Search for an extraterrestrial impact record in Isua sediments

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The cratering record of impacts on the Moon has led to the common belief that the Earth must have experienced an even stronger, gravitationally enhanced late bombardment, culminating around 3.8 Ga and decaying during the next 0.3 Ga.. However, no evidence for such violent impacts or accompanying flux of extraterrestrial dust has been found in the fragmentary terrestrial rock record.

The sequences of sedimentary banded iron formations (BIFs)in the ca. 3.8 Ga Isua supracrustal belt contain heavily disturbed, coarse-grained sediment packages that could possibly be impact related. In order to test this possibility we have determined the content of iridium with precisions of measurement between 2 and 8 parts per trillion (ppt) in a profile across a disturbed bed and adjacent undisturbed BIF.

The measured Ir concentrations are well below typical crustal values and range from less than precisions to 12 ppt.. The Ir concentrations in the disturbed bed do not show meaningful trends or a systematic contrast between this bed and adjacent, finely laminated sediment strata.

The exceptionally low Ir abundances do not provide support for the concept of a high flux rate of extraterrestrial material during accumulation of Isua sediments, placing our study in the group of several recent unsuccessful efforts to find such an enhancement in the oldest terrestrial rock record. Comments in the literature on the missing dust- and impact features make inconsistent reference to the lunar record by assuming that the late lunar bombardment ceased 3.8 Ga ago, ignoring the fact that it continued at a decreasing rate to about 3.5 Ga. The terrestrial record has recently been extended back in time to 4.4 Ga with data indicating the presence of a hydrosphere at several points in the time interval 3.8 – 4.4 Ga. These results can be taken to suggest cooling of the Earth between impact events, variably estimated to partly or entirely vaporize the hydrosphere or to convert the planetary surface to a magma ocean. With increasing density of observations in the earliest planetary record, the need is growing for an alternate explanation of the late lunar bombardment.

Variations in carbonate mineral dissolution rates: experimental uncertainty or fundamental property?

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A review of calcite dissolution rates far from equilibrium reveals that despite high internal consistency among rates reported by a given laboratory, there are significant discrepancies in absolute values. This variation has been recognised before (e.g., Dove and Platt 1996), and has been assumed to reflect differences in reactive surface area. In addition, both atomic force microscopy and vertical scanning interferometry (VSI) rate data for calcite, as well as VSI data for dolomite, are significantly lower than surface area-normalised-rates derived from powdered materials or single crystal rotating disk experiments.

Here, we test the hypothesis that the variation in reported rates reflects the distribution of different reaction mechanisms. VSI data suggest that bulk rates reflect the sum of related but distinct processes: rapid dissolution at deep etch pits (Figure 1; *cf.* AFM data of MacInnis and Brantley 1993, Liang et al. 1996), the development of shallow, emphemeral etch pits, and the relatively slow (in the case of calcite) rate associated with global step movement. In addition, grain boundaries in powders may play a special role in terms of step generation. In our single crystal experiments, large variations in the distribution of deep etch pits at dislocations imply similar variations in the corresponding bulk rate for powders, and thus the expectation of a unique bulk rate may not be warranted. The only rate that may be considered constant for a given set of conditions is that of global step movements.

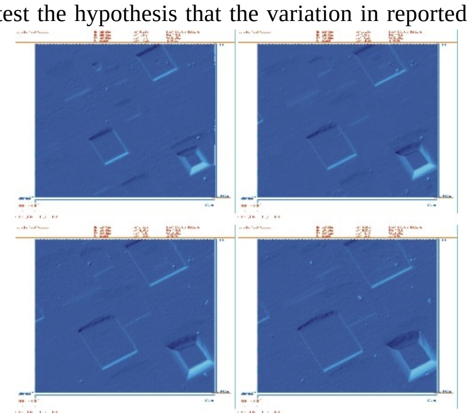

Figure 1: Etch pits at 30 minute time steps (VSI data). Rate = $10^{-11.6}$ mols/cm^2/s, pH 8.8, P_{CO2} $10^{-3.4}$, 25ºC.

References

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