

**SEDIMENT-DISPERSED EXTRATERRESTRIAL SPINEL GRAINS LINK THE HISTORIES OF EARTH AND THE ASTEROID BELT.** B. Schmitz<sup>1,2,3</sup>. <sup>1</sup>Astrogeobiology Laboratory, Department of Physics, Lund University, Sweden. E-mail: birger.schmitz@nuclear.lu.se, <sup>2</sup>Hawai'i Inst. of Geophysics and Planetology, University of Hawai'i at Manoa, USA. <sup>3</sup>The Field Museum of Natural History, Chicago, USA.

**Introduction:** Relict spinel grains (~25–250 µm in diameter) from decomposed extraterrestrial material in ancient sediments can be used to reconstruct variations in the flux of different types of meteorites to Earth through the ages [1]. Meteorite falls are rare and meteorites weather and decay rapidly on the Earth surface, making it a challenge to reconstruct ancient fluxes. Almost all meteorite types, however, contain a small fraction of spinel minerals that survive weathering and can be recovered by acid-dissolution of large samples (100–1000 kg) of slowly deposited sediments of any age. The spinel grains can give detailed information on the types of extraterrestrial matter that fell on Earth at specific times in the past. Our Astrogeobiology Laboratory is constructed for the routine acid dissolution of up to five tons of sediment per year. Preliminary results on ancient meteorite fluxes are now available based on samples from the following periods: early and middle Ordovician, late Devonian, middle and late Jurassic, early Cretaceous, and the Paleogene.

**Methods:** Samples of 300 to 800 kg of pelagic limestone for each geological period studied have been collected in the field and brought to the laboratory. The samples are placed in large plastic barrels and HCl is added by an automatic process. For a 200 kg-sized sample 400 liters of HCl is added. The clay residue remaining after HCl-treatment is sieved and the fraction >32 µm is then dissolved in HF. The final residues are searched under the optical microscope for transparent and opaque spinel grains. Identification of the extraterrestrial spinels is made based on chemical composition, and by using a calibrated SEM-EDS instrument for the analyses.

**Results and Implications:** A precise level in the geological strata has now been located, corresponding to the first arrival of L-chondritic dust after the breakup of the L-chondrite parent body 470 Myr ago. Oxygen isotopic and element analyses of spinel grains have confirmed that there was an at least two orders of magnitude increase in the flux of L-chondritic micrometeorites and meteorites to Earth for at least 2–3 Myr after the breakup [1–3]. For other time periods more complex scenarios are evolving as new spinel grains are being recovered. Because of the scarcity of data with which our results can be compared interpretations will be preliminary until a better overview is acquired. Some generalizations, however, may already be made. For example, ordinary chondrites have been a common constituent of the meteorite flux to Earth throughout the past 500 Myr, but the ratios between the different groups appear to have changed much with time. Sometimes the flux is dominated by L chondrites, at other times LL or H chondrites. During periods without any major breakup events in the asteroid belt the flux of meteoritic matter is low and the ratios between spinel grains from the different ordinary chondrites appear to change at a high rate, about every 100 ka to 1000 ka. This may reflect that meteorites during these periods mainly originate from many different small bodies. In the Ordovician period prior to the breakup of the L-chondrite parent body, LL and H chondrites appear to dominate, but we find also many spinels from other unidentified meteorite types. Oxygen and chromium isotopes may determine the origin of these spinels. A major enigma is that so far we have not found any MgAl-spinels from carbonaceous chondrites, despite such micrometeorites being very common today.

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**Stable Earth - Stable Asteroid Belt Hypothesis:** The distribution of extraterrestrial spinel grains in sediments represents a global signal. Changes in the ratios between different types of spinels can be used in stratigraphy and for linking the histories of Earth's biosphere, tectonics and climate to events in the asteroid belt. In our preliminary data set we see a trend, that "turbulent" periods on Earth, are also "turbulent" in the inner asteroid belt. In the mid-Ordovician the L-chondrite parent body breaks up coincident with the onset of intense global volcanism and prolific evolutionary changes associated with the Great Ordovician Biodiversification Event [4]. Frasnian-Famennian limestone beds representing the late Devonian mass extinction event contain evidence of increases in the flux of micrometeorites to Earth. This may be reflected also by several impact craters of late Devonian age. The late Eocene, when Earth's climate after 250 Myr shifts from greenhouse to icehouse conditions, is characterized by significant asteroid breakups [5]. On the other side of the spectrum, early Cretaceous limestone beds that formed when life changed very little and Earth's magnetic record was unusually stable, indicate stable conditions at the same time in the parts of the asteroid belt that provide Earth with meteorites. For the Proterozoic Eon there is evidence, including lunar craters and K-Ar dates of recently fallen ordinary chondrites, of a temporal coincidence of stable conditions on Earth, such as during the so called Boring Billion years, and stability in the asteroid belt [1, 6–7]. Extraterrestrial spinels may provide a record of gravitational perturbations of at least the parts of the asteroid belt where parent bodies of ordinary chondrites reside. Ultimately this relates to the question, how stable is the solar system over geological time?

It is stressed that the "stable Earth-stable asteroid belt" scenario at the present only represents a working hypothesis that has evolved based on preliminary empirical data, but a hypothesis that can be tested with further spinel searches.

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