BOOK REVIEWS

Routhier, P. *Ou sont les métaux pour l'avenir? Les provinces métalliques. Essai de métallogénie globale.* Orleans: Bureau de Recherche Géologique et Minières, Mémoire no. 105 (1980). 410 pp., 97 figs. Price FFr 290.00.

Where are the metals for the future? It is a good question for times when the world continues to extract and use metals at, on the average, an exponentially increasing rate. Dr Routhier, formerly Professor of Applied Geology at the University of Paris, and after a brief period as Director of BRGM, since 1973 Director of the CNRS project on Metallogenic Provinces, reminds us in his preamble that the earth's crust contains a reserve of minerals which from a (human) practical point of view, does not renew itself. These have been accumulated in concentrated deposits during upwards of 3 billion years. Our knowledge of these reserves, conditioned by predetermined requirements, is still extremely limited. The political vicissitudes affecting the provision of minerals, and the continuing search for workable lower-grade ores, requires in most countries an improved knowledge of the riches of the subsurface. The making of increasingly systematic inventories, though strongly affected by economic conditions, is nevertheless clearly necessary.

Routhier's contribution to mineral inventorying is to propose what he claims to be a new approach to metallogenic provinces. Current expositions of this subject he groups into three (*a*) time-structure-facies, particularly advocated by A. Bilibine, (*b*) lineament or rhegmatic, and (*c*) global tectonic where most ore-generation is supposed to be related to subduction zones; but he argues that none of the hypotheses are satisfactory. Instead, he advocates the recognition of provinces of mineral potential, often forming broad belts, and probably connected with the Earth's mantle. Such belts carry major ore concentrations except where they are affected by metallotects (a term previously introduced by the author, which I can most easily define for English readers as the sum of coincident features leading to strong concentration of metals; it will be evident from this that a wide variety of geological factors may be involved). Metallotects tend to be located, according to Routhier, along linear zones which intersect the metallogenic province at various angles, revealing its potential as a reservoir of metals.

On this basis a number of well-established mineral provinces are analysed: the South Iberian pyritic belt; the copper domain of southern Morocco; the lead-zinc belts of Europe, the province of Hercynian granites with tin and copper deposits, the copper belt of eastern Europe associated with the Kupferschiefer and its equivalents; the zinc-lead deposits of the American Middle West, and the great cupriferous belt encircling the Pacific. An interesting chapter is devoted to the typology of tin and tungsten deposits.

Dr Routhier's research programme was carried out in association with those preparing the Metalliferous Map of the World, for IUGS/UNESCO; this has enabled him to prepare a number of diagrams (many of them colour-printed and enclosed in the back of the memoir) on which not merely the geographical positions of major ore deposits are indicated in relation to a basic form of geology, as on the Metalliferous Map, but major ore provinces and the intersecting metallotect belts are indicated. The map of the United States (fig. 20) is interesting; Allen Heyl's tentative idea that the zinc-lead mineralization may be related to the belt of fracturing following the 38th parallel is adopted. The picture does nothing to lessen the scepticism I feel in company with many others about the validity of this association which appears to have no bearing on the movements of hypersaline brines comparable with those existing now beneath parts of Louisiana, and which almost certainly explain the Mid-West mineralization. Passing the line of the Rocky Mountains, I doubt whether anyone would dispute that the great western mountain region is part of one of the world's great metallogenic provinces as it flows around the structurally stable Colorado Plateau; but to identify metallotects by intersecting linear zones within this region seems a great oversimplification of a complex problem. One of the most interesting maps is that showing the Africa–South America fit. (fig. 71); to make such a map is an exciting project, but in the event the outcome is confusing; it would have been less so had bold lines been used to show the edges of the continental shelves of the two continental masses. The metalliferous correlation across the fit is not as close as might have been expected, no doubt in part due to the fact that some of the ore deposits post-date the separation by continental drift. Turning to the sketch-map of some domains of mineralization in Europe (fig. 10), one such domain is suggested extending from Tynagh in Ireland through the English Pennines to the Oslo graben. Such a province may exist; but I am bound to point out that the positions given for the Pennine orefields are grossly inaccurate, and to express the hope that this inaccuracy does not apply to other

districts. Further, the intersection of the domain by a NNW-trending line may be intended to represent the mythical Pennine Anticline, but I can assure Dr Routhier that the metallotect control in the Pennines is something far more sophisticated. The critical comments notwithstanding, there is a wealth of interesting data in these maps which the student of global-scale distribution of economic minerals will certainly wish to ponder upon. The global coverage is not complete; Mexico and Central America, Canada, and the great mass of the Soviet Union, the last-mentioned with an extensive literature on metallogenic provinces, have not been included; but there is quite enough food for thought.

Dr Routhier complains that his writings are not, generally speaking, read in the English-speaking world, and I think there is substance in his complaint. He had in fact hoped to publish an English-language edition of this memoir, but in the end had to be content with English subtitles and explanations on his ninety-seven diagrams. While sympathizing, I feel bound to point out that, while he is familiar with some of the American literature, his bibliographies suggest that he does not follow the British literature. It is striking, for example, that the fluorspar-producing regions of Derbyshire and West Durham, which have been and are as productive as any European district, are omitted from the fluorine map, and the only references given in the relevant chapter are to four Irish deposits, none of which carries workable fluorspar.

For myself, I regard Routhier as one of the most stimulating writers on ore genesis of our times, a worthy successor indeed to de Launay. His *staccato* logic is memorable; he seeks laws and assertions through the mass of detail to an extent that no English writer dare attempt. I propose to complete this review by summarizing the laws of metallogeny that he has derived from the seven-year long research of which the memoir is a record.

1. Concentrations of a metal come into existence at the intersection of a metallic domain (a volume of lithosphere able to descend to the mantle, having over a long period of time a metallic potential) with metallotects which reveal that potential.

2. Many belts can be broken down into subdomains oriented transversally, in which the rich zones occur.

3. The association of several metals or substances in a deposit can often be considered as due to the superposition of two or more domains.

4. Domains may be independent of major structures, and in the continental plates may pass from one structural region to another.

5. In strongly polymetallic domains, the metals are distributed, on very variable scales, in horizontal and vertical zonality, the most consistent, Cu–Zn–Pb, conforming with the chalcophile order.

6. In relation to time, the first accumulation of metals after 3750 m.y. before present was of Fe (Isua, Greenland); then during the Archaean, Fe, Au, Cr, Pt, Ni; during the Lower Proterozoic, more Fe and Au but also Cu which culminated in the Upper Proterozoic. During Middle Proterozoic time, Pb and Zn appeared at about 1500 m.y., Sn and W at 1.1 m.y.

7. Starting from the moment when a domain became specialized in one or other metal, subsequent events reveal a tendency to perpetuate this specialization. Certain metals or substances appear to be spatially, or spatio-temporally persistent; examples include Sn, W, F, Pb, Zn.

8. The great accumulations of metals reflect strong horizontal and/or vertical gradients in temperature, pressure, and metal-content. Practically the result is that the indications of strong gradients, abrupt lithological changes, or stuctural transition are metallotects which can be used as guides to ore.

The final figure (97) is headed 'for excitement'. There is much in this lengthy and interesting study to stir the imagination and incite the argumentative.

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Embrey, P. G., and Fuller, J. P., Editors. *A manual of new mineral names 1892–1978*. London (British Museum [Natur. Hist.] and Oxford University Press) and New York (Oxford University Press) (1980). x + 468 pp. Price £24·00 ($49.50).

This work is an alphabetically arranged, collected edition of the thirty *Lists of new mineral names* (started by L. J. Spencer and continued by M. H. Hey) that have been published since 1897 in this magazine, with editorial comments and references to significant later investigations. In some respects the result may be considered as a companion volume to Chester's *A dictionary of the names of minerals* (New York, 1896), as the dates run on with minimum overlap. Names of valid species are printed in bold-face type at the start of an entry, but these represent perhaps less than a third of the entries.

This is much more than a routine listing of minerals, synthetic phases given mineral-like names, gem simulants, and industrial products. The editors give the derivation of the names and often their own views on the correct form, e.g. that böhmite is more correct than boehmite, or that yanshynshite is an unnecessary name for a variety of thorogummite. A variety of incidental but useful data is often added: e.g. for jonesite the optical and physical properties, or for lueshite the fact that it