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# 3D Numerical Modelling of Copper Leaching, Transport, and Deposition in Sedimentary Basins

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Sediment-hosted copper deposits are a major global source of copper. This study uses 3D numerical modelling to investigate fluid flow, mineralisation, and copper transport in sedimentary basins. Simulations explore the influence of thermal and salinity gradients, fault architecture, and red-bed heterogeneity on copper leaching, transport, and deposition. Numerical experiments are performed using the open-source IC-FERST code (http://multifluids.github.io/), incorporating buoyancy-driven groundwater flow, heat, salt, and copper transport with dynamic mesh optimisation for computational efficiency.

The case study is inspired by the pre-orogenic stratigraphy of the Katangan Basin in the Central African Copperbelt, noting that many characteristics of this stratigraphy are shared with other copper-hosting sedimentary basins. We simulate fluid flow and copper transport at two key stages of basin evolution: (i) an early stage during evaporite deposition, when dense brines percolate downwards, and (ii) a mid-stage after the basin has developed further, the evaporites have been buried, and there is a thicker basin fill. Modelling flow in these different snapshots allows us to test mineralisation conditions at different diagenetic stages, the impact of an evolving hydrogeological architecture, and the role of heating during burial. Copper leaching is governed by a partition coefficient, while deposition occurs at a constant rate within a specific interval overlying the red beds representing a redox boundary.

The results demonstrate convective cells at two scales. Large (km-scale) convection within permeable faults drives saline groundwater downwards into the basement, where heating drives it back upwards. Over time, asymmetric fault flow develops, with some faults dominated by downward flow and others by upward flow. These large-scale, fault-controlled convective cells are a major driver of copper transport. Small (10s–100s m) scale convection establishes within sufficiently permeable red beds, driving local copper leaching and vertical migration. This vertical flow creates patchy deposits that are not directly associated with faults.

Key controls on mineralisation include leaching efficiency, fault and red-bed permeability, and the presence of a salt source. Early mineralisation occurs only if cool, low-salinity brines effectively leach copper. Mineralisation develops progressively over multiple cycles of convection, rather than a single pass of enriched brine.