



The role of pyrite surface area and thermochemical sulfate reduction in clastic-dominant Zn Deposits.

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It is vital to keep up with the demand for critical minerals during the transition to sustainable energy systems. Doing so requires expanding our knowledge of ore depositional processes. Pyrite is a common gangue mineral in clastic dominated (CD) deposits, which are the highest value Zn deposits. In CD-type deposits, pyrite is often part of the pre-, syn-, and post-ore paragenesis and can therefore provide an important redox buffer and potentially a source of sulfur during ore deposition. The distribution of syn-ore pyrite beyond economic mineralization can also form an important mineralogical halo around CD-type deposits.

In this study we investigate the role of fluid interaction with different types of pyrite on ore formation in the Teena deposit (Australia). The host unit for the Teena deposit is an organic rich, variably pyritic, dolomitic siltstone. We created a series of 2D, reactive transport models using the software X2t (Geochemists Workbench) to investigate the role of pyrite surface area as a major control on ore deposition.

Similar to many CD-type deposits, the main type of pre-ore diagenetic pyrite in the host unit is framboidal, which has a high surface area, whereas syn-ore generations of pyrite tend to be coarser grained. In the models, pyrite surface area was varied from 100 (syn-ore) to 10,000 cm²/g (diagenetic). Organic matter provided a drive for thermochemical sulfate reduction (TSR) in the models, and TSR rates were varied over several orders of magnitude in accordance with laboratory measured values.

As the incoming hydrothermal fluid reacted with the host unit, pyrite and dolomite are dissolved and sphalerite is precipitated. The surface area of pyrite evolved as it dissolved and reprecipitated in the form of a more massive, lower surface area, hydrothermal pyrite.

Models using the higher surface area values for diagenetic pyrite resulted in more compact and higher grade ore deposition. The pyrite at the inlet in this scenario dissolved completely. As the pyrite reprecipitated, it formed more extensive halo ahead of the sphalerite reaction front than in models using the lower hydrothermal surface area. Slower rates of TSR also broadened the pyrite halo and decreased the sphalerite ore grade. Low pyrite surface area coupled with low TSR rates resulted in a disseminated deposit. Based on these results, the paragenetic evolution of pyrite

over the course of hydrothermal alteration and the resulting changes in surface area are an important control on ore grade and the extent of halo formation.