

TRANSACTIONS  
OF THE  
PHILOLOGICAL SOCIETY,  
1908.

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V. — THE MEANINGS AND SYNONYMS OF  
PLUMBAGO. By JOHN W. EVANS, LL.B., D.Sc.,  
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[*Read at the Meeting of the Philological Society on January 11, 1907.*]

HAVING been consulted by Dr. Murray on the history of the word 'plumbago' in connection with the Oxford Dictionary of the English Language on Historical Principles, I gave some attention to the subject, and my interest carried me further than I had originally intended. The main conclusions at which I arrived will be found in the article on that word in the dictionary, but the limits within which it was necessarily compressed did not permit of the presentation of many of the facts disclosed, and at Dr. Murray's kind suggestion I have communicated the present paper to this Society. I have endeavoured, as far as possible, to exclude matters of purely mineralogical or metallurgical interest, except so far as they have a direct bearing on the subject of the paper, but it will be found that the variations in the use of the words with which I deal reflect in a remarkable manner the changing fortunes of the arts and sciences in the centuries covered by the survey. I have only attempted to follow the history of the word 'plumbago' and its synonyms so far as they relate to minerals or metallurgical products. The botanical aspects of the subject lie beyond my province. I had not completed my investigations when the portion of the dictionary which included the word 'plumbago' went to press, and in some cases I have since found earlier instances of the use of words than those which will be found in its pages.

The subject being most conveniently presented chronologically, I begin with the word 'molybdæna,' whose history was for long intimately connected with that of plumbago, but goes back to a somewhat earlier date.

Molybdæna is the Latinized form of the Greek *μολύβδαινα*, and is

derived from *μόλυβδος*, lead. *Μολύβδαινα* was applied to various things connected with the metal, such as a plummet used to obtain a vertical line, a leaden sinker attached to a net, a bullet for a catapult, and a plant associated in some way with lead. In the mineral sense it appears to have been applied to lead oxide obtained as a bye product in smelting gold and silver ores, as well as to a natural substance with similar properties and of similar composition.

Aristotle (*οβιίτ* v.c. 321) tells us ("De generatione animalium," ii, 2) that molybdæna mixed with water and olive-oil makes a large mass from a small one, solid from liquid, and pale from dark.<sup>1</sup>

Four hundred years later Dioscorides gave a more systematic account of the same substance ("Materia Medica," v, 100):—"The best molybdæna is similar in appearance to litharge, yellow in colour and somewhat lustrous. When ground to an impalpable powder it is pale yellow, and on boiling with olive-oil becomes liver-like in hue. Such as is bluish or lead-like in colour is bad. It is formed from silver and gold. It is also found as a mineral in the neighbourhood of Sebaste and Korykos [both on the coast of Cilicia], and of this [substance] the better is that which has the appearance neither of slag nor of stone, but is yellow and shining. It has a [medicinal] power similar to that of litharge and lead slag."<sup>2</sup> In the same treatise (v, 95) he states that some use molybdæna instead of lead filings in preparing lead lotion.<sup>3</sup>

There can be little doubt that *μολύβδαινα*, *σκωρία μολύβδου*, and *λιθάργυρος* are all varieties of lead oxide produced by the smelting of lead and silver ore and the cupelling of argentiferous lead, but it is not apparent what was the exact difference in the application of these terms. The normal lead oxide (Pb O) is yellow or yellowish red, but lead slag is often bluish or greyish black from the presence of a lower oxide of lead or of impurities. It has been employed from time immemorial in the manufacture of lead plaster by boiling

<sup>1</sup> Καὶ ἡ μολύβδαινα μινυμένη ὕδατι, ἢ καὶ ἐλαίῳ, ἐξ ὀλίγου τε πολὺν ὄγκον ποιεῖ καὶ ἐξ ὕγρου στιφρὸν καὶ ἐκ μέλανος λευκόν.

<sup>2</sup> Μολύβδαινα δὲ ἀρίστη ἐστὶν ἡ λιθαργυροφανῆς, ξανθὴ, ὑποστίλβουσα καὶ κιβρὰ ἐν τῷ λειοτριβεῖσθαι, ἐψηθεῖσά τε ἐλαίῳ ἡπατοειδῆς τῷ χρώματι γίνεται· ἢ δὲ ἀερίζουσα ἢ μολυβδόχρους φαύλη· γεννᾶται δὲ ἐξ ἀργύρου καὶ χρυσοῦ· ἔστι δὲ τις καὶ ὀρυκτὴ κατὰ Σεβαστὴν καὶ Κώρυκον εὐρισκομένη· καὶ ταύτης ἐστὶ βελτίων ἢ μὴ σκωριοειδῆς, μὴδὲ λιθώδης, ξανθὴ δὲ καὶ στίλβουσα· δύναμιν δὲ ἔχει ὁμοίαν λιθαργύρῳ καὶ σκωρίᾳ μολύβδου.

<sup>3</sup> Ἐνίοι δὲ προσεμβάλλουσι τοῖς βινίσμασιν ὀλίγην μολύβδαιναν.

with olive-oil and water, oleate of lead and glycerine being formed. The thickening and increase in volume in the process might give some justification for Aristotle's statement. Apparently he applied the term *μολύβδαινα* to an impure variety of the oxide which produced a dark mixture. This would become lighter as the reaction proceeded, for the oleate is, at least at first, light yellow in colour, and by its increase in bulk would mask any impurities which were present.

The 'natural' *μολύβδαινα* probably comprised various 'oxidized' ores of lead, such as the oxide, carbonate, sulphate, phosphate, and the light-yellow molybdate known as wulfenite. Even the carbonate and sulphate, which are properly white, are often yellowish from the presence of hydrate of iron.

The inferior varieties may have included more or less undecomposed lead sulphide, the modern galena, but pure specimens of that mineral were probably represented by the *μολυβδοειδής λίθος* of Dioscorides.<sup>1</sup>

Galen, who lived a century later (*obit* A.D. 200) than Dioscorides, appears to have used the word *μολύβδαινα* in a similar sense. In his "De succedaneis" he gives litharge as a substitute for *μολύβδαινα*,<sup>2</sup> and in his "De simplicium medicamentorum temperamentis," ix, 3. 22, he states that *μολύβδαινα* has an effect similar to that of litharge, that both are soluble, not insoluble like stones, calamine, and sand, but that the solution is most rapid when vinegar is associated with oil, though it also takes place on long boiling with water [and presumably oil]. He saw *μολύβδαινα* scattered about with numerous other stones on the road that leads from Pergamon to Ergasteria, a village, where there were mines, between Kyzikos and Pergamon, 440 stadia from the latter.<sup>3</sup>

<sup>1</sup> It has been contended that this was graphite (*post*, pp. 149-54), but that it was a lead ore is probable from the statement that its therapeutic properties were the same as those of litharge. It has also been suggested (by Gimma, "Fisica Sotteranea," Naples, 1730, ii, p. 131) that the *τετράγωνος* of Hippocrates ("De internalibus affectionibus," cap. 45 and 49, ed. Littre, 1851, vol. vii, pp. 278, 290) was galena, but there is no evidence in favour of this view.

<sup>2</sup> Ἄντι μολυβδαίνης λιθαργυρον.

<sup>3</sup> Μολύβδαινα λιθαργύρη παραπλησίαν ἔχει δύναμιν, . . . ἔστι δ' ἄμφω τὰ φάρμακα τηκτὰ καὶ οὐχ ὥσπερ οἱ λίθοι καὶ ἡ καθμεία καὶ ἡ ψάμμος ἀτηκτα. ταχίστη δ' αὐτῶν ἡ τήξις γίνεται προσλαβόντος ὕδρου τοῦ ἐλαίου. τήκεται γὰρ μὴν καὶ εἰ ὕδωρ μίξας ἐπὶ πλείστον ἐψήσας. . . . μολύβδαιναν, ἐρβύμμενην παμπάλλοις ἅμα τοῖς ἄλλοις λίθοις ἐθεασάμην κατὰ τὴν εἰς Ἔργαστήρια φέρουσαν ὁδὸν ἀπὸ Περγάμου. καλεῖται δ' Ἐργαστήρια κώμη τις, ἐν ᾗ καὶ μέταλλά ἐστι, μεταξὺ Περγάμου καὶ Κυζίκου, σταδίου ἀπέχουσα Περγάμου τετρακοσίου τεσσαράκοντα.

In his "De compositione medicamentorum per genera" (i, 11) he states that *μολύβδαινα* can always be substituted for litharge, but it makes the colour of the product darker.<sup>1</sup> It is therefore probable that it was a darker, less pure variety. It cannot have been the hard metallic sulphide, for in his "De succedaneis" he says that it may be used as a substitute for 'soft' or 'vine' earth.<sup>2</sup>

Paulus Ægineta (vii, 3), who probably lived in the sixth century A.D., appears to employ *μολύβδαινα* in the same sense as Galen and his predecessors.

In the "Historia Naturalis" of the younger Pliny we find passages closely similar to those which I have extracted from the writings of Dioscorides, who was a contemporary, if the date usually assigned to him be correct. It is probable that Pliny took them from the Greek author, though, it may be, they both borrowed from the same source.

As a general rule we find the word *μολύβδαινα*, when used for a mineral or a metallurgical product, simply transliterated into the Latin form 'molybdæna': "Est et molybdæna, quam alio loco galenam appellavimus, vena argenti plumbique communis. melior hæc quanto magis aurei coloris, quantoque minus plumbosa, friabilis et modice gravis. cocta cum oleo iocineris colorem trahit. adhærescit et auri argentique fornacibus. hanc metallicam vocant. laudatissima quæ Zephyrio<sup>3</sup> fiat. probantur minime terrenæ minimeque lapidosæ" (xxxiv (18), 53).

Elsewhere Pliny describes molybdæna as one variety of spuma argenti, viz., litharge obtained in the smelting of silver: "Quidam duo genera faciunt spumæ quæ vocant scirerytida et peumenen, tertium molybdænam in plumbo dicendam" (xxxiii (6), 35).

However, in the passage (xxxiv (18), 50) corresponding to the other quotation from Dioscorides (v, 95) Pliny uses the word plumbago instead of molybdæna: "quidam limatum plumbum sic terunt, quidam et plumbaginem admiscent."

<sup>1</sup> Πάντα γὰρ ὅσα διὰ λιθαργύρου συντίθενται καὶ διὰ μολυβδαίνης δύναται σκευάζεσθαι. . . . πρὸς δὲ τὰς χροὰς τῶν φαρμάκων, ὅσα δι' αὐτῶν σκευάζεται, διαφορὰ τις αὐτῆς ἐστὶ, καθόσον ἐπὶ τὸ φαϊότερον ἔχει τὰς χροὰς ἢ μολύβδαινα.

<sup>2</sup> Ἀντὶ γῆς ἀπαλῆς ἢ ἀμπελίτιδος μολύβδαινα. This γῆ ἀμπελίτις seems to have been a kind of bituminous earth applied to vines attacked by injurious insects (Dioscorides, op. cit., v, 180, and Pliny, "Hist. Nat.," xxxv (16), 56). The French have applied the term 'ampélite' to a soft carbonaceous or bituminous shale, which was sometimes employed for drawing, and known as 'crayon des charpentiers.' See P. Pomet, "Hist. Gen. des Drogues," 1694, iii, p. 87; Dezallier D'Argenville, "L'Histoire Naturelle," Paris, 1742, p. 70, modern French dictionaries, and *post*, pp. 150, 152, 155, 166.

<sup>3</sup> Zephyrium is in Cilicia close to the localities mentioned by Dioscorides.

Elsewhere Pliny uses a third word, galena, both for the native mineral and the furnace product: "Plumbi nigri origo duplex est, aut enim sua provenit vena nec quicquam aliud ex sese parit, aut cum argento nascitur, mixtisque venis conflatur. hujus qui primus fluit in fornacibus liquor stagnum appellatur, qui secundus argentum, quod remansit in fornacibus galena, quæ fit tertia portio additæ venæ. hæc rursus conflata dat nigrum plumbum, deductis partibus non [probably a mistake for 'nonis'] duabus" (xxxiv (16), 47).

'Plumbum nigrum' is lead as opposed to 'plumbum candidum,' or tin. 'Stagnum' or 'stannum' appears to be the alloy of lead and silver first obtained. The lead of this alloy was then converted into slag or 'galena,' also known as 'molybdæna' or 'plumbago.' This was again smelted, and the third product, pure lead, equal in amount to seven-ninths of the slag, was obtained.<sup>1</sup>

Elsewhere, speaking of silver ore, Pliny tells us: "excoqui non potest, nisi cum plumbo nigro aut cum vena plumbi, galenam vocant, quæ juxta argenti venis plerumque reperitur" (xxxiii (6), 31).

In modern times lead is mainly obtained from the sulphide, but in the shallower mines of ancient times the oxidized ores which are found near the surface must have been largely worked, as they are now in uncivilized countries, and the word 'galena,' when used for the mineral, appears, like molybdæna and plumbago, to have primarily signified these oxidized products, though it may have included the sulphide as an inferior variety.

'Plumbago' is only once used in the "Historia Naturalis" in the sense of a mineral product, but it is elsewhere employed in other senses, twice as the Latin equivalent of the plant *μολύβδαινα* (xxv (13), 97; xxix (4), 26), and twice for a lead-like hue in the *zmaragdus*, which diminished its value (xxxvii (5), 18).

The words molybdæna and plumbago do not occur in any other classical Latin author.

In spite of the fact that plumbago is only once used in the sense of a kind of litharge also denoted by the words molybdæna and galena, I am inclined to believe that this was its earliest meaning. Just as ferrugo means the rust of iron and ærugo that of copper,

<sup>1</sup> This is substantially the explanation given by Johann Beckmann, "Beiträge zur Geschichte der Erfindungen," vol. iv, Leipzig, 1797, p. 331; "History of Inventions and Discoveries," vol. iv, London, 1814, p. 11.

so plumbago originally meant the product obtained by the corrosion of lead when heated.

The derivation of the word 'galena,' which is also confined to the pages of Pliny among ancient authors, is very obscure. The writers of the renaissance (*post*, pp. 140-2, 144, 146) believed that it was of Spanish origin, and the fact that Pliny, who used it, obtained much of his information on metallurgical matters in connection with lead and silver from Spain (see for instance xxxiii (6), 31), lends some countenance to the suggestion. The derivations which have been proposed from the Greek *γαλήνη*, a calm, and *γελέω* or *γελάω*, I laugh or shine, do not seem very probable. If it be Latin or Greek, or derived from an allied Aryan idiom, it may be akin to the English 'cloam' and the old Slavonic *glina* (see the Oxford Dictionary, under 'clay' and 'cloam'). It would then have originally meant any yellowish earthy material, and only secondarily that from which lead was obtained.

I have been unable to find a reference to any of the words plumbago, molybdæna, or galena in the writings of the Middle Ages earlier than the "Bibliotheca Mundi" of Vincentius Bellovacensis (A.D. 1190 to 1260), who repeats the statement of Pliny that molybdæna is a third genus of Spuma argenti or litharge.

A fuller reference to the same word is found in the "Pandects," or Dictionary of Medicine, of Matthæus Silvaticus (*obit* 1340), Physician to Robert, King of Sicily, first printed in 1474. Here (ccccliiii) we read "Molibdena .i. plumbum ustum et stercus plumbi sed Dyas. cap. molibdena dicit quod est quasi stercus auri vel argenti," etc. The quotation is, however, not from Dioscorides himself, but from an alphabetical compilation founded on his writings, which appears to have been current in Italy during the later Middle Ages. This was printed in 1478, in black letter with marginal comments, apparently of later date than the text, at Colle (probably the town of that name near Florence). It purports to have been edited and corrected by Petrus of Padua, but whether from the carelessness of the editor or the defective state of the manuscript there are numerous blunders.<sup>1</sup> It reads "Molipdina est quasi stercus auri et argenti," and continues in the same words (except for evident mistakes) as the quotation

<sup>1</sup> The colophon reads: "Explic̃ dyascorides quē petrus paduanēsis legendo corexit et exponendo q̃ utiliora sūt ī lucem deduxit. Impressus Colle p- magistrum joh'm allemanum de medemblick. anno xp̃i millesimo. cccc°.lxxviii°. mense iulii."

by Silvaticus. In the margin we read "molebdina planta est latine dicta plumbago."<sup>1</sup>

The first Latin translation of Dioscorides to appear in print was probably that of Hermolaus Barbarus, well known for his Latin abridgement of Aristotle. The earliest edition in the library of the British Museum is believed to have been printed at Venice in 1516. It is accompanied by "Annotamenta" by Joannes Baptista Egnatius, "in usum etiam mediocriter eruditorum," and followed by "Corollarii," by Hermolaus Barbarus, "libri quinque non ante impressi." In the principal paragraph already cited (v, 100; paragraph 935 of this edition) 'molibdæna' appears both in the heading and the translation, while in that (v, 95; 930) corresponding to the passage in which Pliny uses the word plumbago (xxxiv (18), 50) we find "molybdænam hoc est plumbaginem." In the "Corollarii" (paragraph 936)<sup>2</sup> we read with reference to the former paragraph of the text: "Molybdæna hoc est plumbago, quam et Galenam vocamus: communis est plumbi, et argenti vena. . . . Sunt qui molibdænam inter spumas argenti collocent. Fossilis Molibdæna est et ad vicum Ergasteriam. . . . Nominatur, et Molibdæna, id est Plumbago, herba Plinio," etc.

In the same year a translation by Joannes Ruellius appeared at Paris. In paragraph v, 91 (= v, 100 *supra*), the heading is "De molibdæna seu plumbagine," while in the text only 'molybdæna' is used. In paragraph v, 86 (= v, 95 *supra*), 'plumbago' is employed instead, exactly as in the parallel passage in Pliny.

A later translation and commentaries by Marcellus Virgilius, "Secretarius Florentinus," were printed with the Greek original at Cologne in 1529.<sup>3</sup> Here in paragraph v, 54 (= v, 100), we have the heading: "De plumbagine metallica" followed by "Molybdænam (Romani plumbaginem dicunt)." The translation

<sup>1</sup> I had concluded from internal evidence that this book (which is usually described as a translation of Dioscorides) was printed from a manuscript version of much earlier date, before I discovered that it was quoted by Silvaticus, who appears to have been under the impression that it was the actual work of Dioscorides, though it includes materials from other sources. It must have been compiled long before Silvaticus wrote, and is quite distinct from a brief abstract of Dioscorides in Greek by Stephanus, arranged alphabetically by diseases, a Latin translation of which was published in 1581.

<sup>2</sup> The paragraphs in the "Corollarii" do not exactly correspond with those in the text.

<sup>3</sup> Another edition of the translation by Ruellius appeared at Strasburg in the same year. It contains the commentaries of Marcellus Virgilius as well as the corollaries of Hermolaus Barbarus.

follows, in which plumbago is used throughout, as it is also in paragraph v, 50 (= v, 95). In the commentary we are told: "Galenam bis terve . . . Græcorum metallicam molybdænam Plinius vocavit: non tam ut a molybdæna plumbagineque sui generis herba, . . . appellatione secerneret, quam quia scribente eo suam historiam, hæc erat privatim metallicæ plumbaginis appellatio, ab Hispaniæ Galecia ut credimus facta, in qua celeberrimæ quondam metallorum fere omnium fodinæ fuerunt. Quæ quoniam nostra ætate nulla est, nec habet ea vox aliquam nunc significationis æstimationem, impune et sine invidia relicta a nobis fuit, præsertim in re quæ ex substantia sua certius indicanda erat. Plumbago ob eam causam molibdæna hæc dicta: et ne cum herba misceretur, ex metallo nota illi adjecta est."

We therefore find the word 'plumbago' recognized in the early part of the sixteenth century as the Latin equivalent of *μολύβδαινα*, not only in the botanical but also in the mineral sense, although Pliny had used by preference molybdæna or galena.

The use of these words were discussed at length in the "Bermannus sive de re metallica" of Georgius Agricola, first published at Basle in 1530.<sup>1</sup> A preface by Erasmus (missing in the British Museum copy) was at first undated, but in the edition of 1546 bears the date of 1529. This short work forms an introduction to the study of mineralogy and metallurgy, and is cast in the form of a dialogue. It is remarkable for shrewd good sense and an incisive style. The author argues (pp. 41-4) at some length that the natural mineral substance referred to by Pliny as galena, molybdæna, and plumbago was the mineral principally worked for lead at the time he (Agricola) wrote, viz., the lustrous black sulphide of lead, the galena of modern mineralogy.

"Bermannus:—In his omnibus argenti materia est, atque hic primum vides Galenam sive plumbaginem. Nævius:—Estne hæc plumbago quam Plinius *μολύβδαινα* [*sic*] etiam vocat? Bermannus:—Ita sentio. . . . Colore plumbi, ut videtis, est, atque ob id Græcis *μολύβδαινα*, Latinis plumbaginem dictam arbitror, nisi quis iccerco potius, quod ipsum etiam pro me facit, sic dictam velit, quod ex ea plumbum fiat."

He thought, as I believe correctly, that this lead-coloured mineral was the *λίθος μολυβδοειδής* of Dioscorides (v, 98), which

<sup>1</sup> F. L. Becher ("Die Mineralogen," Freiberg, 1819), however, states that it was issued in 1518 (p. 15) or 1528 (p. 21).

he translates by 'lapis plumbarius,' and states that it differs from "Molybdæna nativa ipsius Dioscorides magis colore quam materia"<sup>1</sup> (p. 45).

The 'molybdæna' found in the furnace had, on the other hand, Agricola admits, different physical characters (p. 43).

He discusses the derivation of the word 'galena,' remarking: "Galena sive Hispanicum, sive alterius gentis vocabulum sit, nihil moror: nam nostrum non esse hinc perspicuum puto, quod serius metalla fodi cœpisse in Germania constet: id certe nostri imitati, eandem rem similiter, ultimis tantum modo literis mutatis, appellarunt," referring apparently to the word 'Glantz.' It is possible, of course, that German miners may have converted a foreign word into one with a similar sound that was already familiar to them. He strongly condemns the suggestion that galena itself was derived from Galicia in Spain, pointing out that Pliny states that only tin, 'plumbum candidum,' is found there. As a matter of fact lead ore does occur in Galicia, but there seems no real evidence in favour of the derivation suggested.

He also speaks (p. 42) of a sterile variety of galena—"Aliud præterea genus Galenæ est, huic, quod jam vobis ostendi, colore nihil dissimile, sed prorsus sterile et ita subtile ut totum violentia ignis consumatur, ac per fumum evaporet."

The book concludes with an appendix, "Rerum metallicarum appellationes . . . autore Plateano," where we read "Galena sive Molybdæna—glantz und blyertz, auch blyschueiff<sup>2</sup>."

In his treatise "De natura fossilium," ed. 1546, p. 366, he adheres to the views expressed in his earlier work, remarking on the question of the derivation of galena, "Quod vocabulum utrum Hispaniense sit, an alterius gentis et linguæ, si Hispani nesciunt, nemo, ut opinor, poterit scire."

<sup>1</sup> In a small treatise published in 1566, entitled "De metallicis rebus ac nominibus observationes variæ et eruditæ, ex schedis Georgii Fabricii: quibus ea potissimum explicantur, quæ Georgius Agricola præterit," we read (p. 19b): "Differunt lapis plumbarius, et plumbago. hæc enim pura est, quam Hispani galenam nominarunt"; and (p. 21b) "Plumbago. Glantz, oder gedigen Bley." "Lapis Plumbarius. Bleyertz."

<sup>2</sup> Bleischweif was granular or fibrous galena. See *post*, pp. 144, 160, 163, 168. It appears also to have been applied to some sterile mineral of a lead-like appearance, possibly graphite. "Bleyschweif ist eine leere Berg-art, so das Ansehen hat, als wäre es gediegen Bley" (Christianus Berwardus, "Interpres Phraseologiæ Metallurgiæ," Franckfurt am Mayn, 1684; also "Erklärung derer Bergmännischen Wörter und Red-Arten," which forms an appendix to the *Institutiones Metallicæ* of G. C. Kirschmaier, Wittenberg, 1687, and other vocabularies; see also p. 29).

In his "Rerum metallicarum interpretatio" (1546) we find the following definitions: "Galena—Glantz unnd pleiertz"; "Galena inanis—Blende"; "Molibdæna, idem quod plumbago"; "Plumbago metallica—Pleiertz, pleischweis" (a misprint for 'pleischweif'); "Plumbago fornacum—Herdplei"; "Plumbarius lapis—Glantz."

It is not clear whether galena sterilis and galena inanis are the same. Blende meant originally any mineral with a deceptive appearance, but at the present time, when used without qualification, it means zinc-blende and galena inanis has therefore been identified with that mineral.<sup>1</sup> Agricola was, however, too careful an observer to assert that the colour of zinc-blende was "nihil dissimilis" to that of galena. There are several minerals which might be converted into volatile products in the furnace, and bear a closer resemblance to galena than zinc-blende. Some of these, such as stibnite (sulphide of antimony) and bismuthine (sulphide of bismuth), were well known to Agricola as distinct minerals. There only remain graphite, the black lead of our pencils, a crystalline form of carbon, and molybdenite, a sulphide of molybdenum, which present great resemblance to each other, and certain rare minerals containing tellurium. There can be little doubt that graphite was the substance mainly referred to as galena sterilis.<sup>2</sup>

Christophorus Encelius Salueldensis (Entzelt of Saalfeld), in his "De re metallica," Frankfort, 1551, i, 34, pp. 66–9, also contends that plumbago, galena, and molybdæna are identical with Glantz, the modern galena. "Ergo nostra plumbago unser glantz, est galena, et molybdæna." "Nam quod Plinius . . . aut Hispani galenam vocant, nos jam glantz dicimus." He too condemns the derivation from Galicia. He suggests as a distinction between molybdæna and galena, that the latter should be employed for lead ore containing silver, and the former for ore free from that metal. After referring to the different colours of lead ores, he says: "A Germanis omnes hæ species dicuntur generali nomine, bleiertz, glantz a splendore, bleischweyff etc." His frequent use of the term 'nostra plumbago' seems to imply that it was in his time the ordinary Latin expression in Germany for lead ore. He characterizes the 'sterile' variety as "nullius momenti, colore non

<sup>1</sup> J. H. Pott, "Dissert. Chimiques," vol. iii, 1759, p. 560; Dana's "Mineralogy," 6th ed., 1892, p. 59; and Hintze, "Handbuch der Mineralogie," vol. i, 1905, pp. 466, 557, but see *post*, pp. 146, 155, 156.

<sup>2</sup> See also *post*, pp. 156, 159, 161.

absimilis frugiferæ, sed prorsus est sterilis, et totam vis ignium consumit.”

The endeavour to follow the steps by which these words or their derivative forms became introduced into the modern languages of Europe and the variations in their meaning presents some difficulty on account of the widely extended use of Latin in writings on scientific and even technical subjects. Latin was in fact a practical means of expression, independent of nationality, and lucidity and accuracy were considered of more importance than a Ciceronian style.

The earliest vernacular publication which is of interest for our present purpose is a translation of Dioscorides into Italian, printed in Venice in 1542. Here (v, 95 = v, 100) we have the heading “De la piombaggine” followed by “Molibdena (Romani plumbagine)”; piombaggine (in one place spelt biombaggine) is used in both passages. In another translation by Marcantonio Montigiano, printed at Florence in 1547, the corresponding heading (v, 54 = v, 100) is “Della vena di Piombo cio è Piombaggine,” and both terms are employed in the text.

In a third translation into Italian by Pier Andrea Mattioli of Siena, with a commentary by the same author, printed at Venice in the following year, the paragraph describing molybdæna (v, 59 = v, 100) is headed “Della Molibdena, overo Piombaggine,” but molibdena alone is used in the text, though in the earlier passage (v, 54 = v, 95) piombaggine is substituted, as plumbago is in Pliny. This translation and commentary proved very popular, and were translated into Latin and French. The later editions owe much to the writings of Georgius Agricola.

The first French edition was an abbreviation published in 1553, under the title “Les six livres de Pedacion Dioscoride d’Anazarbe de la matiere medicinale, translatez de latin en Francois”; “y adioustant,” we are told later, “quelques petites annotations (sachant tres bien le naturel de la nation Francoise, s’estudier et complaire à breveté) extraict du battu à tout marteau l’entier commentaire du S. André Pierre Matthioli Medecin Senois.” Here under the heading “De la Plombagine que les Grecs appellent molyfdena: les Latins Plombago, les Italiens: Piombagine” (v, 50 = v, 100) we read: “Et par ainsi la Plombagine n’est autre chose, que la Litharge ramassée depuis le couler des minieres comme un liect en la fournaise. La Plombagine minerale, n’est autre chose que la vene, qui tient l’Argent, et le Plomb par

ensemble." This is, so far as I know, the first recorded use of plumbagine in French, though the word may no doubt be older. A complete French edition appeared in 1572.

There is a rather earlier use of molybdæna in French in the "Epitome des trois premiers livres de Galien" (1549), by M. Gregoire, where we find in book i (p. 167 of the edition of 1552), under the heading "Des Medicamens qui se font de Molybdæna," "La Litarge et Molybdæna sont presque appliquez à mesme usage."

A Spanish translation of Dioscorides and a commentary by Doctor Andres de Laguna were printed at Salamanca in 1566. Under the heading "De la Molibdena" we find: "Griego Μολιβδαίνα. Lat. Molybdæna, et Galena. Molibdos en Griego significa el Plomo de do tomo el nombre la molibdena, . . . la qual no diffiere de la Galena tan celebrada" (book v, paragraph 59). This reference to the celebrity of galena is not easy to understand, but it indicates that the word was well known in Spain in spite of the fact that it appears in a list of 'nombres latinos' at the end of the book, while molibdena is found in a similar list of 'nombres castellanos.'

Dioscorides was not translated into German, but we find the same words explained in the "Sarepta" of Johann Mathesius, the friend and biographer of Luther. This curious blend of mining, metallurgy, and theology appears to have been originally delivered in the form of sermons to the mining population of Joachimsthal. The preface is dated in 1562, and the book is stated to have been issued in that year, but the earliest edition which I have seen was printed at Nuremberg in 1571, after the author's death in 1565. Here Glantz and galena are employed for argentiferous galena, and Bleischweiff and plumbago for an ore of sulphur and lead. Molybdæna, on the other hand, is used in the sense of litharge.<sup>1</sup>

In the "Meisznische Bergk Chronica," by Petrus Albinus, Dresden, 1590, we find (p. 133) the form plumbagine: "Item es henget auch oft an der plumbagine, ein viride, welches viel Bley

<sup>1</sup> "Glantz, welches die Lateiner Galenam nennen, is ein glauch oder gliu Metall, bricht gern auff silbergengen, helt oft blei unnd silber . . . Bleischweiff oder plumbago ist ein gelblicht metall, voller schwebels, darumb es von bley und schwefel den namen haben soll, oder das es des ganges schweiff ist, Disz helt oft bley und silber" ("Die neunnde Predigt," p. 101b). "Etlich pley versincket in den luckern herd, oder trencket sich drein, disz nennen die gelerten Molybdenam" ("Die dreyzehende Predigt," p. 149b).

gibt." 'Viride' may be pyromorphite and mimetite (phosphate and arseniate of lead with some chloride or fluoride), which are often greenish in colour.

It was not till the publication in 1601 of the translation by Philemon Holland of the "Historia Naturalis" of Pliny that we find any of the words we have been considering used in English. In this translation the words galena and molybdæna are retained throughout. Thus in vol. ii, p. 472, we read: "This minerall or mettall they call Galena," with a marginal note "or Molybdæna"; on p. 474, "As for the third, named Molybdæna, they reckon as a thing by itselfe; to be treated of in the discourse or chapter of Lead"; on p. 517, "As for the third part of the veine which remaineth behind in the furnace, it is Galæna, that is to say, the verie mettall it selfe of lead." The heading of chapter 18, p. 518, includes "of the veine of Lead called Molybdæna or Galena." See also p. 520. When *plumbago* is used in the Latin original for the plant (pp. 236, 359) or for a lead-coloured tinge in the *zmaragdus* (p. 612), it is translated by the same word.<sup>1</sup> On the other hand, when it is employed as a synonym for the mineral molybdæna (p. 519), it is merely rendered by "some lead ore."

'Plombagine,' however, is used both for the natural and artificial mineral product in Cotgrave's French and English Dictionary published in 1611. "Plombagine: f. Pure lead turned almost into ashes by the vehemence of the fire: This is the artificiaall Plombagine, and comes of lead put into a furnace with gold, or silver oare, to make them melt the sooner; (by which employment it gaines some part in the worth of those metallis;) there is also a naturall, or minerall Plombagine, which (as Mathiolus thinketh), is no other then silver mingled with lead-stone, or oare."<sup>2</sup> "Molibdene as plombagine; also the herb leadwort."

Six years later, in the "Surgion's Mate," by John Woodall, printed in London in 1617, we find (p. 113) under the heading

<sup>1</sup> On p. 612, however, it is also rendered by "congealed specks resembling . . . spots of lead."

<sup>2</sup> Cotgrave's explanation is reproduced in the *Glossographia* of Thomas Blount (1656 and 1674) under 'plumbagin.' The definition by E. Phillips in his "New World of English Words," 1658 and later editions, "silver mingled with lead stone, or oar," and that of N. Bailey in his "Universal Etymological English Dictionary," 1721 and later editions, "Lead naturally mingled with Silver," are evidently derived from this source. I am indebted for these and a number of other references to Dr. Murray.

“Minium”: “Plumbago, or red leade, hath the force of binding, mollifying, filling up hollow ulcers with flesh.” This is the only instance, so far as I know, in which ‘plumbago’ is used for minium, the red oxide of lead (PbO), which was in ancient and mediæval times sometimes confounded with cinnabar, the red sulphide of mercury, but never with litharge. The mistake may have arisen from the statement by Johannes Gorraeus (Jean des Gorris) the elder in his “Definitionum Medicorum Libri 24,” first published in 1564 at Paris, that *μολίβδαυα*, or plumbago, was made from boiling lead—“Est medicamentum metallicum ex plumbo fervescente factum” (p. 300, ed. 1578). According to the manner in which the operation is carried out either litharge or minium may be obtained.<sup>1</sup>

In 1565 appeared a volume of tracts on minerals, rocks, and cognate matters, mostly by Conrad Gesner of Zürich. One of these, entitled “De omni rerum fossilium genere,” appears to be a catalogue of a collection of minerals, metallurgical products, and fossils, which must have been very complete for the time. The Latin and German names for the specimens are given, and appear in some cases at least to be derived from Entzelt.

Among the entries are the following (p. 74 and following pages):—“Molybdæna vel plumbago metallica. Hartblei under ofenbruch” . . . Under the heading “Plumbago”:—“Plumbago metallica vel nativa, verbo Hispanico Galena, id est, vena plumbi et argenti communis. Glantz.” “Plumbago simplex quæ nihil nisi plumbum in se continet. Reiner glantz, der nichts dann bley helt.” “Tessellata in lapide calcæreo. Würfflichter glantz in weissem kalchstein.” This is crystallized galena in the modern sense.

Under “Plumbago sterilis” are a number of entries, which show that the term was very loosely employed, at any rate by this author; they include the following:—

“Plumbago sterilis pici similis. Bech blende.” This is pitchblende, at present the principal source of uranium and radium. It is the earliest known mention of the mineral. Pitchblende would not be volatilized in an ordinary furnace, so it cannot be the galena sterilis of Agricola. “Flava nitens, Scharfenbergia prope Misenam. Licht gelbe blende.” Probably a variety of zinc-blende. “Sterilis galenæ similis. Glantz blende.” Probably

<sup>1</sup> See also *post*, p. 168.

graphite or molybdenite. "Sterilis venæ cupri similis. Kupffer blende." Perhaps kupfernichel, an arsenide of nickel.

In the "De rerum fossilium, lapidum et gemmarum maxime, figuris et similitudinibus Liber," published in the same volume, we find (p. 104) one of the earliest references to graphite and its use for pencils: "Stylus inferius depictus, ad scribendum factus est, plumbi eujusdam (factitii puto, quod aliquos stimmi [antimony] Anglicum vocare audio) genere, in mucronem derasi, in manubrium ligneum inserto." A drawing shows the black lead fixed into one end of the handle.<sup>1</sup>

The flaky graphite of Bavaria had been worked from prehistoric times for mixing with clay to form pottery, and the Passau or Ips<sup>2</sup> crucibles, in which this material was employed, were widely used, but it does not seem to have been employed for writing so early as that from the Borrowdale mine, near Keswick, in Cumberland, which was for some three centuries the principal source of supply of the mineral for this purpose.

Metallic lead and silver were used both in ancient and mediæval times for drawing lines. Subsequently in the early renaissance an alloy of two parts of lead and one of tin, known as "lo stile del piombo" or "lapis piombino," was employed for drawing.<sup>3</sup> These terms were probably transferred to graphite when it came into use. Gesner appears to have had this alloy in mind when he wrote, but the name "stimmi anglicum" shows that it was in fact Borrowdale graphite.

In the "Sarepta" of Mathesius, from which I have already quoted, we read (Predigt ix, p. 103b): "Wie man hernach mit silbern stefften auff die hültzern weissen plancketen oder tefelein, oder mit bleyenen auff die gefirnten pergamenenen und mit dinten auff die Eselsheute, und jetzt auff schiferne tafeln mit schiferstein oder auffs papir mit einem newen unnd selbwachsenen metall zuschreiben pfliget."

<sup>1</sup> Pencils of the modern type do not appear to have been introduced till about a century later. See note, p. 155.

<sup>2</sup> See G. Agricola, "De natura fossilium," vol. ii, ed. 1546, p. 197; J. H. G. von Justi, "Grundriss des gesamten Mineralreiches," 1757, p. 213; Beckmann, op. cit., vol. v, 1803, p. 245; vol. iv, 1814, p. 353.

<sup>3</sup> Beckmann, op. cit., vol. v, 1803, pp. 237, 250; vol. iv, 1814, pp. 347, 356; "Anthologia Græca Palatina," vi, 67 and 68; Pliny, "Hist. Nat.," xxxiii (3), 19, and (6), 31. Liddell & Scott, on the other hand, under *μόλυβδος*, suggest that in one of the passages from the "Anthologia" that word is used in the sense of graphite (black lead). There seems, however, no evidence of this. They also quote authority for the use of '*μόλυβδος*' as a test for gold, and believe that here also graphite is referred to. This is, however, most improbable.

This new and self-grown metal that was used for writing on paper can scarcely have been anything else than graphite.<sup>1</sup>

A few years later we find mention of graphite in English books under the name of 'black lead.' In the "Jewell House of Art and Nature, containing divers rare and profitable Inventions," by Hugh Platte, 1583, we read: "upon the which you may trick, either with a fine pointed cole, blacke lead or pen"; "and drawe thereon with blacke lead" (p. 39, ed. 1594).

In the second edition, published in 1587 (but not the first, published in 1586), of Camden's "Britannia," there is (p. 523) the following reference to the Borrowdale mine: "Hic etiam passim reperitur terra illa metallica, sive saxum induratum et micans, nobis Black Leade dictum, quo ad ducendas lineas, et monochromata pictores utuntur. Quod an sit Dioscoridis Pnigitis, vel Melantheria,<sup>2</sup> vel ochra terra calore in nigrum adusta, aut veteribus incognitum, non facile dixerim, et perquirant alii." This passage is literally translated in the first English edition of Camden, published in 1610 (p. 767). "Heere also is commonly found that minerall kind of earth or hardned glittering stone (we call it Black-lead),<sup>3</sup> with which painters use to draw their lins and make pictures of one colour in their first draughts," etc.

The mines of Borrowdale were included in the manor of the same name, which, having belonged to the Abbey of Furness, passed to the Crown in the reign of Henry VIII. It was granted by James I, before the end of the year 1614, to William Whitmore and Jonas Verdon, with "the Wad Holes and Wad, commonly called black Cawke, of the yearly rent or value of fifteen shillings and fourpence."<sup>4</sup> The word 'cawke' is a form of 'cauk' or chalk, but is usually applied to the mineral barytes, sulphate of barium. 'Wad,' also written 'wadt' or 'wadd' or 'wad-lead,'<sup>5</sup> is now applied to the soft hydrous binoxide of manganese. Its

<sup>1</sup> If, as is no doubt the case, these words occur in the first edition issued in 1562, this is the earliest unmistakable reference to graphite.

<sup>2</sup> The terms in which Dioscorides refers to these minerals precludes the possibility of either of them being graphite.

<sup>3</sup> The use of black lead is again referred to in the "Ludus Literarius, or the Grammar Schoole," by John Brinsley, published in 1612, where (p. 47) the reader is told to "note them with a pensil of black lead"; and in the margin we read, "Others with blacke leade thrust into a quill."

<sup>4</sup> J. Otley, "Account of the Black lead Mine in Borrowdale": Memoirs of the Literary and Philosophical Society of Manchester, ser. II, vol. III, 1819, p. 168.

<sup>5</sup> G. Jars: "Voyages Metallurgiques," vol. II, 1780, p. 554. "Mine de plomb pour les crayons nommés Black-lead ou Wad-Léad."

use in the sense of graphite appears to be earlier. It appears from the statements of Camden (*loc. cit.*) and others that German miners were employed in Cumberland in the reign of Elizabeth, and it is possible that the first part of 'Wasser-blei,' the old German name for graphite, may be a corruption of the Cumberland term, or, on the other hand, the latter may have been introduced from Germany.

The term black lead was also employed in England in the sense of metallic lead, as a translation of the Latin 'plumbum nigrum.' It is thus used in Trevisa's translation of the "De Proprietatibus Rerum" of Bartholomæus Anglicus, made towards the end of the fourteenth century, and first printed about 1495. "But of blacke leed is dowble kynde. For blacke leed comith alone of a veyne: other is gendred wyth sylver in medled veynes" (xvi, 80). Black lead was used in the same sense in "A greene Forest, or a Naturall Historie," by John Marplet, published in 1567 (p. 13). There can, however, be but little doubt that at this period the term usually signified graphite from the Borrowdale mine.

Andreas Cæsalpinus of Arezzo, in his "De Metallis libri tres," first published at Rome in 1596 (book iii, cap. 22, p. 211), employs 'molybdæna,' 'plumbago,' and 'galena' in the same manner as Pliny and early commentators on Dioscorides. He refers elsewhere (book iii, cap. 8, p. 186) to graphite in the following terms: "Puto autem molybdoidem [viz. the 'μολυβδοειδῆς λίθος' of Dioscorides<sup>1</sup>] esse lapidem quendam in nigro splendentem colore Plumbeo, tactu adeo lubrico, ut perunctus videatur, manusque tangentium inficit colore cinereo, non sine aliquo splendore Plumbeo: utuntur eo pictores coticulis in cuspidem excisis, ad figuras designandas: appellant autem lapidem Flandriae, quia ex Belgia affertur." This is evidently Borrowdale graphite, which entered the Continent by way of Belgium. He, however, confounds it with bismuth, and says it was used in casting type. He also refers to another 'genus'—"nigrum ut carbo et crustosum, quem pictores Matitam<sup>2</sup>

<sup>1</sup> Apparently μολυβδοειδῆς λίθος, as understood by Falloppius, included (*inter alia*) graphite, for it was "lapis nihil plumbi in se continens," which was employed by the potters ("De Metallis seu Fossilibus," cap. xxv, ed. 1606, p. 327). Several subsequent writers took the same view. Others (e.g., Entzelt, *loc. cit.*; L. Fuchs, "Oper. Didact.," Pars II, De Compos. Med., ed. 1604, p. 65; A. Libavius, "Comment. Alchym.," ii, ed. 1606, p. 116) followed Agricola in considering it to mean our modern galena, as well as in other respects. Falloppius used molybdæna and plumbago for the furnace product, *loc. cit.*, cap. xxvi.

<sup>2</sup> The original matita was red, the word being a corruption of hamatites, the red oxide of iron.

nigram vocant." This may have been a graphitic or carbonaceous shale, the French ampélite (see *ante*, p. 136). Cæsalpinus seems to have thought that both were varieties of lead ore: "Hi lapides si urantur, in Lythargyrum vertuntur, ut vena Plumbi."

In the "Historia Naturale" of Ferrante Imperato, published at Naples in 1599, we read in book iv, chapter 43, p. 122: "Il grafio piombino si preferisce a tutte le materie, che preparino il disegno alla penna e l'inchostro: perciocche facilmente, usandovi industria, si cancella: e no volendo cancellarlo si conserva. Non da impedimento al maneggio della penna, il che fa il piombo per un modo, e il carbone per un' altro . . . è ontuoso al tatto: e al fuoco sommamente indurisce. Puosi ragionevolmente locare nel geno de talchi."<sup>1</sup>

'Grafio' is an Italianized form of the Latin *graphium*, a stile, corresponding to the Greek *γραφίς*, also used in Latin with the same meaning. The form 'graffio' is employed by Gimma (op. cit., vol. ii, 296, 291), who includes in it 'lapis bianco,' 'lapis nero' or 'ampelite,' 'lapis rosso' or 'ematite,' and 'graffio piombino.' 'Ampelite' is also described as 'terra nera,' and comprises both the French ampélite and graphite.

In book xxv, chapter 6, we find a further description of graphite, and also, it may be, molybdenite, under the heading "Gleba Piombina e congeneri": "La Gleba piombina è di color bigio, e di piombo, lubrica nell'esser maneggiata, e ch'imbratta le mani, . . . ritrovasi parte fogliosa che si rissolve tutta in scame: parte consistente in forma soda, qual si taglia in fette lunghe, e se ne fa il grafio detto piombino" (p. 678). Its use for crucibles is referred to.

In book xxvi, chapter 2, p. 694, 'moludena' is employed in the old sense of litharge, obtained in refining silver and gold by means of lead.

Graphite, including probably molybdenite, is also identified with the *μολυβδοειδής λίθος* of Dioscorides by Francisco Imperato in his "De fossilibus opusculum," published at Naples in 1610: "Molubdoides, seu plumbaris lapis a plumbo est longe diversus, licet in plumbi venis reperiatur, cuius succum tantum emittit; et propterea pictores illo ad designandum utuntur; nonnulli stimmi anglicum illum appellitant, propter similitudinem; verum a molybdæna Plinii differt, quam Galenam nuncupant, ut

<sup>1</sup> Many later writers also referred to graphite as a variety of black talc. Talc, it must be remembered, included (as it still does to some extent in popular use) not only the talc but the mica of modern mineralogists (see also pp. 161-73).

infra; at ex dicto plumbari quædam construuntur vasa ad aurum, ac argentum purgandum destinata, necnon alterum ab altero separandum; nam valde ignis repugnat potentiæ" (p. 58). On the other hand, it is distinguished from galena, molybdæna, and plumbago as used by Pliny: "Interdum quoque aurum, cuprum, et argentum, quod lapidum genus, plumbum, et argentum continens, communiter Galena nuncupatur, seu molybdæna apud Plinium; quo nomine appellat etiam illud, quod in fornacis parietibus inhæret, dum plumbum eliquatur, admisto auro, vel argento, quod vere molybdænæ, seu blumbaginis<sup>1</sup> nomen retinet; sed ambæ a puro plumbario lapide distant, qui ejus colorem tantum refert, non autem plumbum, nec ejus pondus habet, et molybdoides nominatur ut supra" (p. 92).

The "Lexicon Alchimicæ" of Martinus Rulandus, published at Frankfort in 1612, distinguishes between molipdina and molybdæna. The former being described as "Gold haat, oder silber haat oder Trüsen." The explanations of molybdæna, plumbago, and galena are extracted from previous authors. An English translation appeared in 1892 bearing the date of 1612 and printed in imitation of the style of that time. Most unwarrantably the words referring to plumbago "factitia," "a Germanis dicitur Thest, oder Herdkleyen,"<sup>2</sup> are translated "it is called by the Germans Graphite, or Compressed Galena," giving the incorrect impression that the word 'graphite' was in use in its present sense as early as the beginning of the seventeenth century. In another place the words "Plumbago, galena et molybdæna, unum et idem sunt" are rendered "Plumbago, Galena, and Black Lead are one and the same," quite misrepresenting the meaning.

A little later we find galena in use in the sense of graphite, as the following extracts from the "De Pictura plasticæ statuaria libri duo" of Julius Cæsar Boulengerus (Boulenger), a Jesuit father, published in 1627 at Leyden, will show (pp. 103-5): "Ante omnia sciendum est, aliud esse levi manu sine coloribus adumbrare creta, sive rubrica, carbone, terra sanguinea, vel galena, seu *μολυβδαίνα*, quam Plinius lib. 34. cap. 18. venam plumbi, et argenti communem esse ait; aliud, coloribus adhibitis pingere . . . Pictoris stylus, seu cretacea graphis, est frustum oblongum rubricæ aut terræ sanguinæ, aut carbo oblongus, aut plumbea graphis, seu

<sup>1</sup> See p. 143 *ante*.

<sup>2</sup> This is apparently taken from L. Fuchs, *loc. cit.*, where, however, we read "Thest oder Herdtbley."

designatrix galena pictoris, vulgo dicitur, crayon, charbon, crayon de mine de plomb de mer, marquant de gris. Opus graphide adumbratum, rubrica, aut plumbo designata pictura. Rudis, et informis designatio totius operis, carbone, plumbo, vel rubrica impolite designatum opus." Again, "postquam rudi Minerva carbone, rubricâ vel galenâ sine coloribus adumbraverimus," and "In rudi illa designatione, quæ carbone fit, aut creta, utimur cretacea graphide, stylo rubricato, vel frusto oblongo rubricæ, carbone, plumbo."

Here "plumbea graphis," "designatrix galena pictoris," and similar expressions appear to be synonyms, represented in French by "crayon de mine de plomb de mer," and can only refer to graphite. 'Plomb de mer' was often used for 'graphite' in the seventeenth and eighteenth centuries. It is probably a translation of the German 'Wasserblei.'

Another Jesuit, Bernardus Cæsius, quotes Bulengerus almost verbatim<sup>1</sup> in his "De Mineralibus," published at Leyden in 1636. On the other hand, he describes plumbago as (1) "communem venam plumbi," (2) "purissimum plumbum, quod ignis ustione, cineris speciem induit" (pp. 257, 613, and 625).

In the "Museum Metallicum" of Ulysse Aldrovandi of Bologna (Parma and Placentia, 1648), we read, p. 167: "Plumbago aliquibus dicitur ærugo plumbi: attamen Plumbago proprie est materia nuncupata Galena, quæ, post fusionem plumbi in fundo fornacis remanet. . . . Verum, apud Plinium, Plumbago triplex constituitur: prima species est Galena vocata, quæ argentum, et plumbum participat, secunda est plumbago, seu Molybdæna artificialis tum Plinii, tum Dioscoridis,<sup>2</sup> tertia est substantia quædam fossilis lapidosa, quæ Plumbago vel Molybdæna naturalis vocatur."

He afterwards quotes the passage in Cæsalpinus which refers to graphite under the name of 'molibdoides,' and continues: "Hujus lapidis aliud genus crustosum, et instar carbonis, nigrum invenitur, quo similiter Pictores utuntur. Ad nostros pervenerunt manus duo lapides crustosi, seu potius escharam æmulantes cum aliquo livore plumbi . . . Primus vocabitur Escharites niger molybdoides, secundus dicetur Escharites cum aliquo rubore molybdoides alter." These specimens apparently consisted either of molybdenite, graphite, or graphitic or carbonaceous shale.

<sup>1</sup> He writes, however, 'molybdæna' for *μολυβδαίνα*.

<sup>2</sup> See also op. cit., p. 182: "Et quod in fundo catini remanebat ad mentem Plinii Galena nempe Plumbago vocabatur."

Later on, p. 177, he adds—"Insuper Pictores, ut nonnulli asseverant, ad imagines designandas, stylo ex materia plumbea parato utuntur. Hodie hujusmodi stylus ex lapide plumbario fabricatur . . . Aliqui ad signandas chartas modico plumbi acuminati utuntur, idque Piombino nominant. Repræsentamus hic iconem styli ex cujusdam plumbi genere facti in mucronem derasi, et manubrio ligneo inserti. Putat tamen Gesnerus esse genus plumbi factitii, quod apud aliquos Stimmi Anglicum appellatur." He gives a copy of Gesner's drawing.

Ole Worm, a Norwegian, in his "Museum Wormianum," published at Leyden in 1655, follows Agricola and Entzelt in identifying galena, plumbago, and molybdæna (spelt molybdæna) with our modern galena, while he distinguishes plumbago, instead of molybdæna, as containing lead alone, from galena, with lead and silver. He admits, however, that some believe galena, plumbago, and molybdæna to be "tria diversa corpora" (p. 127). At the same time he treats graphite as a variety of galena. "Ex nostris officinis Norvagicis, frugiferæ Galenæ tria genera accepi, unum quod Plumbum refert, et manus plumbeo colore inficit, quo etiam ad lineas ducendas utimur, vulgo plumbago Bley-ertz (nobis Bleyas)<sup>1</sup> vulgaris pictoribus usus" (p. 128). The second genus was a liver-coloured ore associated with native silver; the third, perhaps, granular galena. His sterile galena "coloris magis lurido" may possibly be zinc-blende.

He also refers (pp. 128, 135-6) to the use of the words molybdæna, plumbago, and galena for furnace products of the nature of litharge. The two former words continued to be employed in this way for some time after galena had become restricted to the sulphide of lead, with or without silver.<sup>2</sup>

In the latter part of the seventeenth century increased interest was taken in mineralogy in this country.

In the "Πανορυκτολογία, sive Panmineralogicon," or "An Universal History of Minerals," by Robert Lovell, published at Oxford in 1661, we find (p. 38) the following: "Plumbage, *Plumbago* [Latin]. P[lace]. It sticks to the furnace in the purifying

<sup>1</sup> Blyerts became the ordinary Swedish term for graphite, but the German Bleiertz was only exceptionally used in the same sense (see pp. 165, 167, 172).

<sup>2</sup> In the "Notitia Regni Mineralis" of Johannes Jonstonus (Leipzig, 1661), however, galena is used for an ore of lead and silver, "melior quo magis aurei coloris"; galena factitia and molybdæna for the artificial oxide, and plumbago, "si solum sterilis ab igne consumitur, coloris magis lurido" (p. 59).

of Silver or Gold. M[atter]. of Silver or Gold purified, with lead. N[ame]. *Μολύβδαινα*, Molybdæna."

Apparently none of the words galena, plumbago, or molybdæna were yet associated in this country with graphite, for in the "Pinax Rerum Naturalium Britannicarum" of Christopher Merrett, 1666, p. 218, we read: "Nigrica fabrilis, Black ledd, Peculiaris hæc terra Angliæ Europææ et Americanæ et hactenus nomine caruit, ideoque favente Analogia hoc ipsi imposui ad Keswick, in Cumbria. . . . Lapis cæruleus Killow dictus ducendis lineis idoneus in Agro Lancast."

Walter Charleton, in "De Variis Fossilium Generibus," appended to his "Onomasticon Zoicon" (1668), follows Merrett in the use of "nigrica fabrilis" for graphite (p. 219), and the "Museum Wormianum" with regard to the meaning of the words galena and plumbago,<sup>1</sup> except that there is no hint of the use of galena for graphite.

"The Compleat Chymical Dispensatory, in Five Books . . . Written in Latin by Dr. John Schroder . . . and Englished by William Rowland" (1669), contains the following (p. 246): "Molybdæna, or Plumbago. It is Natural, or Artificial; the first is Lead Oar, or that mixed with Silver. The Artificial is a kind of Litharge." This is chiefly of interest as being one of the very few instances in which plumbago has been used in English for compounds of lead.<sup>2</sup>

Of more importance is the "Metallographia, or An History of Metals," by John Webster (1671), who refers (p. 20) to Camden's mention of "a Mine of Black Lead, for which we yet want a Latine name, but that of late Dr. Merrett hath given it the title of Nigrica." On p. 280 he returns to the subject: "Here it cannot

<sup>1</sup> "Galena (forte a *γαλεῖν* splendere; quod instar Argenti venæ splendeat) ex qua Metalla excoquantur, vel Plumbum solum (et tum Plumbago proprie dicitur, Anglice, Lead Ore) vel et Plumbum et Argentum (et tum Galena audit)," p. 298. "Plumbago Graecis *Μολύβδαινα* a Plumb [sic] appellatione sumpta. Fit enim ex Plumbo," etc., p. 307.

<sup>2</sup> I have been unable to see the original from which this was taken, but the "Pharmacopœia Schrödero-Hoffmanniana," published at Cologne in 1684, reads (p. 307) "Molybdæna seu plumbago . . . nativa et factitia," and continues in the same sense as the English translation. On p. 253 there is a note by Hoffmann:—"De Plumbo Scriptorio oder Wasserbley sciendum, vocari illud Molybditem Lapidem, de quo erudite scripsit Cesalpinus, et primam facit speciem lapidis plumbarii; . . . Multo lævior ac friabilior minera Plumbi nigri parum aut nihil fere Argenti in se habens. Exteri et in primis Itali hoc crudum a Nobis petunt, illudque erepolientes denuo iterum ad Nos remittunt pro usu scriptorio." This is the first mention of Wasserblei I have found, but the word probably came into use much earlier.

be amiss to say something of that which we commonly call Black-Lead, because it discoloureth the hands far more then common Lead, and is that whereof Pencils are made for Painters and Scriveners, and many other such like uses. In the North we usually call it Kellow, and some call it Wadt."

Kellow or killow was applied not only to graphite, but to a soft, black, earthy mineral, possibly a carbonaceous or graphitic shale. The word is usually derived from the North Country Collow or Colley soot,<sup>1</sup> but Dr. Murray believes that the change in the first vowel is improbable.

On pp. 344-5 we read: "All that we shall say here concerning Galena, Plumbago, Lapis Plumbarius, and Molybdæna . . . is that there is much said to little purpose, and that in some respects they may be taken for all one; . . . I hold that the main difference lieth in this, that it is to be accounted Galena when it holdeth a sensible quantity of Silver, or however when it holdeth as much Silver as may make it a Mine Royal:<sup>2</sup> but if it hold no sensible quantity of Silver, then it may be called Plumbago; and this I wish every Test-master and every Miner seriously to mind and consider of."<sup>3</sup>

The "Fodinæ Regales" (1670) and "Laws of Art and Nature," 1683, by Sir John Pettus, contain references to black lead,<sup>4</sup> but no use of the words galena, plumbago, or molybdæna.

The uncertainty that prevailed in the use of these words is well illustrated in the "Mineralia" of Joachim Junge, published at Hamburg in 1689. It appears to have been compiled from the author's notebooks after his death, and consists largely of extracts from previous works, with notes, queries, and suggestions. Molybdæna (with plumbago as a synonym) appears to be employed in the sense of litharge (p. 163). The artificial form is distinguished as "molybdæna fornacum," and the mineral as "molybdæna

<sup>1</sup> Beckmann (*op. cit.*, vol. v, 1803, p. 246; vol. iv, 1814, p. 354, states that both wad and killow or collow meant 'black' in the Cumberland dialect. See *ante*, pp. 148, 154, and *post*, pp. 158-9, 163.

<sup>2</sup> The Crown is entitled to all silver-mines.

<sup>3</sup> See also p. 205; on p. 221 we read "in Galena inani, which the Germans call Blend, and our miners in the North, Blue Blindake"; and see p. 280.

<sup>4</sup> "There is also a mineral Lead, which we call Black Lead, something like Antimony, but not so shining or sollid; . . . of late, it is curiously formed into cases of Deal or Cedar, and so sold as dry Pencils." *Laws*, part ii, under "lead"; *Fodinæ*, pp. 5, 7.

metallica, fossilis," while the sulphide is referred to as "galena non flava." Then follow two queries:—"Ob Tetting wisse was und woher das schreibblei sei? Obs aus Engelland"; "bei kanngiessern<sup>1</sup> zu fragen. Ob sie wissen wasz bleyertz (damit wir schreiben) sei: und woher es komme. etliche nennens wasserbley." Under "Observanda" we read, "Plumbago scriptoria nec lapis plumbarius est G. Agric. quia hic durior stibio, nec plumbago G. Agric. quia hæc flava est." In a note (p. 166), apparently made at a subsequent date, the title "Plumbago Anglica sive Galena inanis," he refers to "Terra illa metallica et micans Anglis blacke-leade dicta," and after quoting further from Camden, continues: "Anglica hæc plumbago nec lapis plumbarius sive plumbi speciem gerens, nec plumbago est secundum G. Agricolum quia lapis ita durus est ut facile teri non possit, et plumbum continet, interdum etiam una argentum. Ex eo [viz. lapis plumbarius] ad rubedinem exusto fit minium secundarium menninge."

He says that the galena inanis or blende of Agricola seems to differ from the galena "simpliciter" or Glantz of the same author, "non ut inane a fertili sed specie." The former he renames pseudo-galena, a name employed by several subsequent writers. At the same time he says that plumbum scriptorium appears to differ from galena sterilis.<sup>2</sup>

As Junge died in 1657, his reference to plumbago scriptoria and plumbago anglica constitutes the earliest known definite use of plumbago in the sense of graphite, though, as I have shown (pp. 151-3), galena and even molybdæna had been so used.

In the "Teutsche Material Kammer" by J. J. Marx, published at Nuremberg in 1687, graphite is referred to (p. 78) as "Cerussa nigra. schwartz Bleyweiss," while in the "Vollkommenes Lexicon," which forms an appendix, plumbago fossilis appears as synonymous with Bley Aertz and Bley Schweisz, plumbago with Bley Glantz, and plumbago Plinii with Molybden and Molybdæna.

In the "Histoire Generale des Drogues," by Pierre Pomèt, published at Paris in 1694, we read:—(part iii, p. 42), "Le

<sup>1</sup> Smelters who cast pewter or other metals or alloys into various vessels.

<sup>2</sup> Galena inanis or sterilis, blende, and pseudo-galena continued to be used in a very general sense. In the "Mineralogia" of J. G. Wallerius (1747), p. 249, for instance, Beckblände is defined as "Pseudo galena picea." See also "De Matricibus Metallorum," by J. G. Hoffmann and J. B. Boëmer (1738), pp. 68-9, and A. G. Monnet, "Système de Minéralogie" (1779), p. 180. Nevertheless, as we have seen (p. 142 *ante*), the most usual signification was zinc-blende or sulphide of zinc.

Troisième Plomb mineral est tout au contraire fort usité, et est ce que nous appellons Mine de Plomb noire, Plomb de Mine, ou crayon, parce que le plus parfait sert à designer. Les Anciens luy ont donné le nom de Plombagine et de Plomb de mer, en ce qu'ils ont pretendu qu'il se tiroit du fonde de la mer; les Etrangers [the Dutch] le nomment Potelot" (viz. pot-lead).<sup>1</sup>

A translation into English, with additions from other sources, appeared in 1712. Here (vol. ii, p. 351) we find: "The third sort of Lead Oar is very much us'd, and 'tis that we call Black Lead, or Crayon, . . . The Ancients gave it the Name of Plumbago, and of Sea Lead." This statement, which represented for a long time the only use of the word plumbago for graphite in English, is repeated in the subsequent editions of 1737 and 1748. The latter was edited by the versatile 'Sir' John Hill, who was actor, playwright, physician, botanist, zoologist, and mineralogist, and in more than one capacity called forth the satire of Garrick and the discriminating condemnation of Dr. Johnson. He supplied a note:—"The Molybdæna or Plumbago is a substance of the Litharge kind, . . . Black Lead is the Nigrica Fabrilis, Charlt. Foss. 2. Massa Nigra ad Pnigitem referenda, Worm. 5. . . . It is rather an earth than a metal."

As a matter of fact molybdæna and plumbago had long since ceased to be used in the sense of litharge. Plumbago led the way in this respect, for in Blancard's "Physical Dictionary" (second edition, quoted in the Oxford Dictionary), published in 1693, we find an explanation of the word molybdæna which is evidently taken from Schröder, but the word plumbago is dropped. It is significant too that in the Latin edition, published at Leipzig in 1695, of the "Historia Naturale" of Ferrante Imperato, we find (p. 133) 'plumbago' substituted for 'grafio piombino' in the sense of graphite, while 'molibdæna' is still used like 'moludæna' in the sense of litharge (p. 787). This use of molybdæna did not, however, extend, except for Hill, beyond the first quarter of the eighteenth century.<sup>2</sup>

On the other hand, there is, as I have said, no evidence outside the translation of Pomet of the use of plumbago for graphite in England. For instance, in "Some Observations concerning the

<sup>1</sup> In the "Museum Museorum" of M. B. Valentini, published at Frankfort in 1704, graphite is referred to as "Wasserbley welches sonsten plumbago, cerussa nigra . . . genennet wird."

<sup>2</sup> See, however, Gimma, op. cit. (1730), ii, p. 144, who, however, only quotes previous authors.

substance commonly called Black Lead," by the "late Dr. Rob. Plot, F.R.S." (Phil. Trans., 1698, p. 183), we are told that "The mineral substance, called, Black Lead (our common Lead being the true Black Lead, and so called, in Opposition to Tin, which is the White Lead) found only at Keswick, in Cumberland, and there called, Wadt, or Kellow; by Dr. Merrett, *Nigrica Fabrilis*, . . . whence the most Proper Name that can be given it, perhaps, may be *Ochra Nigra*, or Black Ochre." Nowhere is there any mention of plumbago.

The same is the case with the "Natural History of Westmoreland and Cumberland," by Thomas Robinson, published in 1709, where "Wadd, or Black-Lead" is described as a "black pinguid and shining Earth."<sup>1</sup>

In the early years of the eighteenth century there was a comparative dearth of textbooks on mining and mineralogy. Our chief information is obtained from the writings of Dr. John Woodward: his "Methodica Fossilium in Classes Distributio," an appendix to his "Naturalis Historia Telluris" (1714); his "Fossils of all kinds Digested into a Method suitable to their mutual Relation and Affinity" (1728); and "An Attempt towards a Natural History of the Fossils of England," an explanatory catalogue of his collection, which was afterwards presented to the University of Cambridge. Bound up with the latter are subsidiary catalogues of additions and of the portions of his collection obtained from abroad. The details in the latter are, he tells us, copied from the labels on the specimens, and accordingly furnish us with information of the contemporary use of mineralogical terms on the continent of Europe. This catalogue bears as a whole the date 1729, but portions appear to have been issued earlier. Both in the "Methodica Distributio" and in the "Fossils of all kinds"<sup>2</sup> he identifies *nigrica fabrilis* with wadd and black lead. In the latter publication he also distinguishes between the softer killow (*Killoia molliuscula*) and the harder killow (*Killoia duriuscula*). The former is described as "of a blackish or deep blue Colour, and, doubtless, had its name from Kollow, by which name in the North, the Smut, or Grime on the Backs of Chimneys, is call'd."

<sup>1</sup> After discussing its various applications (except, curiously enough, its manufacture into pencils) he concludes: "for these and other Uses, it's bought up at great Prices by the Hollanders, and others."

<sup>2</sup> A French translation of this was published at Paris and Amsterdam in 1735, an Italian at Venice in 1739, and a German at Erfurt in 1746. See J. E. J. Walch, "Das Steinreich" (1769), i, p. 11.

Among the lead ores he refers to "the sparkling or Steel-grain'd; this commonly yields more or less Silver and is what Dioscorides, and the Naturalists after him, call Molybdæna: Pliny, Galena." Among "Mock ores" he mentions "Blind," "Blend," and "Black Talk, or as the Germans call it, Sterile-Nigrum"; the last may be molybdenite or a variety of graphite.<sup>1</sup>

In the "Attempt towards a Natural History of the Fossils of England" black lead and galena are referred to in similar terms.<sup>2</sup> In the portion entitled "A Catalogue of the Foreign Fossils in the Collection of J. Woodward, M.D.," we find (p. 29), under the heading "Nigrica fabrilis, Black Lead or Wad," a specimen described as "Lapis Plumbarius sterilis, cum quo Scribi potest. Altenbergæ in Saxonia. Wasserbley Ertz; i.e. Black-Lead Ore. M. de Schonberg. ('Tis the Nigrica fabrilis or Black Lead.)" The locality leaves, however, little doubt that this was not graphite, but molybdenite. The following labels (pp. 37-40) are also of interest: "Plumbago super Pyritem aureo colore. Fribergæ in Saxonia. Silberhaltiger Bley-schweiff uff Kupffer Kies." This is argentiferous galena associated with copper pyrites. "Plumbago in Talco cinereo. Snebergæ in Saxonia. Bley-glantz in grauen talc, i.e. Lead-Glitter in grey Talc. M. de Schonberg." Plumbago is explained in similar terms on two other labels. The expression 'lead glitter' is a very fair translation of 'Bley-glantz,' but it was not adopted by other authors. "Plumbago tesselata. Fribergæ in Saxonia. Wurfflicht Glantz-Ertz, i.e. Diced Glitter Ore. M. de Schonberg." There are several references to galena. "An addition to the Catalogue of the Foreign Native Fossils in the collection of J. Woodward, M.D." (1725), includes the following entries (p. 16): "Plumbago ad Altenburgia [? Altenberg], ex Minis Stanni. Dr. Henckell. This is Wad, or Black-Lead, with White-Spar." The association with tin ore makes it probable it was molybdenite. "Molybdæna grossior grober bleyglantz, i.e. Coarse Lead, shining, hic ubi vis obvia, continens 60 Libras Plumbi, et 1, 2, 3. Lotos Argenti. Saxonix. Dr. Henckell." "Molybdæna, Granis minutioribus Saxonix. Dr. Henckell."<sup>3</sup>

<sup>1</sup> See p. 8 of the "Methodica Distributio," and pp. v, 2, 3, 43, 55, and 56 of the "Fossils of all kinds."

<sup>2</sup> pp. 185, 211. In some cases the 'black lead' is stated to be connected with copper ore; it would therefore probably be molybdenite, not graphite.

<sup>3</sup> Dr. A. Hutchinson, of Pembroke College, Cambridge, has kindly examined the specimens referred to, which are still preserved in the Woodwardian Museum, with their original labels, and has enabled me to verify my surmises as to their real nature.

These and other labels illustrate the variations in the use of these words at this time. Plumbago is used by Dr. Schonberg for the mineral galena, and by J. F. Henckel, the author of the "Pyritologie" and other mineral works, for molybdenite and probably graphite. Molybdæna is employed both by Woodward and Henckel in the sense of lead sulphide. Galena is used by Scheuchzer with the same meaning, but Woodward, De Schonberg, and Leopold apparently employ it to include other sulphides. I have been unable to find any of these words in Henckel's German publications, but in a note in Latin on Zinc, *Observatio lxxx*, "Acta Physico-Medica . . . Naturæ Curiosorum [Dresden] Nürimbergæ," vol. iv, 1737, pp. 308-11, we find molybdæna<sup>1</sup> employed for zinc-blende, sulphide of zinc, while galena is used by Henckel for the common ore of lead, the sulphide.

In the years that intervene between these catalogues and the birth of modern chemistry towards the end of the eighteenth century, the most striking feature is the predominant position taken by the Swedish men of science, whose industry and enterprise laid the foundations for the marvellous advances that followed. This was especially the case with mineralogy, where the volume of their work exceeded that of the rest of Europe. We have seen that during the seventeenth century 'lapis plumbarius,' 'plumbago,' 'galena,' and, exceptionally, molybdæna were at one time or another employed in the sense of graphite, including probably molybdenite, with which it was confounded. In the period now under consideration it was 'molybdæna' that was usually employed in this sense; 'galena' became identified, as we have seen, with the mineral that now bears that name, and it will not be necessary to follow its history further in much detail. Plumbago, on the other hand, was used in three distinct senses:— (1) following Worm, for galena free, or nearly free, from silver, in which case the word galena was restricted to the argentiferous varieties; (2) for the fine-grained and occasionally fibrous varieties of galena, which were known in German as Bleyschweif;<sup>2</sup> and (3) for graphite or molybdenite.

<sup>1</sup> This is translated in the French edition of Henckel's works, published in 1760, by 'plombagine,' vol. ii, pp. 494-6. 'Plumbago,' on the other hand, is employed (vol. i, p. 35) to translate 'Bleyschweif,' 'Arsenicalisches Bley-Ertz' in the "Pyritologia," published in 1725 (p. 91).

<sup>2</sup> This fine-grained variety was by some authors believed to contain arsenic as well as sulphur and lead (see preceding note and pp. 163, 165, 167).

It was soon discovered that the supposed mineral which corresponded to both our graphite and molybdenite did not contain lead, as the earlier writers had supposed; but there was much difference of opinion as to its real composition. Those that experimented with molybdenite came to the conclusion that it was a compound, probably a sulphide, of zinc, and, as we have seen, Henckel confused it with zinc-blende. Others thought it might contain tin. Those who had graphite to deal with believed it to be a kind of 'talc,' either steatite or mica, combined with some combustible material, or, what was the same thing, some material containing the principle of combustibility, 'phlogiston.' Iron was known to be present, and by some it was thought to be the substance that was 'phlogisticated' or combustible. Gradually these ideas, which contained distinct elements of truth, became more definite, till the results of Scheele's work only required the magic of Lavoisier's theory to transform them into the views that we now hold.

Graphite (including molybdenite) is dealt with at some length in vol. iv of the "Universal Lexicon" of J. H. Zedler, Halle and Leipzig, 1733. Among the names with which it is credited are Schreibe-Bley, Bley-Schweiff, Test, Zwitter, and others, such as Plumbago and Molybdæna, that have already been mentioned. The Italian Marchesita di plombo and Spanish Marquesita del plomo are also said to have the same meaning. The article appears to be largely founded on Pomet.

In the first edition of the "Systema Naturæ" of Linnæus, published at Leyden in 1735, we read, "Mica . . . particulis impalpabilibus. Sterile nigrum," and "Zincum . . . sterile micaceum? an hujus loci? Molybdæna, Blyerts." The former was probably molybdenite, the latter a confusion between graphite and molybdenite.<sup>1</sup> In the revised edition of 1740, published at Stockholm, these species are merged into one (p. 4):—"Mica particulis squamosis, inquinantibus Molybdæna Blyack."

In the edition of 1744 (Paris) there are again (p. 11) two species, "Zincum micaceum atrum. Sterile nigrum" and "Zincum cinereum fusco-inquinans. Molybdæna, le Plomb de Mer ou Plomb de Mine." The former appears to be molybdenite, the latter graphite.

<sup>1</sup> In the German edition of 1740 (Halle), *Sterile nigrum* is translated *Schwartzte Blende*; and *Molybdæna* by *Wasser-Bley* (pp. 8 and 14).

In the "Tabulæ Metallurgico-docimastica" of A. G. Berlichius, which forms an appendix to the edition of the "Schediasma de Tinctura" of Gabriel Clauderus, published at Nuremberg in 1736, galena, Blende, and Bley Glantz are apparently synonymous, in the sense of lead sulphide. 'Plumbago metallica' or 'Bley-schweif,' which is "Splendens instar Plumbi nigri" and heavy, and is said to contain more or less silver, is, I imagine, granular galena. 'Galena inanis' is evidently zinc-blende. Finally, "Molybdæna, Wasser-Bley," "Ex atro paulo splendescens instar plumbi," and more or less heavy, probably includes graphite and molybdenite (see tables K to N).

In 1737 appeared at Leyden a "Dissertatio Academica sistens Nihil," by Isaac Lawson, a Scotch medical student, who afterwards became a medical officer in the British Army. 'Nihil' or 'pompholyx' is sublimated oxide of zinc, and in the course of the dissertation (p. 13) attention is incidentally drawn to a very slight sublimate obtained from the mineral known as molybdæna when heated in a retort.<sup>1</sup>

"Datur minera, quæ dicitur Molybdæna; sub quo nomine mineram plumbi quidam intelligunt; nos autem hic intelligimus mineram plumbei coloris, micaceam, haud duram, ponderosam satis, ad tactum admodum saponaceam, pinguem, corpora solida lubricantem, ex cujus frustis purioribus et longioribus hodie fiunt styli scriptorii."

"Pondus hujus mineræ specificum insigne docere videtur metallici quid inesse, quamvis nullo experimento hactenus mihi noto constitit, quodnam metallum in ea reperiatur." After describing the results of his experiments, he continues: "Unde probabile videtur semimetallum quoddam contineri in Molybdæna, ipsum forte Zincum, quamquam nulla arte adhuc nota potuit extrahi."

There can be no doubt that the mineral with which he experimented was molybdenite, which, however, the author believed to be identical with graphite.

The mineral described by J. G. Hoffmann and J. B. Boëhmer, in their "De Matricibus Metallorum," published at Leipzig in 1738, as associated with tin, was also probably molybdenite, though they too identify it with graphite used in lead pencils. "Hi ipsi lapides stanni divites, aliam insuper satis sterilem

<sup>1</sup> Neither graphite nor molybdenite is volatile, when heated out of contact with the air.

secum ducunt Mineram, quæ Plumbago ab aliis Molybdæna nuncupatur" (p. 69). Plumbago seu Molybdæna mihi est illud minerarum sterilius genus, quod calore [*sic*] cum Galena convenit, sed leve, molle atque friabile est, plumbi nihil continet, digitos, chartam aliaque corpora livido nigricante colore pingit, proptereaque ad scripturas atque picturam plerumque adhibetur; nostratibus Reiss-Bley, Bleystift-Ertz dicitur. Equidem me non latet Agricola. . . . Plumbaginem atque Molybdenam veram Plumbi Mineram nuncupare, ast hodie prædictus significatus magis obtinet. Interim nonnulli aliam Molybdænam inter atque Plumbaginem faciunt differentiam et [Plumbaginem] Plumbi venam radiatam Antimonio similem, scil. Bley-Schweif, salutant. Molybdænam vero Wasser-Bley nuncupant" (note, p. 70). The word 'plumbaginem' appears to have been omitted.

In the "Elementa Artis Docimasticæ," a treatise on metallurgy by J. A. Cramer, published at Leyden in the succeeding year, vol. i, p. 262, we read: "Inter Mineralia nondum examinata imprimis considerationem meretur Molybdæna, alias quoque vocata Cerussa Nigra, Plumbum marinum Germ. (Wasser Bley.), non confundenda cum Galena Plumbi quæ, licet eodem nomine quandoque designetur, prorsus tamen ab illa discrepat. Est Molybdæna Minerale coloris Plumbei, ex squammulis micaceis contextum, mollius, ut cultro facile corradî queat, pondere Lapides Micaceos simplices, quos fere quoad texturam refert, longe superans, ad tactum valde saponaceum, corpora solida affricu suo lubrica reddens: . . . Stylis itidem Scriptoriis usu pervulgato inservit." There can be little doubt that the author included both graphite and molybdenite in his molybdæna. His "Galena Tessellata, Germ. Bley Glantz" (p. 214), is evidently galena in the modern sense of the word. 'Plumbago' is not mentioned, but 'Bleyschweif' is described as an arsenical sulphide of lead (p. 215).

Two editions of an English translation by Cromwell Mortimer were published in 1741 and 1764. They do not differ in any important respect from the Latin original. Both read "Molybdæna . . . in English, Wad or Black Lead," and refer to the mine at Borrowdale, p. 181 (1741). They are chiefly of interest as representing one of the few instances in which molybdæna has been used in English in the sense of graphite.

A similar use of the word is found in the "Natural History of Cornwall," by William Borlase, published in 1758 (p. 130): "Molybdæna, or the pencil lead . . . some small gravels of this

will mark paper as free as the molybdæna from Cumberland . . . They came from a work in Camborn, called Huelcrafty" [Wheel Crofty].<sup>1</sup>

In 1739 the "Mineralogie" of Magnus von Bromell was published in Swedish at Stockholm. A German translation appeared in the following year, under the title "Mineralogia et Lithographia Suecana" (Stockholm and Leipzig). Here we find (p. 106, corresponding to p. 59 of the original), "Plumbago, Molybdæna, oder Bley-Ertz, ist eine andere weiche, leichte, glänzende und gar zu reife Bley-Malms-Art, welche die Hände färbt, wann man sie bearbeitet, und dienet dazu, dasz man damit auf Knochen, Papier und Pergament mahlen und schreiben kan." The Bley-Ertz of some localities was apparently a bituminous or oil-bearing shale. He also mentions its use for 'Bley-Federn,' also referred to as "Reisz- und Schreib-Federn."

In 1740 an interesting paper by J. H. Pott appeared in vol. vi, p. 29, of the "Miscellanea Berolinensia" of the Societas Regia Scientiarum of Prussia,<sup>2</sup> under the title "Examen chymicum plumbi scriptorii vulgo plumbaginis," in other words graphite. He commences with a long list of synonyms which had been employed at different times and in different languages. These include, besides 'plumbago,' 'plumbago scriptoria,' and 'plumbum marinum' in Latin; 'molybdites,' 'molybdoides,' and 'molybdæna' in Greek; 'plomb de mere' [*sic*], 'plombagine,' 'mine de plomb noire,' 'plomb de mine,' and 'plomb minerale' in French; 'Black Lead' in English; and 'Wasser-Bley,' 'Reisz-Bley,' 'Schreibe-Bley,' and 'schwartz Bley-Weisz' in German. The mineral was, he says, called by the old workers in France 'Pott Loot' or 'Poteloot' ("quasi Töpfer-Bley"), and it was also known as 'Crayon' ("quasi Creta nigra") and 'Cerussa nigra.' Inferior varieties were referred to as 'Eisen-Farbe' and 'Eisen-Schwärzte.' Other names quoted from various authors are 'Eisendach,' 'argilla ferri,' 'Ochra nigra,' 'nigrice fabrilis,' 'Cadmia ferruginea,' and 'galena sterilis.' It is doubtful whether some of these really referred to either graphite or molybdenite. He cites (p. 33) as an error the statement in Bohn's Kauffmann<sup>3</sup> (ii, p. 61) that 'Reisz

<sup>1</sup> The occurrence of the Cornish mineral in a metalliferous mine renders it probable that it was molybdenite.

<sup>2</sup> A French translation is included in "Dissertations chymiques de M. Pott," vol. iv, p. 1. Paris, 1759.

<sup>3</sup> I have not been able to identify this reference, but a later publication of Bohn is referred to on p. 169.

Bley' is prepared by the Italians from Bley Ertz, and also that of the author of a "Lexicon Economicum" (p. 326),<sup>1</sup> who thought that plumbum scriptorium was a pure mineral of lead found in mines, but that common plumbum scriptorium was prepared from lead, especially in Saxony.

He then describes his own experiments, admitting, however, that he does not know if the plumbago he treated was the same as that employed by Lawson. He declares that he obtained no evidence of the presence of sulphur or zinc. He notes (p. 36) that the mineral decomposes potassium nitrate [a characteristic reaction of graphite].<sup>2</sup> Finally, he comes to the conclusion that he was dealing with a "terra talcosa, igni et menstruis indomita, pauco martiali [iron] et pauciore acido Vitriolico." It was probably Borrowdale graphite with a little iron pyrites, which is nearly always present.

Seven years later appeared the first edition of the "Mineralogia" of J. G. Wallerius (Stockholm, 1747). Here, under "Lapides Apyri," we find (p. 131): "Blyertz Spec. 126. Mica pictoria nigra, manus inquinans. Molybdæna." He describes it as consisting of small scales arranged without order, grey-black in colour, with feeble lustre, and communicating to the hands, paper, and linen a grey colour like that of lead. It preserves its colour and consistency in the fire. He enumerates three varieties: (1) "Ren Blyertz, Molybdæna pura"; (2) "Oren Blyertz, Molybdæna impura"; (3) "Blyertz Tärningar, Molybdæna tessularis." He refers to Lawson's experiments, and alludes to the possible presence of zinc. The two former varieties no doubt included both graphite and molybdenite;<sup>3</sup> the third would seem to be the modern galena. This, however, appears (p. 292) as a separate species: "Bly glants Tärninge Malm—Plumbum, sulphure et argento mineralisatum, minera, tessulis minoribus vel majoribus, vel granulis, micante. Galena. Plumbago metallica." Plumbago is, also, used as a synonym of Bleischweif, which is supposed to contain lead, sulphur, and arsenic: "Blyschweif — Plumbum, sulphure et

<sup>1</sup> See the third edition of an "Allgemeines Oeconomicum Lexicon," Leipzig, 1753, edited by G. H. Zincken, p. 362. Pott refers, of course, to an earlier edition which I have not seen.

<sup>2</sup> "cum 2. p. Nitri mixtum . . . demum levissime detonat, ejus ratio forte in involutione parci principii inflammabilis sita est"; . . . "cum p. semis Nitri mixtum itidem transpellit spiritum nitrosam sub rubris vaporibus."

<sup>3</sup> Other authors who class these minerals among the micas are A. F. C. Hempel ("Terrarum atque lapidum partitio," Göttingen, 1762, p. 18) and J. E. I. Walch ("Das Steinreich," Halle, 1769, vol. ii, p. 37). See also p. 150.

arsenico mineralisatum, minera pinguiori fere malleabili, Plumbago." On p. 136 we read "Klitbärg. Ollaris mollior, pinguis, niger, micaceo-lamellosus, vix cohærens, pictorius. Talcum nigrum." This may include ampélite (*ante*, p. 136) or graphite. Translations were subsequently published in French and German.

In the Latin edition of the "Systema Naturæ" of Linnæus, published both at Stockholm and Leipzig in 1748 and Leyden in 1756, graphite is not referred to, and neither 'molybdæna' nor 'plumbago' is recognized in the nomenclature. However, in the Catalogue of the Museum Tessinianum, published at Stockholm in 1753 and believed to be the work of Linnæus, the following entry appears (p. 54): "Molybdæna. Zincum fusco inquinans. Mica pictoria nigra, manus inquinans (Wall. Min., 131). Huc Refertur usquedum certiora innotescant."

In the "Systema Minerale" of Johann Lucas Woltersdorff, published at Berlin, also in 1748, we find graphite described under "Metalla ignobilia" as "Ferrum . . . Nigricans, splendens, unctuosum, inquinans. Molybdæna. Wasser-Bley. Nigrica Fabrilis, Reiss-Bley."<sup>1</sup>

In 1754 there appeared at Stockholm, in the "Kongl. Svenska Vetenskaps Academiens Handlingar" (Proceedings of the Royal Swedish Academy of Science), vol. xv, p. 189, a paper entitled "Rön om Bly-Erts" (the usual Swedish term for graphite), by B. Qvist, describing experiments on a mineral occurring in flexible plates, which must have been molybdenite. He heated it in a current of air and obtained a white sublimate.

In the "Elementa Mineralogiæ" of F. A. Cartheuser, published at Frankfort in 1755, there is no undoubted reference to graphite, but fine-grained galena is separated from the cubical variety under the name of 'Plumbago' or 'Bleischweiff' (p. 66).

The year 1758 was marked by the appearance at Stockholm of yet another Swedish Mineralogy, the "Försök til Mineralogie" of Axel von Cronstedt. This proved very popular, and was translated into French, German, English, and Italian, in some cases more than one edition being published.<sup>2</sup> On p. 139 of the original edition, which was issued anonymously, we read: "Iärn

<sup>1</sup> Graphite is also classed under the ores of iron as "Ferri Minera pictoria: Molybdæna" by M. T. Brünnich in his Mineralogy, published in 1777 in Danish (p. 247) and in 1781 in German (p. 255). See also *post*, pp. 168, 172, 174, 177.

<sup>2</sup> It is also closely followed in the "Lithophylacium Bornianum, Index Fossilium quæ collegit et in Classes ac Ordines disposuit Ignatius S.R.I. Eques a Born" (Ignaz von Born), published at Prague in 1772.

och Tenn, Sulphur ferro et stanno saturatum. Blyerz. Wasserbley. Molybdena." It is divided into three varieties. The first is "Molybdena membranacea nitens," which is described as platy and shining, and of the same colour as 'Blyglants.' Bispbergs Klack, Bastnäs wid Riddarhytta, and Altenberg are given as localities, and it is stated that a specimen from Bispberg was that employed by Qvist in his experiments. This, therefore, is molybdenite. The second, with "Textura Chalybea," is apparently graphite;<sup>1</sup> and the third, with "Textura micacea et granulata, Grof Blyertz," described as consisting of small flakes or granules, appears to represent flaky graphite.

In 1762 J. C. Valmont de Bomare published a Mineralogy at Paris, which was largely founded on Wallerius. Here species 87 (vol. i, p. 124) is "Molybdène, Mica des Peintres, Crayon ou Mine de plomb, etc. (Molybdena Mica pictoria. . . . Pseudo-Galena Wolt. Plumbarius, etc.)." He remarks: "Le crayon se trouve communément avec les mines d'étain; il en contient aussi quelquefois abondamment." He believed it, however, to be essentially a kind of talc.<sup>2</sup> Other species are "Galène ou Mine de plomb en cubes . . . plumbago metallica . . .," and "Mine de plomb sulphureuse et arsenicale, . . . Bleychweif Germanorum, . . . Plumbago nonnullorum"<sup>3</sup> (vol. ii, pp. 98, 103).

In the same year appeared at Leipzig the "Practisches Mineral System" of R. A. Vogel. Here, under the heading "Wasserbley, Reissbley. Molybdæna, Plumbum scriptorium" (p. 66), we read: "Das Wasserbley ist ein leichter, schwarzgrauer zerreiblicher und abfärbender Glimmer; aus dem man lange nicht gewusst hat, was man machen soll, und es daher für eine Art eines Bleyerzes gehalten hat. Es ist aber nicht ein Gran Bley darinn, sondern vielmehr etwas, obwohl sehr wenig eisenhaftes; hiernächst aber ein wenig Phlogiston: das übrige und meiste ist eine talkichte, dem Feuer widerstehende Erde." He describes how the Germans made the 'leads' of pencils by cementing the powdered graphite, and continues: "Es ist aber noch ein Geheimniss, mit was für einer Materie die Engländer ihr Wasserbley schmelzen." As a matter of fact the English graphite was cut directly from the mineral.

<sup>1</sup> Boru (op. cit., i, p. 61) gives "Keswig Angliæ" as the locality for "Molybdæna textura chalybea."

<sup>2</sup> See note, p. 150 *ante*.

<sup>3</sup> See *ante*, p. 160, for the use of plumbagine and plumbago in the French edition of Henckel's works, published in 1760.

He is the earliest, so far as I am aware, to assert the existence in graphite of phlogiston, the first step to the recognition of the mineral as a form of carbon. Pott, however, recognised the possibility of the occurrence of a "parcum principium inflammabile" (*ante*, p. 165). Vogel distinguishes three varieties of galena: (1) "Galena tessulata"; (2) "Galena granulata, punctata"; (3) "Bleichweif, Plumbago," the last being "in einer derben und fast streifichten Gestalt" (p. 456).

In the fourth edition, published in 1762, of the dictionary of the Académie Française, plombagine is explained as "Substance minérale de la nature du talc. C'est la même qui est plus connue sous le nom de Crayon, ou de Mine de plomb." In the edition of 1718 the word is not included, while in the "Dictionnaire des Arts et des Sciences," part of the first edition, printed in 1694, it is explained in the terms employed by Mattioli.

Some entries in the "Dictionnaire Universel des fossiles propres et des fossiles accidentels" of E. Bertrand, published in 1763, illustrate the confusion in the nomenclature at this time. "Le Crayon des Peintres, appelé mine de plomb, est aussi un Mica. C'est le Molybdæna de Pline, le Molybdoides de Dioscoride. . . . On appelle aussi en François ce crayon fossile, plombagine et plombacine, du Latin plumbago. . . . Il y a une matière qu'on appelle aussi mine de plomb, qui est rouge. Quelques Droguistes le nomment tout - aussi mal - à - propos minium" (vol. ii, p. 43). "Plombagine. Plumbago. On s'accorde peu sur la vraie application de ce nom. 1°. Les uns entendent par là les gèbes de plomb minéral cubiques qu'on appellent galènes. 2°. D'autres désignent par là une autre sorte de mine de plomb qui est arsénicale et sulphureuse. 3°. Henckel<sup>1</sup> appelle de ce nom une sorte de crayon, plumbago scriptoria. . . . C'est le mica des peintres. . . . Ce dernier fossile ne contient point de plomb. Henckel croit qu'il est plutôt ferrugineux. . . . C'est que les Anglois nomment Black Lead. . . . Nous croyons qu'il feroit plus exact d'appeler galène la première espèce de minéral, plombagine la seconde, molybdène la troisième. Il feroit à souhaiter que les Naturalistes s'accordassent une fois dans leur nomenclature" (vol. ii, p. 133). On the other hand, we find (vol. ii, p. 63) "Molybdæne. Molybdæna. En Allemand Bleiertz.

<sup>1</sup> I cannot find any evidence of the use of the word in this sense by Henckel, except in the labels given by Dr. John Woodward.

Mine de plomb. Ce mineral contient toujours du plomb." See also vol. i, p. 166.

The first definite recognition of the fact that molybdæna and its numerous synonyms comprised two entirely different substances is in the "Naturgeschichte des Mineralreichs" of J. W. Baumer (Gotha, vol. i, 1763; vol. ii, 1764). Here in part 4, devoted to the earths, chapter iv dealing with the clay-earth (thonerde), we find (vol. i, p. 151): "Das Wasserbley, molybdæna, kan am füglichsten unter die glimrigen, etwas Eisen, Zinn und Schwefel haltigen Erden gerechnet werden. Man findet dasselbe zu Bispberg, Bastnäs und Gran in Schweden, und Altenberg in Sachsen." Both the supposed composition and localities point to molybdenite (see also ii, p. 105). On the other hand, in the fifth part, Stones, chapter iv, clay-like (thonartig) stones, we are told (i, p. 217): "Das Wasserbley, Reissbley, Molybdæna, Plumbum scriptorium, bestehet aus kleinen dünnen unordentlich zusammengefügtten Schuppen, und ist ein leichter schwarzgrauer abfärbender Glimmer. Es bestehet aus einem brennbaren und eisenhaften Wesen, nebst einer talckigen Erde." He refers to its occurrence at Keswick, and its use for pencils and crucibles (see also ii, p. 139). There can be no doubt that the combustible substance containing iron was graphite. It is curious that Baumer should have retained the same names for two substances which he evidently thought were unrelated the one to the other.<sup>1</sup>

Galena is described as the commonest lead ore, and as containing lead and silver, while bleischweiff or galena punctata is stated to contain arsenic in addition.

The term 'plumbago' is not used by Baumer, but in the "Neueröffnetes Waarenlaager," by G. C. Bohn, published in the same year at Hamburg, we have (col. 134) the entry: "Bleyweiss, das schwarze, oder Wasserbley, sonst auch Reiszbley, Schreibley, Plumbago, cerussa nigra, und von den Franzosen Crayon genannt."

On the other hand, in an English book of a somewhat similar character, the "Commercium Philosophico Technicum," by W. Lewis, M.B., F.R.S., also published in 1763, we find neither molybdæna nor plumbago employed, only black lead (p. 325).

<sup>1</sup> See also C. F. G. Westfeld, "Mineralogische Abhandlungen," Göttingen and Gotha, 1767, p. 51, and the "Catalogue Systématique," by P. F. Davila, assisted by J. B. L. de Romé de Lisle, published in the same year, where "Molybdene ou Crayon" is classed under talc, and "Molybdene ou Mica des Peintres," from Bispbergs-Klack and other Swedish localities, and therefore presumably molybdenite, under zinc (pp. 120, 372).

The author cites both Qvist and Cronstedt, and describes experiments in which he himself demonstrated the almost entire dissipation of graphite by heat.

In the edition of the "Systema Naturæ" published in 1768, which was, as usual, more detailed than those that preceded it, Linnæus dealt at some length with these minerals, but he had no suspicion of the wide difference between graphite and molybdenite. He makes (p. 121) a genus of 'Molybdænum,' of which Plumbago or Bleyertz is one species. "Molybdænum tritura cærulescente," or, as we should now say, molybdænum with a bluish streak. He identifies it with the mineral investigated by Qvist, the "Sulphur ferro et stanno saturatum" of Cronstedt, and the "Mica pictoria nigra manus inquinans" of Wallerius. He is rather oracular as to its composition: "Metallum proprium inde inducere nulla ars chemica etiamnum didicit. An metallum oppositum Hydrargyro, quod nunquam fusile, ut illud semper? Non introduco ideam novi metalli sed colloco obscuras species metallicas in loco gratis expetito, usquedum Regulus coronetur." This appears to point to molybdenite, but he refers to its use for pencils, crucibles, and other purposes for which graphite is employed. The second and third species of the genus molybdænum included manganese ore and wolfram (tungstate of iron and manganese). The different forms of galena appear as species of the genus Plumbum (p. 312).

In the first English edition of Cronstedt, published in 1770, under the title "An Essay towards a System of Mineralogy," we find (p. 156) the heading "Iron and Tin, Sulphur ferro et stanno saturatum, Black Lead, or Wadd, Molybdæna." The term plumbago is nowhere used. In the following year appeared "Fossils arranged according to their obvious characters," by J. Hill, M.D., to whom reference has already been made. He followed Linnæus in employing molybdænum as a generic name with a number of species, some of which corresponded to graphite or molybdenite.

Another reference to graphite is met with in "A Political Survey of Britain," by John Campbell, LL.D., published in 1774 (vol. ii, p. 37). "Black Lead is what some have supposed, with very little Reason, to be the Molybdæna or Galena of Pliny; <sup>1</sup>

<sup>1</sup> Giovanni Antonio Scopoli, in his "Principia Mineralogicæ," Prague, 1772, tells us "Veterum Molybdæna ad genus plumbi pertinebat. Recentiores nimia licentia nomen hoc dederunt Micæ particulis minimis, inquinantibus, atro-plumbeis" (pp. 38, 40).

others stile it Plumbago." In a note he says: "Foreign authors call by that Name [molybdæna] a Substance found in Prussia, which serves for making Pencils, and comes from thence to be confounded with ours, which it in no other Circumstance resembles."

This is the first instance outside the pages of the translation of Pomet in which plumbago is employed in English in the sense of graphite. Even on the Continent the use of the various forms of the word in that sense had been comparatively rare, but it was gradually becoming more common. For instance, in the "Éléments de Minéralogie Docimastique," by B. G. Sage, published at Paris in 1772, the third species of tin is "Molybdène, plombagine, crayon noir" (p. 241). Here both graphite and molybdenite appear to be included and considered to form one mineral species.<sup>1</sup>

In the first edition of Valmont de Bomare's Mineralogy, published in 1762, plumbago was, as we have seen, only employed in the sense of galena. In the second edition, published twelve years later, we find a list of synonyms (vol. i, p. 193), including, amongst others, molybdène, mica des peintres, mine de plomb noire des peintres, crayon; molybdæna, sterile nigrum, plumbago scriptoria, mica nigrica aut colore vario fabrilis. A list of vernacular names follows, including potelot, mine de plomb noire ou savonneuse, plomb de mer, plombagine, plomb de mine, ceruse noire, talc noir friable, blende and fausse galène. He supposes it to contain zinc, and possibly lead. He still uses (vol. ii, pp. 176, 186) plumbago metallica and plumbago nonnullorum in the same sense as in the first edition.

In his "Dictionnaire raisonné Universel," published in the succeeding year, he gives a similar list of scientific and popular synonyms of graphite or molybdenite, including molybdène, molybdæna, nigrica fabrilis, plumbago scriptoria, and plombagine. He expresses his belief that the mineral is a steatite, viz. massive talc in the modern sense, formed of iron, sulphur, and zinc, and similar in nature to zinc-blende (vol. v, p. 468). At the same time he abandons the use of plumbago in the sense of galena.

In 1775 the second volume of a Latin revision of the Mineralogy of Wallerius was published at Stockholm under the title "Systema

<sup>1</sup> He believed it to be an altered form of tin. See note to the German edition by N. G. Leske, Leipzig, 1775, p. 248. On the other hand, in the 2nd edition, published in 1777, he describes it as "un mica martial et alumineux" (vol. i, p. 194), and as "Mica gris, onctueux, coloré par le fer" (vol. ii, p. 206).

Mineralogicum," in which (vol. ii, p. 249) we find: "Ferrum corrosum, Volatile, mineralisatum, minera nigrescente, squamosa, pictoria, magneti refractaria. Molybdæna." "Plumbago. Non-nullorum." A number of synonyms are given, and we are told that it is "in igne aperto ad maximam partem Volatilis, ad 70 vel 80 pro-Centenario avolans; in igne vero clauso fortissime persistens sine aliqua mutatione." The first variety, "Molybdæna pura, membranacea, nitens," is evidently the "molybdæna membranacea nitens" of Cronstedt, and therefore the mineral molybdenite. The other varieties, "M. micacea, arenaria" and "M. textura chalybea," are apparently both graphite.

The references to galena and bleischweif (vol. ii, pp. 302-6) are practically the same as in the original work. There is an interesting note on plumbago: "Plumbaginis vox diversimodo sumitur a Mineralogis; alii hoc nomine Galenam plumbi . . . indicarunt, quam distinctionis gratia, vocarunt Plumbaginem Metallicam; alii Molybdænam hoc nomine compellarunt, quam inter Mineras ferri descripsimus, eandemque vocarunt Plumbaginem scriptoriam. Alii hanc, quam heic descripsimus, mineram plumbaginem simpliciter vocarunt, quos, ad evitandam confusionem secuti sumus."

In 1778 a German edition of the mineral portion of the "Systema Naturæ" of Linnæus, translated and enlarged by J. F. Gmelin, was published at Nuremberg under the title "Völlständiges Natursystem des Mineralreichs." Here (vol. iii, p. 66) the genus Molybdænum is used in the same manner as in the Latin edition of 1768 already quoted. The first species is *M. plumbago*, with the synonyms Wasserbley, Löschbley, Reissbley, Schreibley, Töpferbley, Schwarzbleiweisse, Bleyerz, schwarz Bleyerz, Eisenfarbe, Eisenschwärze, schwarze Kreide, schwarzer Ocker, Blende, Blyertz (*Swed.*), black lead ore, blacklead, plomb de mer, mine de plomb, noire, crayon noir, plumbagine, molybdène, *μολυβδιτης*, plumbago, plumbum nigrum, mica pictoria, and molybdæna. The translator seems to have had no suspicion that there were two entirely different substances to which these different expressions were applied.

The two other species of Molybdænum are the same as in the Latin edition. In the genus Plumbum there are several species, including *P. galena*, Bleyglanz, galena; *P. compactum*, Bley-schweif, plumbago (pp. 212, 222). Another genus, 'Galena,' included a number of sulphides of different metals (pp. 85, 96).

The obscurity that had so long prevailed with regard to the

true nature of graphite and molybdenite, then known alike as molybdæna or plumbago, was at length dissipated by the work of C. W. Scheele, which was published in the Proceedings of the Royal Society of Sweden in 1778 and 1779.

The first paper, which appeared in 1778 (Kongl. Sven. Vet. Acad. Hand., vol. xxxix, p. 247), and was entitled "Försök med Blyerts, Molybdæna," commences by the statement that the author is not treating of the common blyerts of the shops, but with what Cronstedt called "Molybdæna membranacea nitens," and on which Qvist and others made experiments. He demonstrates that this substance, which he refers to throughout as molybdæna, was a combination of sulphur with an acid of metallic nature which he separated out. This was an accurate statement of the facts in the language of a time when the part played by oxygen in nature was still unrecognized.

In the succeeding year he published another paper (op. cit., vol. xl, p. 238), "Försök med Blyerts, Plumbago," in which he shows that the blyerts well known in commerce, the "molybdæna, textura micacea et granulata" of Cronstedt, now known as graphite, was a mineral sulphur or charcoal, the constituent parts of which were aerial acid (carbonic acid gas) and a considerable amount of phlogiston. This again is correct in terms of the old phlogiston phraseology, in which phlogiston is a kind of negative oxygen, so that aerial acid + phlogiston = carbon. A small quantity of iron was, he said, probably present in the form of pyrites, which yielded sulphurous fumes on heating. He showed that this blyerts was also obtained as a residuum when cast iron was dissolved in acid. The word blyerts is used throughout, plumbago only appearing in the title.

It is not quite clear why Scheele allocated to molybdenite the term molybdæna, which had for many years been on the whole more frequently applied to graphite. Apparently, at the time of the first paper he thought that the Swedish term blyerts was sufficient for the better known mineral. Afterwards, when he wanted a Latin term for graphite, plumbago was the most commonly known word that still remained available. However this may be, his usage decided the future application of the terms.<sup>1</sup>

<sup>1</sup> Even as late as 1779 we find molybdene and plombagine used as synonyms. A. G. Monnet, "Nouveau Système de Minéralogie," Bouillon, 1779, p. 180. Again, in the "Mineralogie" of J. F. Gmelin, published at Nuremberg in 1780 (p. 85), graphite is still (and apparently molybdenite as well) referred to only as Wasserbley, and considered to consist of talc, with much iron, often sulphur, and more rarely tin.

A translation of the second paper into French by 'M. Mgn. de Dijon' appeared in "Observations sur la Physique," vol. xix, 1782, p. 162. In this translation the word *plombagine* is used throughout for graphite. The next volume, published in the same year, contained (p. 342) a translation by 'Madame P. . . de Dijon' of the earlier paper, and in this *molybdène* is used in the same way as *molybdæna* in the original.<sup>1</sup>

English translations of these papers, by Thomas Beddoes, appeared in the "Chemical Essays of Charles William Scheele," published in 1786, and in these the terms *molybdæna* and *plumbago* are used in like manner<sup>2</sup> (pp. 227, 243).

In the "Sciagraphia" of Tobernus Bergman, yet another Swedish mineralogist, published at Leipzig and Dessavia in 1782, we find (p. 93), "*plumbago*" described among inflammable bodies as "*Phlogiston acido aëreo satiatum*," with the comment "*Compositionem genuinam detexit D. Scheele*," and "*molybdæna*" as "*Phlogiston acido, tam vitriolico, quam molybdænæ adunatum, vel, quod eodem recidit, sulphur cum acido molybdænæ conjunctum*."<sup>3</sup>

An English translation, by William Withering, appeared in 1783, where we read (p. 64): "*Phlogiston saturated with aerial acid. . . Plumbago. Black-lead*," and "*Phlogiston united to the acid of vitriol and of molybdæna; or what amounts to the same, sulphur joined to the acid of molybdæna. . . Molybdæna [Latin], Molybdæna [English]*."

In the "Elements of Mineralogy," by Richard Kirwan, F.R.S.,

<sup>1</sup> It appears that Romé de Lisle was engaged in the study of graphite at the same time as Scheele, and had obtained results which, if rightly interpreted, would have disclosed the real constitution of the mineral. He was not convinced by Scheele's work, and expressed his belief that Scheele's *molybdæna* was identical with *mine de fer micacée grise*, viz. micaceous iron ore, an oxide of iron, and that his *plumbago* owed its action on nitre "*au fer noirâtre phlogistiqué, en un mot à l'éthiops martial natif et à la matière grasse qui s'y rencontrent*." See B. G. Sage, "*Elémens de Minéralogie Docimastique*," 2nd edition, 1777, vol. i, p. 194, and vol. ii, p. 207; P. J. Macquer, "*Dictionnaire de Chimie*," 2nd edition, 1778, under *molybdène*; Romé de Lisle, "*Crystallographie*," 1783, vol. ii, p. 501, and "*Description Méthodique*," 1773, p. 165.

<sup>2</sup> *Molibdena* and *piombaggine* were adopted in the same senses in Italian in a note to the article "*Molibdena*" in the translation of Macquer's "*Dictionnaire de Chimie*," by G. A. Scopoli, vol. vii, Paris, 1784, p. 69.

<sup>3</sup> In the second volume, published in 1783, of a German translation of the Latin edition of Wallerius, cited above, the latter is followed more or less closely, so that we find the words *molybdæna* and *plumbago* employed in the same way as before, but a brief reference is made to Scheele and Bergman, and the new distinction between the terms (pp. 235-9, 297).

published in 1784, we have a fuller explanation of these terms. "Plumbago, Reissbley, of the Germans, Blyertz, of the Swedes." "In a strong heat and open fire it is wholly volatile, leaving only a little iron, which seems to be only accidentally found in it, and a few grains of silex. It is probable that 100 grains of it contain 33 of acrial acid, and 67 of phlogiston" (p. 158). "Molybdena, Molybdena membranacea, Cronst. . . . Wasserbley of the Germans." "It resembles plumbago" (p. 357).

Similar views are expressed in the "Handbuch der Mineralogie," by John Fibig, published at Mainz and Frankfort in 1787 (pp. 52, 273), and the second English edition of Cronstedt's work by John Hyacinth de Magellan (1788) (pp. 451, 863).<sup>1</sup>

There was still a certain confusion of ideas, and the fact that plumbago was essentially a form of carbon was apparently still unrealized. Its recognition, however, could not have been long delayed for those who appreciated the importance of Lavoisier's discovery of the true nature of combustion and the part played in it by oxygen, which was now taking the place in chemical theory of its shadowy correlative phlogiston, had not a new misunderstanding arisen. In a paper read before the Académie des Sciences by Vandermonde, Monge, & Berthollet in 1786 (Obs. sur Phys., xxix, 1786, pp. 283-4; Mem. Acad. Roy. Sci., 1786, pp. 193-6), these authors concluded from the production of fixed air by the chemical action of plumbago on oxide of lead or arsenic, that plumbago contained carbon; other experiments showed that it contained iron; they therefore declared that plumbago was a compound of carbon and iron, and for some thirty years this view of its composition was generally accepted.

Meantime, however, the great mineralogist and geological pioneer Werner had bestowed on the mineral a new name, which, it would seem, first appeared in 1789 in the "Bergmännisches Journal," in an article entitled "Mineral System des Herrn Inspektor Werners mit dessen Erlaubnis herausgegeben von C. A. S.

<sup>1</sup> The latter writer states (p. 452) that Pelletier demonstrated that when plumbago "is pure, it neither produces any fixed or inflammable air; both which, when found, are entirely owing to the substances that are mixed with it." As a matter of fact, in the paper referred to, "Sur l'analyse de la Plombagine et de la Molybdene" (Obs. sur Phys., vol. xxvii, 1785, pp. 343 and 434), Pelletier states that plombagine should be regarded as "une substance inflammable particulière," and adds that "les substances dans lesquelles l'air fixe ne paroît pas entrer, donnent après leur décomposition des indices de cet être" (p. 357).

Hoffmann." Here, under "Brennliche Wesen," we find (p. 380) a mineral species "Graphit," with a note (p. 395) "Von andern wird es Reissbley, wie auch (sehr unschicklich) Plumbago genannt," and under "Metallarten," "Molybdän," "Wasserblei" (p. 386).

In the same year was published the "Museum Leskeanum, Regnum Minerale, quod ordine systematico disposuit atque descripsit D. L. Gustavus Karsten." Here (vol. ii, pt. 1, pp. 337-40), under the heading "Graphit," after a long list of authorities and synonyms come the following notes:—"Ehedem war es entweder schlechthin zum Wasserblei (Molybdaen) gerechnet, oder nur specifisch von ihm unterschieden." "Die neuern Mineralogen nennen dieses Fossil durchgängig im Lateinischen plumbago; da aber dieser Name schon von Aelteren, dem Bleischweif gegeben ist; so hat Herr Werner ihn mit graphites vertauscht, weil sein häufiger Gebrauch zu Bleistiften diesen sehr passend macht. Man könnte daher auch im Deutschen leicht, den sonst gewöhnlichen Ausdruck Reissblei, in Schreibblei umändern."

It would be interesting to know if Werner, in choosing the term graphites, had the Grafo of Ferrante or the graphis plumbea of Boulenger in his mind. Curiously enough, we find the almost identical word graffites in the 'Speculum Lapidum' of Camillus Leonardus (Venice, 1502, p. 32b), as a synonym of Galactides, an ash or milk-coloured stone, apparently similar to chalk, found in the rivers Nile and Athaleus.

On p. 562 of the same volume we find Molybdän and Wasserblei used as synonyms, with molybdænum as the Latin and molybdena as the English equivalents.

In the "Delectus Opusculorum ad Scientiam Naturalem spectantium," published at Leipzig in 1790, is included the Systema Regni Mineralis, Anni MDCCLXXXVIII, of Werner. Here, on p. 555, we find Graphites (Reissbley Plumbago); and on p. 560 Molybdænum galenare (Wasserbley). In each case there is a reference to Karsten's Museum Leskeanum. Apparently this classified list of minerals was first compiled in 1788, but there is no evidence that it was ever published in that year.

Graphite was now used as synonymous with plumbago, both by those who adhered to the old system of chemical nomenclature and those who adopted the new views. J. F. Gmelin, in his "Grundriss der Mineralogie," published at Göttingen in 1790, writes (p. 381): "Reissblei (Schreibblei, Löschblei, Töpferblei, Graphit, Eisen-schwärze, Bleierz, Plumbago) enthält ausser etwas ( $\frac{1}{10}$ ) Eisen, bloss

veste Luft [fixed air or carbonic acid gas] und brennbares Wesen [phlogiston]"; while in a catalogue published by Ignaz von Born at Vienna in the same year we find (vol. ii, pp. 295-9), "Plombagine; Carbure de Fer." "Mr. de Fourcroy regarde la Plombagine comme du charbon formé dans l'intérieur du globe ou enfoui dans la terre." "Plombagine grise. Graphite. . . Elle est composée de Carbone et d'un dixième de Fer." "Barrodal près de Keswig" is given as a locality.

"A plan of a course of lectures on Mineralogy," by John Hailstone, Cambridge, 1792, contains the following (p. 72): "Plumbago. Base of fixed Air united to a small portion of Iron, Black Lead, Graphite." This is, so far as I am aware, the first use of the word graphite in English.<sup>1</sup>

In the thirteenth edition of the "Systema Naturæ" (1793), 'graphites' is used as the generic and plumbago as the specific name of graphite (p. 284), and plumbago is not employed in any other sense. Molybdenite becomes molybdæna vulgaris (p. 309).<sup>2</sup> Meantime Pelletier (op. cit., p. 442) and P. J. Hjelm had separated the metal contained in molybdenite, and the latter had given it the name of molybdenum ("Kongl. Sven. Acad. Nya, Hand.," vol. ix, 1788, p. 288).

In 1796 the second volume of the second edition of Kirwan's "Elements of Mineralogy" was published in Dublin. On p. 58 of vol. ii we find: "Carbon, combined with one-tenth, or one-eighth of its weight of Metallic Iron. Plumbago. Graphite of Werner, Reisbley of others. Blyertz of the Swedes."<sup>3</sup>

On p. 319, under the heading "Molybdenite (Molybdenum of Hjelm)," an account is given of the metal molybdenum. The first mineral species under this heading is described as "Mineralized by sulphur. Molybdæna, or Molybden, Wasserbley of the Germans, Bleyertz of the Swedes" (p. 322).

<sup>1</sup> See also "A System of Mineralogy," founded chiefly on the plan of Cronstedt, by J. G. Schmeisser, London, 1794, p. 303, and "A Systematic Arrangement of Minerals," by William Babington, London, 1795, p. 25.

<sup>2</sup> In "A General System of Nature," by Sir Charles Linnæus, London, 1806, pp. 237, 309, Molybdenum is made the generic name of the mineral in analogy with the procedure of Linnæus in the case of the compounds of the other metals, and following the editions of 1768 and 1778.

<sup>3</sup> On p. 184 we find as the third species of iron "Mineralized by Carbon. plombaginous, or meaceous iron ore. Eisen Glimmer of Werner. . . the single scales are somewhat Transparent, and transmit a reddish light." This is what is now known as specular iron ore, a variety of hæmatite ( $\text{Fe}_2\text{O}_3$ ). It contains no carbon and is in no way allied to plumbago (see p. 166 *ante*).

In 1807 Brongniart, in his *Mineralogy* (ii, p. 92), apparently misunderstanding Karsten, applied his term molybdenite to the mineral sulphide instead of the metal, and it has since continued in general use in this sense, both in French and English. In Germany the older form *Molybdän* has continued to be used for the sulphide, but 'Molybdän glanz,' first employed by Karsten (Tab., 1808, p. 70), is also in use in Germany. The name 'edler Molybdänglanz' was given by A. Breithaupt ("Vollst. Char. Min. Syst.," 1832, pp. 273, 233) to an auriferous variety of nagyagite, a mineral containing sulphur, tellurium, and antimony, and the terms *argent molybdique* (Born, op. cit., 1790, ii, p. 419) and *Molybdän Silber* (Werner, "Letz. Min. Syst.," 1817, pp. 18, 48) were applied to a variety of tetradymite (a sulphotelluride of bismuth), containing silver. These and other tellurium minerals, which are similar in appearance to molybdenite, are often associated with gold, and the references to the occurrence of gold with 'molybdæna' in early writers (e.g., Berlichius, loc. cit., and Brünnich in his notes on Cronstedt's *Mineralogy*, German edition of 1770, p. 181, and appendix to the English edition of 1772, p. 14) render it probable that they were included under that term.

The mineral known as plumbago or graphite continued to be considered a carbide of iron till Karsten in 1826 ("Arch. Bergbau u. Huttenk.," vol. xii, pp. 91-6) and Sefstrom in 1828 ("Jern Contorets Ann.," vol. xii, pt. 1, 1829, p. 145) showed that the old view, that the iron was only present as an impurity in the form of iron pyrites, was correct, and that the mineral was merely a pure form of carbon.

The name of graphite appears to have come earlier into general use in Germany, where, however, *Reiszblei* still survives, than in France or England. In France *mine de plomb* and *plombagine* are still widely used, though graphite is the recognized scientific expression for the mineral. In English we have the choice of the three terms *black lead*, *plumbago*, and *graphite*, but the French form *plombagine* has been occasionally used. At the present day the term *black lead* is still popular, while *plumbago* is almost confined to the language of commerce and of the arts, including mining. Graphite has long been firmly established in scientific literature, and is gradually extending its sphere of employment. This is particularly the case in America, as is illustrated by the fact that while the term *plumbago* was employed as a heading in the first volume (1892) of the "Mining Industry," annually

published in New York, this designation was changed to graphite in subsequent issues.<sup>1</sup>

In Italian both *grafitto* and *piombaggine* are still in use, and in Spanish *grafito* and *plombagina*, as well as *lápiz*, *lápiz plomo*, *alquifol* (properly *galena*), *carbon*, *chacal*, *mina de plomo*, and *piedra mineral de plomo* (E. Halse, *Dict. Span. Min. Terms*, 1908, p. 176).

In tracing the history of these words I have had often to pass from country to country, and from one idiom to another; for the literature of science is to some extent at least international in character, so that it is impossible to give an intelligible account of its technical terms if the attention is confined to one state or a single language. The stream of speculation and research to which we owe our knowledge of the laws of nature and our control, such as it is, over its forces, has wandered far on its way to where we stand, and has paid but little heed to frontiers of any kind, even the narrow seas that have in so many ways fostered our individuality among the peoples of Europe.

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<sup>1</sup> See also "Graphite," by F. Cirkel, Ottawa, 1907, in which *plumbago* is only used in quotations, though the subject is treated from the economic standpoint.