

DEVELOPMENT OF ORE DEPOSIT THEORIES IN EUROPE.

Sir: In his instructive essay "The Origin of Metallic Concentrations by Magmation,"¹ J. E. Spurr gives a review of the theories concerning the formation of ore deposits. In this connection he discusses particularly the contrast between the lateral secretion theory and the magmatic water theory, and refers to the former as the German, and to the latter as the French school.

Anyone acquainted with the development of theories concerning ore deposits in Europe knows, that it is altogether unjustifiable to refer to the theory of lateral secretion as any one national school and to the magmatic water theory as any other national school. It is true, to be sure, that the great French scientist Elie de Beaumont formulated the volcanic emissions theory in the modern way. It is also true that since then no other theory has been able to gain a foothold in France, presumably because scientific activities are centralized in France as in no other country. The authority of a scientist like Elie de Beaumont necessarily made itself felt for a particularly long time. But similar theories had already been formulated by others long before Elie de Beaumont, as, for example, even in the seventeenth and eighteenth centuries by the German scientists Becher² and Lehmann.³ To be sure at that time all geological

¹ ECON. GEOL., vol. XVIII., 1923, p. 617.

² "Actorum laboratorii chymici Monacensis seu Physicae subterraneae," libri II., Frankfurt, 1669.

theories were still incomplete and fantastic. After the victory of vulcanism over neptunism, the modern theories of the formation of ore deposits by ascension gained recognition in Germany as well as in France. Thus some time before Elie de Beaumont published his "Note sur les émanations volcaniques et métallifères,"⁴ C. G. A. von Weissenbach wrote: "Most of the modern German geologists regard the metallic veins as deposited by sublimation or as the residue of mineral springs."⁵

The ideas fundamental in the lateral secretion theory were also stated in more or less fantastic form by various scientists⁶ as early as the eighteenth century. This theory found its most ardent champions in the second half of the nineteenth century in the German scientists Sandberger and Bischof. Through the influence of Sandberger this doctrine spread to North America, where it maintained itself during several decades as the only recognized one. Nevertheless it is wrong simply to call the lateral secretion theory by any national name, for not only have some scientists in other countries, contemporaneously with and also before Sandberger, supported similar views, as for instance Dieulafait⁷ in France and Wallace⁸ in England, but one must also bear in mind that Sandberger's theory never obtained such general recognition in Germany as it did in North America before 1890. In Germany there was always a large group of

³ "Von den Metallmüttern und der Erzeugung der Metalle," Berlin, 1753.

⁴ *Bull. Soc. Géol. de France*, II. ser., vol. 4, 1847, p. 1249-1332.

⁵ C. G. A. v. Weissenbach, "Über Gangformationen. Ein Fragment." Published in: B. Cotta, "Gangstudien oder Beiträge zur Kenntnis der Erzgänge," Freiberg, 1850. Weissenbach had written the cited paper shortly before his death in 1846.

⁶ Delius, "Vom Ursprung der Gebirge und der darin befindlichen Erzadern," Wien, 1770.

Gerhard, "Versuch einer Geschichte des Mineralreichs," Berlin, 1781.

Lasius, "Beobachtungen über die Harzgebirge," Hannover, 1789.

⁷ L. Dieulafait, "Existence de baryte et de la strontiane dans toutes les roches primordiales, etc. Filons métallifères à gangues de baryte," *Comptes-rendues Acad. Sci. Paris*, vol. 87, 1878, p. 934. Further notes by Dieulafait concerning lateral secretion are published in the same journal, vol. 89, 1879, p. 453, vol. 96, 1883, p. 70 and vol. 98, 1884, p. 568 and p. 634.

⁸ W. Wallace, "The Laws which Regulate the Disposition of Lead Ore in Veins Illustrated by the Mining Districts of Alston Moor, London, 1861.

eminent scientists who opposed the lateral secretion theory. Even the ideas of v. Groddeck⁹ are more akin to the ideas of Posepny than to those of Sandberger. In still closer agreement with our modern views are the theories which Cotta¹⁰ formulated as early as the middle of the last century. Furthermore, immediately after Sandberger had formulated his theories, he was very energetically and successfully opposed by Stelzner.¹¹ Likewise Beck,¹² the well known teacher of economic geology in Freiberg, although he has recognized the validity of the lateral secretion theory in a limited—and well justified—domain, adopts for the rest a point of view similar to that of Stelzner. Thus the magmatic water theory seems always to have more supporters in Germany in the last half century than Sandberger's lateral secretion theory.

A survey of the development of ore deposit theory during the last century makes it clear that although our views have gained in precision and rigor, the increase in the number of fundamentally new ideas of theoretical importance is very small. It can be shown that nearly all theories of ore deposition were formulated, fundamentally at least, as early as the eighteenth century, though in more or less fantastic form.

Also Spurr's theory of the formation of metallic veins by

⁹ A. von Groddeck, "Die Lehre von den Lagerstätten der Erze," Leipzig, 1879. P. 331, he quotes the different theories on vein-filling as: "Congenerationstheorie, Lateralsekretionstheorie, Descensionstheorie, Ascensionstheorie," and then he says: "Wir sehen, dass eine Erklärung nicht für alle Gänge passt, und dass die verschiedenen Forscher, welche die angeführten Theorien aufstellten, nur darin fehlten, dass sie aus einzelnen Fällen richtig abgeleitete Anschauungen unlogisch verallgemeinerten."

¹⁰ B. v. Cotta, "Die Lehre von den Erzlagertstätten," Freiberg, 1859. P. 187, he says: "So zeigt sich also nicht nur die Möglichkeit, sondern auch die Wahrscheinlichkeit der Erzgangbildung als eine sehr mannigfaltige, stets aber scheint sie in einer gewissen Verbindung mit nachbarlichen, oft kurz vorhergehenden Eruptionen von Eruptivgesteinen gestanden zu haben."

¹¹ A. W. Stelzner, "Die Lateralsekretionstheorie und ihre Bedeutung für das Pribramer Ganggebiet." Berg- u. Huttenm., *Jahrbuch d. k. u. k. Berg-akad.*, vol. 37, 1889. A. W. Stelzner, "Beiträge zur Entstehung der Freiburger Bleierz- und der erzgebirgischen Zinnerzgänge," *Zeitschrift f. prakt. Geol.*, 1896, pp. 377-412.

¹² R. Beck, "Lehre von den Erzlagertstätten," Berlin, 1901.

magmation is by no means new. It was widespread in Europe in the first half of the nineteenth century after the victory of the vulcanistic views over Wernerian neptunism. Petzold¹³ thought all ore veins to be magmatic injections; even Elie de Beaumont regarded some iron ores as intrusives,¹⁴ and some of his sentences prove evidently, that many geologists of his time had views very similar to the views of Spurr;¹⁵ but Elie de Beaumont himself did not approve these views.¹⁶

The most ardent champion of the magmation-theory in the last century was the Frenchman Fournet.¹⁷ In the twentieth century Weinschenk¹⁸ declared the pyrrhotite-lodes of Bodenmais in the Bayrische Wald as magmatic injections; Vogt and Brögger had similar views regarding some Scandinavian sulphide-ores.¹⁹

¹³ A. Petzold, "Geologie," Leipzig, 1845, p. 481-501: Über das Vorkommen der Metalle überhaupt und über das Alter und die Entstehungsweise der metallführenden Gänge insbesondere.

¹⁴ E. de Beaumont, "Note sur les émanations volcaniques et métallifères," *Bull. Soc. Géol. de France*, II. ser, vol. 4, 1847. P. 1262, he says: "Il existe même dans différentes contrées des masses de fer oxidulé et de fer oligiste qui peuvent être considérées elles-même comme des roches éruptives."

¹⁵ P. 1285 of the same work he says: "Beaucoup de géologues sont portés à admettre que tous les filons ont été remplis par l'injection de matières en fusion."

¹⁶ P. 1284: "Tous ces faits qui s'enchaînent et qui s'expliquent naturellement lorsqu'on admet que les substances contenues dans les filons sont *volcaniques à la manière du soufre* (= products of sublimation), deviendraient autant d'énigmes inexplicables, si on soutenait qu'elles sont *volcaniques à la manière des laves*."

¹⁷ M. J. Fournet, "Sur l'état de surfusion du quartz dans les roches éruptives et dans les filons métallifères," *Compt.-rend. Acad. Sci.*, vol. 18, Paris, 1844, p. 1050.

M. J. Fournet, "Aperçus relatifs a la théorie des gîtes métallifères," *Compt.-rend.*, vol. 42, 1856, pp. 1097-1105. P. 1103 of this paper he says: "Des masses a l'état de fusion pâteuse, telle qu'ont du l'être assez ordinairement celles des filons, ont été capables de maintenir en suspension les fragments des parois qu'elles ont entraînés avec elles au moment de l'injection."

M. J. Fournet, "Aperçus relatifs a la théorie des filons," *Compt.-rend.*, vol. 43, 1856, pp. 345-352 and pp. 894-900.

¹⁸ Weinschenk, "Die Kieslagerstätten im Silberberg bei Bodenmais," *Abhandl. d. Kgl. Bayr. Akad. d. Wissensch.*, II. Klasse, vol. XXI., 2 Abt., 1901.

¹⁹ Vogt, "Über die Bildung von Erzlagerstätten durch magnatische Differentiation," *Fortschritte der Mineralogie, Kristallographie und Petrographie*, vol. 2, 1912, p. 24.

The theory which Spurr has called the "Zonal theory" and which has been recently much discussed, was, fundamentally at least, already well known to Cotta seventy years ago.²⁰

New perhaps is the idea of ore formation by magmatic differentiation which was first introduced into science in definite form by Vogt at the end of the last century. Nevertheless v. Groddeck²¹ regards the magnetite deposits of the Taberg type as magmatic segregations; the same scientist believes a similar manner of formation to be possible also for sulphide-ores.²² Thus the fundamental idea of ore formation by magmatic differentiation has previously been expressed.

Little attention was given also in the earlier decades to the secondary enrichment of sulphide ores. The zones of enrichment had been known for a long time, to be sure; but the true explanation of their formation was found only at the end of the last century.

Thus, although there are but few new ideas to be mentioned, nevertheless the development of theories on ore deposition in the last hundred years has brought with it a great advance, that is, the knowledge that the manifoldness of the ore deposits can not be explained by a single theory. Every theory is correct in the last analysis, *i.e.*, when limited to particular cases, and every theory is incorrect when regarded as of universal validity. The universally valid theory has done great harm since the beginning, not only to the development of theories on ore deposition, but also to geology as a whole. Historical investigations are, in this respect, very instructive. They show us that we can only then achieve our end if we cease to proceed onesidedly and dogmatically, and if we without prejudice take into account all the theoretical possibilities.

K. HUMMEL.

UNIVERSITY OF GIESSEN,
GERMANY.

²⁰ B. v. Cotta, "Die Lehre von den Erzlagerstätten," 2. ed., Freiberg, 1859, Pt. I., pp. 129-131.

²¹ A. v. Groddeck, "Die Lehre von den Erzlagerstätten," Leipzig, 1879, p. 142 and p. 278.

²² *Loc. cit.*, p. 278.