



## **Copper isotope fractionation in sedimentary copper mineralization**

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Copper isotopes are potentially powerful new geochemical proxies for oxidation – reduction processes and metallic cycling in sedimentary copper ores. This research presents a Cu-isotope study of copper mineralization in the Precambrian and Cambrian rocks of the Timna valley, southern Israel. The historically mined ore deposits of the Timna valley represent a wide range of phenomena including altered Precambrian quartz porphyries; Cu-sulphide deposition during Early Cambrian marine dolomite diagenesis and its oxidation to give malachite; epigenetic remobilization giving veins of paratacamite and copper silicates in Cambrian sandstones and shales. The isotope measurements ( $^{65}\text{Cu}/^{63}\text{Cu}$ ) were made using MC-ICP-MS after ion chromatographic separation of the copper.

In agreement with the results of experimental studies showing that there should be a significant  $^{65}\text{Cu}/^{63}\text{Cu}$  isotopic fractionation between reduced and oxidized copper minerals,  $\delta^{65}\text{Cu}$  values of Cu-sulphides are significantly lower (-3.4 to -1.2 permil) than Cu(II) minerals (-1.2 to 0.5 permil). Cu(II) minerals, which are the modally dominant copper minerals in the system, give average  $\delta^{65}\text{Cu}$  values of  $\sim 0.08 \pm 0.5$  permil, consistent with the fact that the primary source of sedimentary copper in the Timna area was the Precambrian igneous rocks. Isotopic zoning in the Cu-sulphides of the Cambrian dolomites suggest they were precipitated from small disconnected solution reservoirs. Mass balance modeling of the Cu-isotope system was made using Matlab software. The calculations indicate that the main copper reservoir is the Cambrian sandstone and shale sequence and that the Cu-sulphide reservoirs are relatively small. Thus, most of the copper transport in the Timna basin occurred in relatively oxidized conditions. The calculated reservoir sizes are in agreement with field observations and

suggest that copper isotopes are able to trace both the oxidation-reduction cycles and mass transfer during sedimentary copper mineralization.