METEORITE AND ASTEROID CHROME SPINEL FLUXES TO EARTH THE PAST 500 MA AS RECONSTRUCTED FROM SEDIMENT-DISPERSED CHROME SPINEL, FOSSIL METEORITES AND IMPACT-CRATER AGES

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Introduction: Until recently almost nothing was known about the flux rates and types of meteorites and micrometeorites that fell on Earth in deep time. Meteorite falls are rare and meteorites weather and decay rapidly on Earth's surface, making it a challenge to reconstruct ancient fluxes. Most meteorite types, however, contain a small fraction (~0.1-0.3%) of very resistant spinel minerals that survive weathering and can be recovered by acid-dissolution of large samples (100-1000 kg) of slowly deposited sea-floor sediments of any age. Based on this approach, statistically robust estimates for the flux of the chrome-spinel bearing types of meteorites and coarse micrometeorites have now been established for fifteen Phanerozoic time windows [1-2]. Flux data exist now, e.g., for the middle Cambrian, mid-Ordovician before and after the LCPB breakup, late Silurian, late Devonian, middle Jurassic, early, middle and late Cretaceous, Paleocene and late Eocene. Our approach mainly provides a flux record of the types of micrometeorites containing common large (>32 µm) chrome-spinel grains. This includes the ordinary chondrites, primitive achondrites and HED meteorites [3]. The flux variations of such micrometeorites based on sediment-dispersed chrome spinel have been shown to also reflect the variations in the flux of corresponding larger, centimetre- to decimetre-sized meteorites [4-5]. Other types of meteorites that have not yet been found in sedimentary rock but do contain large chrome-spinel grains include R chondrites, lunar and martian meteorites.

Asteroid and micrometeorite fluxes compared: Although the ~200 impact craters known on Earth represent only a small fraction of the craters originally formed, the available data suggest an excess by one order-of-magnitude of craters, by number, in the interval ~470-440 Ma in the Ordovician [6]. Most of these "excess" craters may be related to the breakup of the L-chondrite parent body (LCPB) in the asteroid belt 465.8 ±0.3 Ma [7]. This is the only obvious peak in the terrestrial crater-age record that can currently be attributed to an asteroid shower and breakup event. Spatial crater densities in regions with high potential for crater preservation (e.g., eastern Canada, Scandinavia) also support a one order-of-magnitude increase in the flux of large (>0.1 km) impactors following the LCPB breakup. A similar pattern as seen in the cratering record is emerging in studies of the flux of micrometeoritic chrome-spinel through the Phanerozoic, with so far only one major spike in the flux, and associated with the LCPB breakup [8]. Similarly, the record of K-Ar gas retention ages of recently fallen meteorites only locates one major breakup, the LCPB event, during the Phanerozoic. On the other hand, astronomical backtracking studies of the orbits of asteroid family members indicate about 70 major family-forming breakups within the past ~540 m.y. which apparently have not left any clear imprint in Earth's geological record [1]. An observed nearly constant flux of ordinary chondritic chrome-spinel grains throughout the Phanerozoic, except after the LCPB event, indicates that the present situation - with a clear overall dominance of ordinary chondritic matter in the large (>500 µm) micrometeorite and macroscopic meteorite fractions - has prevailed at least for the last 500 m.y [1,8]. This is also supported by generally high ratios in our samples of chrome-spinel grains from ordinary chondrites compared to other types of spinel-bearing meteorites. The chrome-spinel data together with the abundance of fossil meteorites (1-21 cm in diameter) on the Ordovician sea floor also sets an upper limit at one order of magnitude in the increase in flux of large (>0.1 km-diameter) L-chondritic projectile to Earth following the LCPB [8]. Such an increase would not stand out in the global cratering record if ordinary chondritic impactors had only represented a small fraction of all Phanerozoic impactors. The origin of impactors delivered to Earth during the past 500 m.y. has mirrored the flux of large micrometeorites and meteorites, with ordinary chondrites being an important or, most likely, the dominant (in numbers) component throughout the sampled time intervals [8].