Diagensis and Mineralization of the Kupferschiefer, Sangerhausen Basin, Germany

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ABSTRACT

Upper Permian Kupferschiefer black shale of the Sangerhausen Basin, Germany reveals complex textural and temporal relationships among diagenesis, Cu-Zn-Pb-mineralization, and hydrocarbon generation/ migration. These relationships provide a partial record ofthe evolution of permeability within the shale. Metalliferous mineralizing fluids likely migrated primarily through the underlying Weissliegend sandstones, possibly in more than one ore-forming episode. Locally the mineralization moved up-section, breaching the roughly 0.5 m thick organic-rich shale, which is more calcareous upward and is overlain by Zechstein carbonates. Some mineralization is found in the Weissliegend, Kupferschiefer, and Zechstein units, with Cu-Fe sulfides, Cu sulfides and Cu-Zn sulfides dominating the mineralization near the base of the shale, where clay and silt contents are greatest. Sulfides in the more calcareous upper part of the shale are mainly of Zn and Pb. Evidence of authigenic non-ore minerals and of cross-stratal and bedding- parallel fluid migration within the shale is compared for mineralized and non-mineralized localities. Mineralized shale from the retired Wettelrode mine shows isolated well-developed filled-fractures at high angles to bedding now filled variably with barite, calcite, gypsum, sulfide minerals, and bitumen stringers. Bedding-parallel fractures now filled mainly by barite and lesser gypsum and calcite host some sulfide minerals, as well as isolated bitumen inclusions, are more common and more closely spaced than the cross-cutting fractures. Both the abundant bedding parallel filled-fractures and thin stringers of barite parallel to bedding suggest a degree of rather pervasive permeability parallel to bedding. In addition to the mine section, samples from four cores represent non-mineralized and moderately mineralized examples of the Kupferschiefer. Stronger mineralization in the core samples appears to correlate with better development of filled-fractures at high angles to bedding. In the core sections, these fractures are typically filled by calcite with lesser gypsum and barite and isolated bitumen inclusions. Authigenic phases in the matrix of the shale at all five locations include barite, celestite (minor), gypsum, anhydrite, albite, illite, calcite, dolomite, and ferroan dolomite. Barite, albite, and illite all appear to be more abundant in more strongly Cu-mineralized sections. In the lower part of the shale, the carbonates are more common where Cu-mineralization is weak to absent. Spatially, barite, albite, and illite are closely associated, with barite commonly hosting small illite inclusions and enclosing larger patches of albite. Within individual cores and the mine section, spatial variability in the relative abundances of barite and sulfide minerals suggests the barite abundance tracks the advance of oxidizing brine into the shale from the underlying sandstone. Interpretation is, however, complicated by the possibility of multiple episodes of diagenesis and mineralization.