Estimating and finding seafloor and sub-seafloor sulfide mineralization: optimists versus pessimists?

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Portugal, a small nation in Western Europe, detains exclusive economic rights over a very large area of the North Atlantic deep sea floor, and presented to ISA a claim for an extension of its legal continental shelf, to a total of nearly 4 million km^2, or 42 times the size of the country above sea level (Abreu et al., 2012). Portugal has also strategic options towards the South Atlantic and many of its nations, namely Brazil.

Underwater mining is about to begin, marking the onset of a new era. Two classes of resources are technically very close to feasibility: polymetallic nodules and seafloor massive sulfide (sms) deposits. Other issues being actively addressed by the scientific community are the environmental impacts (which must be negligible) and the economic significance of the mining operations.

Several influential, recent publications have addressed the issue of estimating the resource base of seafloor massive sulfide (sms) deposits (Cathles, 2011; Hannington et al., 2011; Hannington 2011, 2013). From a cursory evaluation of these and related articles, it may appear that some authors are optimists, whereas others are pessimists. Thus Cathes (op. cit.) estimates that at an efficiency of 3%, the amount of copper in seafloor mineral deposits, 106,000•10^6 mt, would last >6,000 years at the current rate of extraction, whereas Hannington and co-authors found the amount of copper and zinc in the easily accessible neovolcanic zones of the global oceans to be of just 30•10^6 mt.

The large discrepancy in the two estimates is not a matter of optimism versus pessimism, but rather results from the fact that two different reservoirs are being estimated. Cathles evaluates the total metal retained in mineral deposits in the oceanic crust (exposed plus concealed) whereas Hannington et al compute exclusively "significant massive sulfide accumulation" *on* the seafloor, in the easily accessible neovolcanic zones of the global oceans. The Cathles estimate differs in two main aspects: a) the whole area of the global oceans is included; and b) the implicated mineralisations are not only on, but also under the seafloor.

Recently Hannington (2013) evaluated the various mechanisms of Cu mobility and fixation in the oceanic crust, of relevance to the Cu of the subducting slab. Some very interesting conclusions of this study include (1) the relevance of sub-seafloor mineralization and alteration, with more than 80% of the labile Cu that may be released to subduction fluids driven off a downgoing slab, and 2) massive sulfide deposits, nodules and manganiferous crusts may account for only ~3% of the Cu metal of the subducting slab. The possible implications for arc-related mineralizations are obvious and far-reaching. For the future of underwater mining, it is no less obvious that the real targets will be sub-seafloor orebodies, in a not too distant future. The new challenge will soon be finding the concealed orebodies, and mining them with minimal disturbance of the deep sea ecosystems.

References

Abreu, M. P., P. N. Coelho, N. Lourenco, A. S. Campos, P. Conceição, R. Costa, F. C. Dias, A. Calado, M. A. Martins, M. Neves and Restante.Equipa.EMEPC (2012). Extensão da Plataforma Continental, Um Projeto de Portugal - Seis anos de missão (2004-2010). Lisboa, Estrutura de Missão para o Alargamento da Plataforma Continental - EMEPC.

Cathles, L. (2011). "What processes at mid-ocean ridges tell us about volcanogenic massive sulfide deposits." Mineralium Deposita **46**(5): 639-657.

Hannington, M. (2011). "Comments on "What processes at mid-ocean ridges tell us about volcanogenic massive sulfide deposits" by LM Cathles." Mineralium Deposita **46**(5-6): 659-663.

Hannington, M. D. (2013). "The role of black smokers in the Cu mass balance of the oceanic crust." Earth and Planetary Science Letters **374**: 215-226.

Hannington, M., J. Jamieson, T. Monecke, S. Petersen and S. Beaulieu (2011). "The abundance of seafloor massive sulphide deposits." Geology **39**: 1155-1158.

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