

From source to sink: Experimental and modelling constraints on copper mobilisation and deposition in sedimentary basins

Matthew Jackson, Carl Jacquemyn, Meissam Bahlali and Jamie Wilkinson

Department of Earth Science & Engineering, Imperial College London

Sediment-hosted copper deposits account for approximately 23% of the world's discovered copper and typically host higher grade ores than other types of hydrothermal deposits. Their global economic significance has stimulated over a century of research devoted to understanding their geological setting and controls of formation. This has demonstrated that most deposits were formed by leaching of copper and other metals from source rocks; transport of the metals in oxidising, chloride-rich brines as they flow through porous, permeable rocks or along faults; and precipitation of copper as sulphide minerals under reducing conditions. Many deposits were formed at redox boundaries between permeable, oxidised continental red-beds and reduced, lacustrine or marine sediments, although the discovery of major deposits in reduced units of the glaciogenic Grand Conglomerat in the Central African Copper Belt has expanded the range of suitable host lithologies.

Although this general model for copper ore formation is broadly accepted, there are still major uncertainties and controversies concerning the timing of mineralisation, the source rock(s) from which copper and other metals are extracted, the efficiency with which brines can leach copper from the proposed source rock(s), the composition of the brines responsible for metal leaching and transport, the temperatures and depths at which metals are leached and deposited, the forces that drive brine flow, and whether mineralisation occurs during a single pass of metal enriched brine, or during circulation of brine with multiple cycles of metal enrichment and mineral deposition. These knowledge gaps severely impact our ability to develop predictive models for copper localisation in basin systems and, more widely, the controls of basin metallogenic potential.

The aim of this project is to constrain mechanisms of extraction, transport and deposition of copper using laboratory experiments combined with advanced, basin-scale numerical models built with georealistic geometries. The laboratory experiments will use an established methodology to: (1) use aqua regia leaching to evaluate potential fertility of red bed sequences from different basins worldwide and from different parts of the Katangan Basin in the Central African Copper Belt; and (2) determine the efficiency with which copper and other metals can be leached from potential source rocks by simulated natural brines (incorporating secular variability in brine compositions) at relevant conditions of temperature, pressure and oxidation state [1,2]. These data will be used in an advanced numerical modelling tool [3,4] to explore: (i) the conditions and processes that lead to mobilisation and transport of copper in brines, including the control of heterogeneous stratigraphic architecture in terms of distribution of carbonate-bearing and reduced facies; (ii) the implications of potential interactions of such brines with petroleum during its generation and migration; and (iii) how copper deposition can be optimised in such flow regimes in terms of structural geometries and stratigraphic architecture. The modelling will focus on potential controls on localisation of copper mineralisation in the Central African Copper Belt using appropriate, camp-scale, basin geometries.

The project builds on methods and results developed in the NERC-funded CuBES project (Copper Basins Exploration Science), minimizing the need for further method development and allowing rapid delivery of new results and insight. The project is designed to address fundamental controls of sediment-hosted copper deposit genesis, including secular variations in seawater-derived brine chemistry and paleoclimatic and geodynamic impacts on fertile basin fill and architectures. This will have direct implications for better defining the exploration search space for new deposits of this type.

References

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