GEOCHEMICAL SIGNATURES IN ROCKS AT ISUA OF A LATE HEAVY BOMBARDMENT BY COMETS

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The ~3.8 Gyr old Isua greenstone belt in Greenland coinsides in age with the final phases of the Late Heavy Bombardment (LHB) of the inner solar system. During an expedition to Isua we collected three different types of sedimentary rocks and measured the iridium abundances in 37 individually mortered samples, by use of neutron radiation and subsequent gamma-gamma spectroscopy [1]. The results showed a cosmic enrichment of a factor 7 (~150 ppt) above present day upper crust (~20 ppt). Although this is a clear cosmic signal, it is surprisingly low relative to the CI meteoritic abundance of 560,000 ppt and relative to the high values found in K/T boundary layers. The iridium abundance of impact melts on the Moon is even lower (<10 ppt) than the Isua values.

If the LHB had been dominated by asteroids, then both the lunar rocks and the Isua rocks would have reflected the high cosmic abundances found in representative meteorites. The measured low iridium abundances requires the LHB impactors to have been low in iridium. Furthermore, the difference in lunar and Isua iridium abundances show that the fraction of the impactor mass that mixed with the lunar crust must have been smaller than the fraction that mixed with the Earth. This imposes strict constraints on the possibly velocities of the LHB impactors (relative to the escape velocity of the Moon and Earth) that are consistent with the velocities of comets but inconsistent with that of present day Near-Earth-Asteroids.

We constructed a simple impact model constrained by the known lunar crater counts and total impact energy, in order to better understand the differences comets and asteroids would cause in the expected iridium abundances. In such a model it is possible to find reasonable parameters that can explain both the lacking lunar iridium and the low value at Isua, provoded the impactors were comets with relatively high velocities and a composition dominated by ices. For asteroids we were unable to find a parameter set that could explain both the lunar and Isua abundances.

We conclude here that the seemingly contradicting evidences derived in the literature from elemental abundances (including iridium), isotopic ratios, and crater size distributions, may call for a mixture of LHB sources, but that the measured lunar and Isua iridium abundances can only be explained by comets being the dominant contributor to the Late Heavy Bombardment.

References: [1] Jørgensen et al. (2009) Icarus 204, 368-380.