Goldschmidt 2000
September 3rd–8th, 2000
Oxford, UK.

Journal of Conference Abstracts
Volume 5(2), 201

Coexisting Altered Glass, Fe-Ni Oxides, and Shocked Spherules at the K-T Boundary, Stevns Klint (Denmark): Direct Evidence of Meteorite Impact

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The Cretaceous-Tertiary (K-T) boundary at Stevns Klint, Denmark is noteworthy for its large Ir anomaly that is taken as evidence of extraterrestrial components. The origin of the smectite-rich marl has been variously interpreted to have a detrital, meteorite-impact, or volcanic origin (Rampino & Reynolds, 1983, Kastner et al., 1984, Elliott et al., 1989, Elliott, 1993). We have carried out scanning electron microscopy (SEM) and transmission electron microscopy/analytical electron microscopy (TEM/AEM) observations of the impact and contiguous layers within the K-T marl at Stevns Klint. TEM images show abundant smectite, much of which occurs with layers curving around and grading in to cores of nanometer-scale glass shards. The smectite composition is unusual in having both significant octahedral Al and Mg, and it is intermediate between trioctahedral and dioctahedral smectite. The glass and smectite major element compositions are similar and unique relative to glasses of terrestrial and extraterrestrial origin with except for one kind of glass at the K-T boundary in Haiti. Abundant 10-20-nm-diameter iron oxides having as much as 10% Ni and minor Zn are intergrown with smectite. We interpret these domains to be altered meteorite fragments, which formed when impact glass was transformed to smectite. Micrometer-sized spheres of quartz consisting of separate angular grains were observed. The direct association of impact glass, meteorite fragments, and shocked quartz is unambiguous evidence for meteorite impact. These data may imply fall out of globally distributed impact-derived particles over an extended time period. Nanometer-scale relict meteorites, impact glass and smectite should serve as indicators for other possible impact events in the geological record.

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