Nanofragmentation as potential marks of multiple low-velocity impacts in carbonaceous chondrites

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The research focuses on the paradox between the low shock stage of carbonaceous chondrites and the marks of hypervelocity impacts, indicated by magnetic parameters which shows the mark of significant alteration triggered by impact induced shock.

Solving the paradox above a theory about the role of multiple impact produced structures instead of one energetic hypervelocity impact has been already introduced. Based on this theory, we propose a hypothesis and test of nanoscale fragmentation as evidence for multiple low-intensity impacts by nanoscale mineral components. Nano-scale minerals may be created and re-aligned by the physical weathering of coarser grains triggered by the shock of multiple impacts. Our goal is to support or decline the hypothesis by performing magnetic fabric studies, which are capable of separating the ultra-fine grain components, i.e., the possible indicator of nanofragments and their character.

Scanning electron microscope, rock magnetic and magnetic fabric studies were conducted on three carbonaceous chondrites: Allende, Jbilet Winselwan (Jbilet) and Murchison. FeNi alloys, iron sulphides (pyrrhotite) and magnetite were the main magnetic minerals contributing to the magnetic fabric. The fabric was foliated, and the susceptibility ellipsoid was oblate, thus indicating that impacts are an important process in the development of the fabric; this finding is consistent with previous studies. Significant differences were revealed between the studied meteorites by comparison of the anisotropy of the magnetic susceptibility and the frequency dependence of the anisotropy of magnetic susceptibility parameters (a sensitive indicator of the alignment of nano-size magnetic grains).

Comparison of the three studied meteorites suggested a complex ‘impact history’. The foliated well-aligned directions in the fabric of the studied meteorites and homogenized (non-scattering fabric parameters) may suggest the influence of a hypervelocity impact, which probably influenced the fabric of the (parent body of the) meteorite at the regional level. In contrast to the influence of the hypervelocity impact, which caused the fracturing and dislocation of the grains in the entire fabric, the repeating low-velocity impact potentially induced 1.) the weakening of the foliation (e.g., Allende, Murchison) in general and 2.) the formation and dispersed distribution of nanofragments (e.g. Allende and Jbilet) by e.g. physical erosion of the coarser grains or their re-alignment (e.g., Murchison). This phenomenon might appear differently in various parts of the meteorite, in which heterogeneity (in the magnetic parameters –scattering data) might indicate the limitation in spreading of the effect of multiple low-intensity impacts.

Keywords: multiple low velocity impacts, magnetic fabric alteration, nanofragmentation

