Deep-seated Sediment-hosted Zn-Fe-Pb and F-Ba Mineralization in the North German Basin

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Abstract

Recent years have seen an increased interest in employing models in mineral exploration that are similar to those that successfully aid exploration in the hydrocarbon industry. Sediment-hosted deposits in large basins lend themselves to this approach. In various parts of the North German Basin (NGB) hydrothermal Zn-Fe-Pb sulfide and F-Ba mineralization occur as open space fillings, veins, and fracture coatings in Paleozoic sedimentary rocks and volcanic units at depths of up to four kilometers. As part of the collaborative r4-research project MinNoBeck, we compiled a comprehensive petrographic inventory and detailed mineralogical and geochemical investigation to decipher the processes involved in the formation of these mineralized zones. A particular focus was put on the sediment-hosted Zn-Fe-Pb sulfides in the western part of the NGB, the Lower Saxony Basin, which shares many characteristics that are typical for carbonate-hosted base metal sulfide deposits. Petrographic observations, fluid inclusion and isotope data provide evidence that the Zn-Fe-Pb sulfide mineralization was deposited by highly saline metal-rich basinal brines at temperatures of ~160°C. Carbon and oxygen isotope data point toward fluid mixing augmented by structurally-controlled fluid migration during the onset of the Upper Cretaceous basin inversion as the primary ore precipitation mechanism with no magmatic component. In the Altmark-Brandenburg Basin steeply-dipping F-Ba ± calcite, anhydrite, quartz veinlets in Permo-Carboniferous sandstones and volcanic units are evidence for enhanced post-Variscan structurally-controlled fluid flow in this region. Sulfides are, apart from rare occurrences of chalcopyrite, absent in this part of the NGB. This is interpreted to reflect the deeper paleogeographic basin position of the Altmark-Brandenburg Basin without carbonate aquifers, the lack of reductants such as hydrocarbons, diagenetic pyrite, or organic matter, and the predominance of nitrogen-rich fluids as documented by fluid inclusions. Microanalytical investigations of sphalerite and fluorite revealed the complex zoning and cyclical growth patterns that are also reflected in characteristic minor and trace element compositions. These patterns have been interpreted to represent continuous growth during a single event with intrinsic crystallographic and small-scale physico-chemical variability in the corresponding hydrothermal fluid being the governing factors for compositional variations. Our investigation aims to aid future research of deeply covered sediment-hosted deposits and to more accurately target future resources at depth to meet future resource demands.