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Magmatic and hydrothermal metal migration through a slow-spreading oceanic crust: Central Sudetic Ophiolite

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We investigated the distribution of chalcophile metals, sulfur, and sulfides in 142 slow-spread crust samples of the Central Sudetic Ophiolite (CSO), Poland, including the lowermost crust of the Nowa Ruda Massif (NRM), the full-crust profile of the Ślęża Massif (SM), and the Przecławice IG-2 borehole lower crust (605 m deep).

In situ analytical methods revealed the predominance of magmatic sulfides of pyrrhotite, chalcopyrite, and pentlandite. Hydrothermal sulfides are composed of pyrite, chalcopyrite, sphalerite, cobaltite, and galena, although pyrrhotite also occurs. Ilmenite and titanomagnetite are the main oxides. Mg# decreases upward, averaging 84 for troctolites, 62 for gabrroic rocks, 47 for diabases, 51 for basalts. The oxide-rich gabbro of SM evolved to lower Mg# (38) than the regular gabbro (71). Przecławice IG-2 gabbro is less evolved, with an average Mg# of 70.

On average, Cu, Cr, and Ni decrease upward from 79 ppm, 683 ppm, and 288 ppm in the lowermost crust to 65 ppm, 568 ppm, and 94 ppm in the overlying gabbroic body to 31 ppm, 64 ppm, and 40 ppm in the gabbro-dike transition zone, respectively. Elevated concentrations of TS (2203 ppm), accompanied by significant concentrations of Cu (74 ppm), Zn (260 ppm), and Co (95 ppm), implied an enrichment process in the sheeted dikes. The metal concentrations of the IG-2 borehole reveal magmatic differentiation trends in smaller-scale gabbroic bodies, with notable sulfur enrichment at 164-139, 357-331, 427, and 548-565m depths, reaching up to 3350 ppm. $\delta^{34}S_{whole\text{-}rock}$ of the SM gabbro, Przecławice IG-2 borehole, and NRM samples reflect a mantle signature (+0.1 to +1.9‰, −1.8 to +1.5‰, −0.5 to 1.5‰). Heavy sulfide-S δ^{34} was introduced (0.7 to 3.4‰) to the SM's dikes. $\delta^{34}S_{In\text{-}situ}$ of pyrrhotites (+1.2 to +10.0‰), chalcopyrites (+0.5 to +6.6‰) and pyrites (+3.1 to +4.8‰) of the SM's dikes contribute to a bulk hydrothermal sulfide $\delta^{34}S_{in\text{-}situ}$ (+2.1 to +3.6‰) consistent with $\delta^{34}S_{whole\text{-}rock}$ (+1.8 to +3‰) in the four respective samples. Magmatic processes control chalcophile metal transport throughout the SM lower crust, while seawater-related hydrothermal activity is evidenced in the overlying dike by δ^{34}S values; mantle δ^{34}S signatures within the S-enriched borehole intervals reflect post-magmatic hydrothermal fluids.