In-situ Cu and Fe isotope evidence for inorganic and organic components in the HYC Pb-Zn ores

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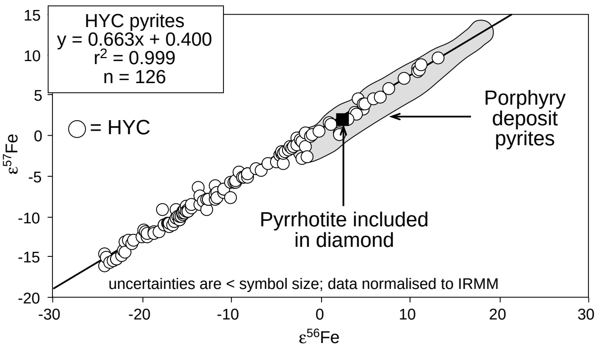
Ore deposition in the 1640 Ma HYC deposit (northern Australia) took place in a shallow marine setting, is syn-diagenetic, and related to brine fluids moving through a sub-basin. The polycyclic hydrocarbon distribution within the deposit is consistent with a large thermal gradient and suggests that ore deposition is linked to interaction between the hydrothermal fluid and organic matter in the sediment at a temperature below 300°C (Chen, pers. comm). We have obtained in-situ Cu and Fe isotope data for pyrite and chalcopyrite from the same samples studied by Chen and colleagues and one higher-T sample, close to where the fluid entered the system, that span a lateral distance of ~1500m.

Figure 1 shows a linear relationship between ε^{57}Fe and ε^{56}Fe values in pyrites from HYC. The ε^{57}Fe values vary between –24 and +13 and overlap values found in magmatic porphyry-deposit pyrite. Chalcopyrite ε^{65}Cu values vary between +0.1 and +16.

Figure 1: Fe 3-isotope diagram



ε^{65}Cu and ε^{57}Fe values from the two highest-T ore samples (500 m apart) initiate a trend of increasing ε^{65}Cu and ε^{57}Fe values with distance that is interpreted to represent thermochemical sulfate reduction (TSR). This trend is consistent with the lighter isotopes being removed from the fluid first. The lower-T ores yield large ranges in both ε^{65}Cu and ε^{57}Fe on either side of the extrapolated TSR trend. We interpret these ranges as a result of living bacteria preferentially using molecules with light Cu and Fe isotopes, causing them to drop out of solution in the ore zone. This interpretation is supported by mass balance considerations; there are equal proportions of heavy and light ε^{57}Fe values above and below the TSR trend.

Spatially-averaged erosion rates from cosmogenic nuclides in sediments: Ten years later

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The technique of determining spatially-averaged erosion rates from cosmogenic nuclides was first presented in a series of talks in 1992 and 1994, and later published by Brown et al. (1995), Bierman and Steig (1996), and Granger et al. (1996). This cosmogenic technique was touted as a method for measuring erosion rates over a 10^3 to 10^5 year timescale for which there was no reliable alternative. For the first time the erosional impacts of land use, climate, and tectonics could be routinely measured. Ten years later, with contributions from numerous researchers, we can evaluate this technique's impacts on geomorphology.

Recognition of natural variability

Cosmogenic nuclides have better quantified the range of erosion rates both within and across different tectonic environments. For example, erosion rates in the stable Appalachian Plateau are very slow (1-3 m/My) while the tectonically active northern Apennines erode much faster at 600 m/My. Comparison with fission track exhumation rates and sedimentary basin fills imply that these areas have maintained similar erosion rates for millions to tens of millions of years.

Erosion rates through time

Disequilibrium between cosmogenic erosion rates and modern sediment yields can be due to land use, climate change, or natural episodic sediment delivery to streams.

One way to distinguish among these causes is by examining changes in erosion rate through time, by analysing cosmogenic nuclides in buried sediments that retain their erosional inheritance (e.g., in terraces, lakes, or caves).

Landscape Evolution

The concept of a steady-state landscape, where erosion rates are uniform over space and time, is intellectually appealing but difficult to demonstrate in reality. Perhaps the greatest contribution of cosmogenic nuclides is that it is no longer sufficient to ask whether steady-state landscapes exist. Instead, our research should be driven to explain the natural variability that we observe in terms of erosional processes, climate, and tectonics, and to carefully quantify the changes in erosion rate through time.