Secrets* (Steele, 1920, pp. xlviii–li, 115–16). The text Albert used has been printed by Steele and Singer (1928, pp.47 –9), who tentatively identify the translator as Plato of Tivoli (*fl.* 1134–45). The fascination of the *Emerald Table* was due partly to the romantic tale of its discovery, as an inscription on a slab of emerald in the dark tomb of Hermes, and partly to its enigmatic character. Since it is short, and also typical of much Hermetic lore, an English translation may be of interest:

True, without falsehood, certain, most certain.
That which is above is like that which is below, and that which is below is like that which is above,
For the preparation of the miracles of one thing.
As all things were from the meditation of one, so all things are born from this one thing by combination.
Its father is the sun, its mother the moon.
The wind carried it in its belly. Its nurse is the earth.
This is the father of the wonder of the whole world.
Its power is perfect.
If it is cast upon the earth, it will separate earth from fire, subtle from gross.
Gently, with great skill, it ascends from earth to heaven. Again it descends from heaven to earth, and receives power from above and below.
Thus you will possess the glory of the brightness of the whole world, and therefore all darkness will flee from you.
This is the strong strength of all strength, for it will overcome everything subtle and penetrate everything solid.
Thus was this world created.
From this will come miraculous combinations, and this is the manner of them.
Therefore I am called Hermes [Trismegistus], having the three parts of the wisdom of the whole world.
And this completes what we have said about the work of the sun.

This cannot be said to convey any very clear chemical ideas. Some readers took 'sun' and 'moon' (*sol, luna*) to refer to gold and silver, and the 'work of the sun' (*opus solis*) to be the preparation of the *elixir* for transmutation; and many, like Albert (I, i, 3), attempted to interpret other phrases in terms of actual chemical procedures.

There is also Hermes's *Book of Alchemy*, quoted by Albert (especially in Book IV) as *Hermes in alchimicis* and by Arnold of Saxony (Stange, pp. 42–45) as *Liber alchimie Hermes*. This seems to be the title of the manuscript containing the above version of *The Emerald Table* (Steele and Singer, p.46): *Incipit Liber Hermetis de blchkmkb*, the last word being a primitive cipher for *alchimia*; and it includes some of the 'sayings of Hermes' that Arnold and Albert quote. But it must also have contained material of a quite different sort, recipes for making brass, red and white lead, and green copper pigments, &c. Such knowledge was ancient and widespread, but the wording of some of Albert's and Arnold's quotations is the same as the *Book of the Priests* (*Liber sacerdotum*, Berthelot, 1893, Vol. I), which is a compilation, probably from many sources, translated from the Arabic. Perhaps this was sometimes ascribed to Hermes, or perhaps its author merely drew part of his materials from a *Book of Alchemy* that Arnold and Albert found under the name of Hermes.

8. The 'Callisthenes' mentioned by Albert (III, i, 7) is Khalid ibn Yazid, some scribe (or Albert himself) having mistaken *Calit* or *Kalid* for an abbreviation of the Greek name Callisthenes. The original Callisthenes was a relative of Aristotle who accompanied Alexander the Great to Persia, where he died, or was killed, after quarrelling with Alexander. His name was later borrowed by the author of a romantic history, the source of some of the 'Alexander stories' so popular in the Middle Ages. But all this has nothing to do with alchemy.

Albert is really citing Khalid ibn Yazid's *Book of the Three Words* (*Liber trium verborum Kalid regis*, Manget, Vol. II), which says that nature always tries to develop metals into the most perfect form of silver or gold, but is often unsuccessful because matter contracts some 'disease' or 'corruption' from its surroundings; and alchemy is the art of perfecting these imperfect metals.

9. Avicenna (*Abu Ali ibn Sina*, 980–1037) was one of the great philosopher-scientists of Islam. Among his many writings are two of encyclopedic scope, the *Canon of Medicine* and the *Book of the Healing of the Soul* (*Khitab al-Shifa*). The latter deals with philosophy and natural science in the form of commentaries on Aristotle, although Avicenna's views were also influenced by neo-Platonism and Muslim theology.

In Albert's *Book of Minerals* more than half the citations of Avicenna come from one short work, *De congelatione et conglutinatione lapidum*, which has been shown (Holmyard and Mandeville, 1927) to be an excerpt from the *Khitab al-Shifa*. It was translated into Latin about 1200 by Alfred of Sareshel; and since it seemed to fill an apparent gap in the *Meteorologica* (see Appendix A, 4) where a treatment of minerals is wanting, it was often copied into manuscripts of that work, and was even cited under Aristotle's name (e.g. by Arnold of Saxony). Albert, however, knew that it was really Avicenna's (III, i, 9). It consists of three chapters: I, The origin of stones; II, The origin of mountains; III, Minerals and metals. Albert used part of Chapter I, on 'thunderstones' in his *Meteora* (III, iii, 20), and Chapter II, on mountains, in his *Properties of the Elements* (II, ii, 5); the rest he used in the *Book of Minerals*. Avicenna's Chapter I explains that stones are made from Earth and Water, either by *congelatio* (solidification of a liquid) or by *conglutinatio* (cementing together of solid particles), under the influence of a *vis mineralis* (mineralizing power). Chapter III sets forth the Sulphur-Quicksilver theory of metals, and expresses some scepticism about the possibility of transmutation.

Several other works on alchemy have been ascribed to Avicenna, but their authenticity has been doubted because they do not show this scepticism. Albert (III, i, 4 and 9) quotes one called *Avicenna's Letter to King Hasen* (*Avicennae ad Hasen regem epistola*, Zetzner, Vol. 4), in which the author says that he has found the arguments and counterarguments of the alchemists foolish and confusing, and has had to discover for himself how to make the *elixir*. Stapleton (1962) discovered an Arabic manuscript of this, *A Treatise written for Abul-Hasan Sahl*, whom he identified as a member of a family for whom Avicenna wrote other treatises; and suggested that this was an early work, composed before Avicenna abandoned his belief in transmutation.

Still another work ascribed to Avicenna is called *The Soul in the Art of Alchemy* (*De anima in arte alchimiae*, Manget, Vol. I). The title reflects the author's interest in 'soul' or 'spirit', that is, in solutions and distillations as the best methods of disintegrating and reconstituting metals. Even if based on something of Avicenna's, the extant text was probably written in Spain in the early thirteenth or late twelfth century. Vincent of Beauvais (*Mirror of Nature*, Book VIII) repeatedly cites it as Avicenna's. Albert, however, seems to quote (III, 1, 4 and 9) only the final section, *Avicenna's exposition of the physical stone for his son, Abu Ali* (*Declaratio lapidis physici Avicennae filio suo Aboali*); this apparently circulated as a separate work (D. W. Singer, 1928, Vol. I, p. 117).

10. Gilgil (*Abu Daud ibn Juljul*, tenth century) was a Mozarab physician who lived in Spain. He is said to have translated or assisted in the translation of Dioscorides' *Herbal* (see Appendix B, 2), and to have written a commentary identifying the drugs mentioned in that work with a supplementary treatise on

additional drugs. These may be the works to which Albert refers (III, 1, 4), though it is not clear whether he had seen a Latin translation or merely citations in other writers. He calls Gilgil *mechanicus non philosophus*, 'a practical man not a theoretical scientist', and demolishes his theory that metals are essentially of the same nature as glass, and therefore must be composed of materials, such as 'ashes', that are used in making glass.

APPENDIX E

IDENTIFICATION OF MINERALS AND ROCKS

ALBERT had a remarkably wide knowledge of minerals and rocks, but in writing about them he himself felt the lack of a systematic nomenclature (I, i, 6). Many names had come down from antiquity or from the Arabs, though some of these were strangely distorted in transmission, so that similar pronunciations sometimes led to the confusion of two different minerals (e.g. *celon(i)tes* and *silenites*). But many minerals were still 'nameless' (*innominati*) and Albert had to describe them as best he could in his own words; this was particularly true of ore minerals and common rocks (see 2 and 3 below).

For these reasons 'identification' (that is, supplying the name that would be used today to designate these materials) is not always easy. Some minerals are described by Albert in unmistakable terms (e.g. gold, rock crystal); but some had several different names (e.g. opal, pyrite); and some names included several different minerals (e.g. *smaragdus*, many green stones; or *marchasita*, many sulphides with metallic colour and lustre 'from which no metal is ever smelted'). Still other minerals have changed their names, or were in process of changing them in Albert's time (e.g. *chrysolitus* and *topasion*, which were originally topaz and chrysolite, respectively; or *saphirus*, originally lapis lazuli, later sapphire).

In attempting this task I have found the following works useful (full references are given in the Bibliography):

Commentaries and notes on Theophrastus (especially the edition of *On Stones* by Cayley and Richards), and on Pliny (Bailey, *The Elder Pliny's Chapters on Chemical Subjects*, is excellent though it does not include Book XXXVII; Ball, *A Roman Book on Precious Stones*, on Book XXXVII, supplies some information).

Another helpful source is Georgius Agricola: although he lived in the sixteenth century, he was well acquainted with both Pliny's and Albert's works, and tried to systematize the mineralogy of his own time (the Hoover translation of *De re metallica* contains valuable notes; but the Bandy translation of *De natura fossilium* is rather poor).

Among more 'modern' books, Dana's *Textbook of Mineralogy* (revised fourth edition by W. E. Ford, 1932) should be noted, since it includes, and gives the meanings of, many old names. Papers dealing with medieval and later lapidaries have been published by Van der Velde (1941–3) and by Strunz (1952); these offer numerous mineral identifications, though I do not agree with all of them.

In the following lists I have given identifications that seem to me certain, or very probable, or, in some cases, marked by a query (?), at least possible. I have given Albert's Latin names (if he used any), or a translation of the phrases on which my identifications are based.

1. *Minerals*

Albert certainly had not seen all the 'stones' included in his 'lapidary tractate' (II, ii), but his remarks show that he actually knew a good many of them, and for these I have been guided by his descriptions, even when they are at variance with other identifications (e.g. *granatus* as garnet; *topasion* as pyrite). In this list I have omitted most ore minerals, since these are more easily identified in connexion with their metals (see 2 below), but I have included a few things that are not technically 'minerals'—rocks, fossils, sea-shells—because Albert included them in his lapidary.

Agate	II, ii, 1, *agathes*; 8, *hiena* ?
Alabaster (gypsum)	II, ii, 12, *nicomar* (in part); 17, *sarcophagus* (in part)
Almandine	II, ii, 1, *alamandina*
Alum minerals	V, 4, *alumen*
Amber	II, ii, 17, *succinus*; 3, *chryselectrum* (in part); 7, *gagates* (in part) ?; 10, *ligurius* ?
Amethyst	II, ii, 1, *amethystus* (in part)
Arsenopyrite	II, ii, 11; V, 6, *marchasita* (in part)
Asbestus	II, ii, 1, *abeston*; 8, *iscustos*
Balas ruby (spinel)	II, ii, 2, *balagius, palatius*; 3, *carbunculus* (in part)
Barnacle shell	II, ii, 17, *sagda*
Beryl	II, ii, 2, *beryllus*; 4, *diacodos* ?
Biotite (mica)	II, ii, 17, *specularis* (in part)
Borax	II, ii, 12; V, 7, *nitrum* (in part)
Calcite	II, ii, 7, *galaricides*; 17, *samius* ?
Carnelian	II, ii, 3, *corneleus*
Cats-eye	II, ii, 8, *hiena* ?
Chalcanthite	II, ii, 11, *medius*; V, 3, *atramentum*; II, ii, 4, *dyonysia* ?
Chalcedony	II, ii, 3, *chalcedonius*; I, ii, 2, *corneola*
Chalk, see Calcite	
Chrysoberyl	II, ii, 3, *chryselectrum* (in part) ?
Chrysolite (olivine)	II, ii, 3, *chrysolitus*
Chrysoprase	II, ii, 3, *chrysopassus*
Cinnabar	II, ii, 19, *varach* ?

Citrine	II, ii, 3, *chryselectrum* (in part) ?; 18, *topasion* (in part) ?
Clay minerals	II, ii, 16, *ramai, bolus armenicus;* 7, *galaricides* ?; 17, *samius* (in part) ?
Coal	II, ii, 1, *absinthus* ?
Cobaltite, see Arsenopyrite	
Coral	II, ii, 3, *corallus*
Corundum	II, ii, 8, *hyacinthus*; 1, *adamas* (in part) ?; 7, *gelosia* ?
Diamond	II, ii, 1, *adamas* (in part); 7, *gelosia* ?
Dolomite	II, ii, 11, *magnesia, magnosia* ?
Emerald (beryl)	II, ii, 17, *smaragdus* (in part)
Emery (corundum)	II, ii, 3, *smirus*; II, iii, 6, *sabotus*
Fluorite	II, ii, 1, *amethystus* (in part)
Fossil ammonite	II, ii, 4, *draconites* (in part)
Fossil echinoid	II, ii, 3, *cegolites*; 7, *gecolitus*; 8, *judaicus lapis*
Fossil trilobite	II, ii, 2, *borax, crapodina* ?; 12, *nusae* ?
Garnet	II, ii, 7, *granatus*; 3, *carbunculus* (in part)
Geode	II, ii, 5, *echites;* 14, *peranites*
Goslarite	V, 7, *nitrum* (in part)
Halite	V, 2, *sal*
Heliotrope	II, ii, 5, *eliotropia*
Hematite	II, ii, 5, *ematites*; 19, *varach* ?
Jade	II, ii, 8, *jaspis* (in part) ?; 17, *smaragdus* (in part)?
Jet	II, ii, 7, *gagates* (in part); 9, *kacabre*; 17, *succinus* (in part) ?
Lapis lazuli (sodalites)	II, i, 20, *zemech*; 17, *saphirus* (in part)
Magnetite	II, ii, 1, *adamas* (in part); 11, *magnes, magnetes*; 1, *andromanta* ?; 13, *oristes* ?
Malachite	II, ii, 11, *melochites*; 17, *smaragdus* (in part)
Manganite	II, ii, 11, *magnesia, magnosia* ?
Marble	II, ii, 12, *nicomar* (in part); 13, *onyx, onycha* (in part); 17, *sarcophagus* (in part)
Marcasite, see Pyrite	
Melanterite, see Chalcanthite	
Moonstone (feldspar)	II, ii, 17, *silenites* (in part) ?
Muscovite (mica)	II, ii, 17, *specularis* (in part)
Nacre (mother-of-pearl)	II, ii, 3, *celontes*, 17, *silenites* (in part)
Natron, see Borax	
Onyx and onyx marble	II, ii, 13, *onyx, onycha*; 9, *kacamon* ?; I, ii, 2, *onychinus*

Opal	II, ii, 5, *exacontalitus*; 13, *ophthalmus*, *orphanus*; 14, *pantherus*; 8, *hiena* ?; 17, *silenites* (in part) ?
Orpiment	II, ii, 6, *falcones* (in part), *auripigmentum*; V, 5, *auripigmentum*; II, ii, 17, *specularis* (in part) ?
Pearl	II, ii, 11, *margarita*
Peridot (olivine)	II, ii, 14, *perithe* (in part), *peridonius*
Phonolite	II, ii, 3, *calcaphanos* ?
Plasma	I, ii, 2, *prama* ?
Prase	II, ii, 14, *prassius*; I, ii, 2, *prama* ?
Pumice	II, ii, 17, *syrus*
Pyrite	II, ii, 11; V, 6, *marchasita*; II, ii, 3, *chryselectrum* (in part); 5, *epistrites*; 14, *perithe* (in part); 18, *topasion* (in part); 19, *virites*; 1 *andromanta* ?
Pyrolusite, see Manganite	
Quartz pebble	II, ii, 1, *alecterius* ?
Realgar	II, ii, 6; V, 5, *falcones*, *arsenicum* (in part)
Rock crystal	II, ii, 3, *crystallus*; 8, *iris*; 2, *beryllus* (in part); 4, *diamon* ?; *diacodos* ?; 9, *kabrates* ?
Ruby (corundum)	II, ii, 3, *carbunculus* (in part), *rubinus*
Sal ammoniac, see Halite	
Sapphire (corundum)	II, ii, 8, *hyacinthus* (in part); 17, *saphirus* (in part)
Sard	II, ii, 17, *sardinus*
Sardonyx	II, ii, 17, *sardonyx*
Selenite (gypsum)	II, ii, 17, *specularis* (in part); *silenites* (in part) ?
Serpentine	II, ii, 17, *smaragdus* (in part) ?
Smaltite, see Arsenopyrite	
Stibnite, see Pyrite	
Sulphur	IV, 1, *sulphur*
Topaz	II, ii, 18, *topasion* (in part) ?
Tourmaline	II, ii, 10, *ligurius* ?
Trona, see Borax	
Turquoise	II, ii, 18, *turchois*
Zircon	II, ii, 8, *hyacinthus* (in part) ?

2. *Metals, Alloys, and Ores*

Albert knew as metals only the seven traditionally assigned to the seven planets (III, i, 6), and a few alloys of these. Nor did he clearly distinguish metals from their ores, though he sometimes used the word *minerae* for the stuff that is mined, instead of the more usual *mineralia*, minerals in general. Most often, however, he described ore minerals as metals 'incorporated with stone'. Because they do not 'look like' metals, he did not recognize as of any interest such common ores as cassiterite (tin) or sphalerite (zinc—though he knew other zinc minerals used in making brass.)

Antimony, see Tin	
Arsenic	II, ii, 6; V, 5, *arsenicum*, black
Alloy, see Copper	
Ores: orpiment	II, ii, 6; V, 5, *auripigmentum*, yellow
realgar	II, ii, 6; V, 5, *falcones* or *arsenicum*, red
Bismuth, see Tin	
Copper	IV, 6, *aes, cuprum*
Alloys: brass (zinc)	IV, 6, *aurichalcum*
bronze (tin)	IV, 4, the melt for bells
bronze (arsenic)	II, ii, 6; IV, 6, copper made white like silver
Ores: bornite, chalcocite, chalcopyrite, pyrrhotite, &c.	III, 1, 10, copper incorporated with stone, veins of copper
Mansfeld copper slate	III, ii, 5, copper stone
Malachite and other green copper minerals	II, ii, 11, *melochites*; 17, *smaragdus* (in part)
Gold	IV, 7, *aurum*
Alloy: electrum (silver)	V, 9, *electrum*
Ore: native gold	IV, 7; III, 1, 10; III, ii, 6, gold, in sands, in veins
Iron	IV, 8, *ferrum*
Alloy: steel	IV, 8, *chalybs*
Ores: hematite	II, ii, 5, *ematites*
limonite (bog iron)	V, 8; III, i, 10, black grains in watery earth
magnetite or specular hematite	III, i, 10, iron incorporated with stone
magnetite (magnetic)	II, ii, 1, *adamas* (in part); 11, *magnes, magnetes*
Lead	IV, 3, *plumbum*
Ore: galena	III, i, 10, lead incorporated with stone
Mercury	IV, 2, *argentum vivum*
Ores: native mercury, cinnabar	III, i, 10, quicksilver found running out IV, 2, stone from which quicksilver is obtained by heating; II, ii, 19, *varach* ?
Silver	IV, 5, *argentum*
Alloy, see Gold	
Ores: native silver	IV, 5, flexible strings of silver
argentite, argentiferous galena, &c.	III, i, 10; III, ii, 6; IV, 5, silver incorporated with stone, veins of silver
cerargyrite, &c.	III, i, 10; IV, 5, mushy silver

Tin	IV, 4, *stannum*
Alloy, see Copper	
Ore: stannite ? but more probably stibnite, bismuthinite, or native antimony or bismuth	III, i, 10, tin incorporated with stone
Zinc	V, 8, but called tin ?
Alloy, see Copper	
Ores: smithsonite, hemimorphite, &c.	IV, 8, *calamina*
Goslarite	V, 7, but called *nitrum* ?

3. *Rocks*

Albert had no term for 'rock' (see I, ii, 3, introductory note), and his names for different kinds of rock seem to be those used by stonemasons (e.g. marble, *marmor*, for any buildstone that will take a good polish; freestone, *quadrum*, for any that can be quarried in rectangular blocks).

Basalt, see also Flint	I, ii, 2, black stones so hard they cannot be cut, only polished ?
Chalk	I, ii, 4, *creta*, white, soft
Clay	I, ii, 1, *lutum*, *glis*, very sticky
Coal	II, ii, 1, *absinthus* ?
Conglomerate	I, ii, 1, *sabulosus lapis*, gravelly stone; 7, little stones stuck together as if by cement
Flint (and other very hard stones)	I, ii, 3; 4, *silex*, extremely hard
Fossils: in rocks	I, i, 2, holes shaped like moonshells; I, ii, 8, stones containing shapes of animals
in a concretion	II, iii, 1, like a chick in an egg
ammonite	II, ii, 4, *draconites*, snakestone
echinoid	II, ii, 3, *cegolites*; 7, *gecolitus*; 8, *judaicus lapis*, like an olive stone, or acorn.
trilobite	II, ii, 2, *borax*; 12, *nusae*, toadstone ?
Granite	I, ii, 3, marble containing small red bits (feldspars ?) or fragments that shine like metal (micas ?) ?
Gravel	I, i, 3; 8, little stones on the banks and bottoms of rivers; I, ii, 1, *sabulum*
Gypsum (alabaster)	I, i, 6; I, ii, 3, *alabastrum*, a kind of marble, very white; II, ii, 12, *nicomar* (in part); 17, *sarcophagus* (in part)

Marble, see also Gypsum	I, ii, 3; 4, *marmor*, good building stone
Onyx marble	I, i, 3, water descending drop by drop turned into stone (stalactites); I, ii, 3, *guttae*, dripstone of varied colours mixed together; II, ii, 13, *onyx*, *onycha* (in part); II, iii, 1, pictures in marble
Petroleum	II, iii, 6, *naphtha*, *bitumen*
Phonolite	II, ii, 3, *calcaphanos* ?
Porphyry	I, i, 6, *marmor porphyricus*, a kind of marble; I, ii, 3, flesh-red with white spots
Pumice	I, i, 2; I, ii, 3; 6, *pumex*; II, ii, 17, *syrus*, porous, floats on water
Quartz (vein)	III, ii, 6, very hard stone from which fire is struck with steel
Quartzite, see Flint	
Sand	III, i, 10, *arenae*, sands in rivers
Sandstone	I, ii, 1, a stone of very fine gravel; 3; 4, *quadrum*, freestone, good for building
Serpentine	II, ii, 17, *smaragdus* (in part) ?
Shale	I, i, 2, something intermediate between stone and clay, earthy layers in stone
Slate	I, ii, 5, cleaves straight; III, ii, 6, fissile black stone used in building houses
Travertine	I, i, 7, water of rivers or springs turned into stone; 8, divided into drops (pisolite)
Tufa, tuff	I, ii, 3; 4, *tofus*, greyish, soft, porous

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