Chemical reaction path model of epigenetic Pb-Zn mineralisation process, example from the Century deposit, northern Australia

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Knowledge of base metals sediment-hosted mineral systems and the proxies developed to aid their exploration are mostly based on empirical data used to characterise ore deposits. Process-driven models do however provide further understanding of ore-forming processes. For example, geochemical reaction path modelling is effective at predicting mineral alteration assemblages associated with mineralisation, testing hypotheses of ore-forming processes and developing mineralogical/geochemical vectors for exploration.

In this study, we focus on the Century deposit in Mount Isa, northern Australia, where we test an epigenetic model using a 1D fluid infiltration model. The geological concept includes circulation of a meteoric fluid at depth passing through an evaporite-bearing sequence (source of chloride and sulphates) and basalts (source of the base-metals), rising through a fault, and deposition of base-metals in organic-rich shales. The first model is conceived to generate the oxidised metalliferous brine, which is then used in a second model to infiltrate carbonaceous shales.

The results support the view that thermochemical sulphate reduction is the key mechanism by which base-metals are deposited. Additionally, our models predict a series of alteration zones with increasing Pb, Zn, and Na contents, and decreasing Ca and Mg values towards the orebody. Various carbonate haloes are predicted: siderite, dolomite, and calcite in order of proximity to the deposit. Our results highlight that geochemical models are useful in enhancing our understanding of ore-forming processes (e.g. epigenetic vs syngenetic) and predicting the hydrothermal footprint of the orebody.