# Resolution of crystal dissolution and growth processes at multiple scales

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It is almost a commonplace that the central challenge in applying experimental reaction rates to field processes operating beyond the laboratory environment involves understanding the role of scale. The lack of this understanding and the theoretical framework required handicaps our capability to integrate local nanoscale observations over environmentally significant lengths. For example, although we have been able to observe step movement for many years, linking these data to processes such as continental weathering fluxes or subsurface diagenetic reactions requires knowledge of apparent scaling factors for which there is no satisfactory, uniform treatment. As a start to solving this problem, we need to reconcile the distribution and frequency of events at the molecular level with the overall macroscale reaction rate, at do so at diverse space scales simultaneously.
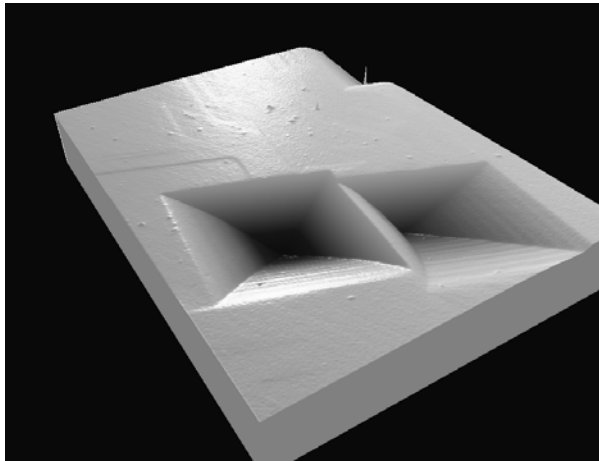


**Figure 1:** Calcite dissolution at screw dislocations, VSI data.

We demonstrate one approach to this problem by combining the high resolution, inherent flexibility and speed of vertical scanning interferometry with a statistical treatment of surface roughness parameters [1], using examples of simple experiments involving carbonate dissolution, nucleation, and growth.

[1] Fischer & Lüttge (2007) *Amer. J. Sci.* **307**, 955-973.

# Copper and lead isotopes as tracers of copper redox cycling

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The Cu and Pb isotopic systems can provide better understanding of the evolution of Cu ore deposits. We apply these isotope systems to the historic Timna mining area (southern Israel) where copper ores have undergone several redox mobilization cycles originating in Precambrian igneous Cu porphyries, through deposition in sedimentary Cambrian carbonates and sandstones, and remobilization into Lower Cretaceous sandstones. Each sedimentary redox cycle typically gives a mineralogy consisting of Cu-sulphides replaced by Cu(II) minerals (Cu-carbonates and Cu-silicates). Cu-isotopic fractionation is observed between adjacent Cu-sulphides and Cu(II)-minerals in all geological units and averages at $\Delta^{65}_{CuS-Cu(II)}$ = 1.7 ± 0.86 ‰. Mass-balance modelling [1], shows that these differences can be interpreted in terms of abiogenic Cu-isotope fractionations. A significant difference in Cu and Pb isotopic compositions is found for Lower Cretaceous rocks at different localties: Mt Amram and the Timna basin itself (Fig. 1). These variations can reflect different Eh-pH conditions, whereby lower $\delta^{65}$Cu and Cu-sulphides were precipitated under less reducing conditions, but Pb isotopes also indicate different sources whose origin is being explored. Cu and Pb isotopic systems can therefore expand our understanding of ore deposits genesis.
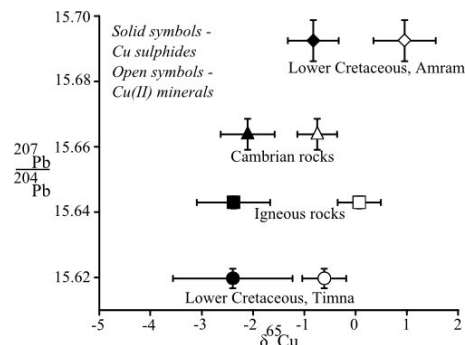


**Figure 1:** $\delta^{65}$Cu vs. $^{207}$Pb/$^{204}$Pb of the different samples groups.

[1] Asael *et al.* (2007) *Chemical Geology* **243**, 238-254.