Geochemical controls on the concentration and distribution of gold and silver in seafloor massive sulfide deposits

S. FUCHS[1*], M. HANNINGTON[1] & S. PETERSEN[1]

[1]GEOMAR – Helmholtz Centre for Ocean Research Kiel, Wischhofstrasse 1-3, 24148 Kiel, Germany
[*]sfuchs@geomar.de

Massive sulfides on the modern seafloor represent an important modern analog of anceint Cu, Zn, Fe and Pb deposits. They are also an important sink for Au and Ag and with grades similar to ancient deposits mined on land. Numerous, previous studies showed that the tectonic / geological setting and the nature of metal-transporting hydrothermal fluids play a critical role for the concentration of metals in individual deposits. Cu-, Zn-, Fe- and Pb-bearing sulfide minerals precipitate mainly in response to drastic changes in the temperature, pH and redox state of the high-temperature fluids. The mineralization pathways of Au and Ag, including their hydrothermal transport and formation of discrete minerals / alloys, however, are more complex.

For this study, we calculated geochemical models using compositions of high-temperature vent fluids from different deposits at mid-ocean ridges and back-arc spreading centers to gain insight into the hydrothermal transport and deposition of Au and Ag. The results are compared with geochemical data from various seafloor massive sulfide deposits to reveal key mechanisms responsible for Au and Ag enrichment. Almost all of the investigated fluids are highly undersaturated in Au and Ag, the concentrations of which are controlled by the source rather than by the fluid chemistry. Fluids associated with back-arc environment are generally more oxidized and have a lower pH than fluids from mid-ocean ridges, resulting in a higher Au and Ag solubility. Conductive cooling is a very efficient mechanism to concentrate Au at higher and Ag at lower temperatures. Mixing with infiltrating seawater, however, increases the solubility and limits the precipitation until massive amounts of seawater are involved (>50:1 by volume). Solubility is also increased by the abiotic formation of CH_4 and similar hydrocarbon compounds that occurs at lower temperatures (< 200 °C). Although, the models confirm overall geochemical enrichment of Au and Ag with the base metals, the grades in the models are always lower than they are in nature. This indicates that other processes (e.g., absorption of metal-colloids) also contribute to total budget of Au and Ag in seafloor massive sulfides.