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Asteroids (21) Lutetia and (2867) Steins: same origin but different evolution ?

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Abstract

Asteroids (21) Lutetia and (2867) Steins which have recently been visited by the Rosetta spacecraft of the European Space Agency are both members of very small populationss of bodies among the vast majority of asteroids. After having been the archetype of the M taxonomy class, Lutetia is now an Xc type (DeMeo et al. 2009). Steins is classified as an igneous E-type asteroids, more precisely in the new Xe subclass (DeMeo et al. 2009) which contains only 7 known members.

The composition and henceforth origin of asteroids rely on their association to meteorites if proper analogs based on visible, NIR and MIR reflectances can be identified. Following the most recent spectroscopic works, the association of Lutetia to enstatite chondrites appears robust (Vernazza et al. 2011). The case of Steins is less clear but aubrite meteorites are favored although several features in its spectrum still poses problems and we actually may not have in our present meteorite collections the proper analog (Clark et al. 2004).

The trend of these associations with meteorites which represent a reduced, volatile-poor, anhydrous end-member of early solar system materials (Rubin 1997, Scott 2007) thought to have formed in the inner region of the solar nebula, near the proto-Sun implies that neither Lutetia nor Steins formed at their present location in the asteroid belt and are probably part of the population of interlopers. The dynamical mechnanism that transported them from the inner solar system to the main belt is likely to be similar to the one explaining the origin of iron meteorites as remnants of differentiated planetesimals formed in the terrestrial planet region (Bottke et al. 2006). Extended dynamical simulations reveal that, at the time where terrestrial accretion was ongoing, a small fraction (<2%) of the planetesimals residing in the 0.5-1.5 AU region were scattered out by emerging protoplanets and achieved main-belt orbits, thus becoming dynamically indistinguishable from the rest of the main-belt population.

However based on the physical properties derived from the recent flybys, Lutetia and Steins have followed very different evolutions. With a density of 3.4 g/cm^3, Lutetia appears as a primordial planetesimal having suffered at most minimal shattering from the largest impacts. On the contrary, the shape of Steins suggests complete restructuring in a rubble-pile as a consequence of the catastrophic disruption of its parent body.

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