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Migration of chalcophile elements in the oceanic lithosphere and implications for future SMS prospecting along the Mid-Atlantic Ridge (MAR, 26-33°N)

JAKUB CIĄŻELA[1], MICHAL TOMCZAK[2], DARIUSZ MARCINIAK[3], MR. BARTOSZ PIETEREK[4] AND AGATA KOZLOWSKA-ROMAN[2]

[1]Institute of Geological Sciences Polish Academy of Sciences
[2]Państwowy Instytut Geologiczny - Państwowy Instytut Badawczy
[3]Institute of Geological Sciences, Polish Academy of Sciences
[4]Adam Mickiewicz University Poznań

Presenting Author: j.ciazela@twarda.pan.pl

The highest-grade seafloor massive sulfide (SMS) deposits seem to be hosted in plutonic rocks, often in the oceanic core complexes (OCC). OCCs expose the lower crust and mantle uplifted to the seafloor along detachment faults at the ultraslow-to-intermediate spreading ridges. In fact, SMSs occur at slow- (86%) rather than at intermediate- (12%) or fast-spreading ridges (2%). This is reflected in the distribution of regions authorized by the International Seabed Authority (ISA) for sulfide exploration with all seven contractors, including Poland, operating on slow- to intermediate-spreading ridge segments with OCCs. Slow-spread oceanic crust is thinner and more heterogeneous than fast-spread oceanic crust which affects sulfide differentiation during magmatic processes and metal transport between the mantle and the ocean floor. To better understand sulfide differentiation in slow-spreading ridges, we investigated igneous rocks from two extensively sampled OCCs with high (Atlantis Bank, 57°E, Southwest Indian Ridge) and low (Kane Megamullion, 23°N, MAR) magma supply. In large gabbroic bodies of Atlantis Bank, sulfides differentiate mostly through fractional crystallization. Sulfides fractionate early and accumulate at the lower part of gabbroic bodies enriched by ~50% in Cu and by ~100% in S compared to the upper parts. Besides, gabbro bodies located deeper in the crust are enriched in chalcophile elements compared to shallower gabbro bodies. In Kane Megamullion with low magma supply, sulfides typically differentiate through melt-mantle reaction. This process may be global (Marciniak et al., this session; Pieterek et al. this session), but it becomes increasingly significant at ridge segments with low magma supply and thin crust, where the melt-mantle reaction can proceed to very shallow depths. Melt-mantle reaction leads to high sulfide enrichment at the contacts of gabbro and peridotite often shallow under the ocean floor.

Most SMSs, especially with the highest Cu grades, occur along slow-spread oceanic lithosphere with relatively low magma supply. The peculiar distribution of the seafloor massive sulfide seems to reflect the style of magmatic differentiation determined by magma supply. These results will aid in exploration for SMS deposits within the Polish contracted area along the MAR (26–33°N), where the lithosphere structure mostly resembles that at the Kane Megamullion.