Physical properties of some early Earth impactors: Cometary dust particles and cometary nuclei

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Since organic molecules have been discovered in cometary comae, it has often been claimed that comets have played an important role in supplying material needed for life to originate. This hypothesis, which requires the fragile organic material not to have been destroyed during impacts, is comforted by recent studies.

Porosity of cometary dust particles,

Further analysis of the properties of 1P/Halley dust particles has allowed us to estimate that they are low-density (< 100 kg m^{-3}) fluffy aggregates. Particles ejected during the breaking-off of C/ 1999 S4 LINEAR also seem to be large fluffy aggregates of submicron-sized grains.

Structure of cometary nuclei

Observations of C/1996 B2 Hyakutake have allowed the structure of its nucleus to be better known. The modeling of the movement of bright condensations inside the inner coma confirms that cometary nuclei could be somehow rubble piles of cometesimals, the size of which could be of a few tens of meters.

Prospective

Future space missions to small bodies, together with experiments devoted to the formation of aggregates under conditions representative of those which prevailed at the origin of the solar system (specially with the ICAPS facility on board the ISS) should allows us to better assess the physical properties of comets, and to understand how organic particles (of presolar origin) existing inside small solar system bodies could have survived during impacts

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Nucleosynthesis by Spallation Reactions in the Early Solar System

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Introduction and Modeling: Recently, ^{7}Li and ^{10}B excesses in CAIs resulting from the *in-situ* decay of ^{7}Be and ^{10}Be have been reported (Chaussidon and Robert 1995; Chaussidon et al. 2002; McKeegan et al. 2000; MacPherson et al. 2001, Sugiura et al. 2001). Whereas it might be possible to explain the ^{10}Be by nucleosynthetic processes (Cameron 2001), the ^{7}Be half-life ($T_{1/2}$ = 53.29d) strongly argues against ^{7}Be production in extrasolar sources and injection into the solar nebula. Therefore, the finding of life ^{7,10}Be in the early solar system supports scenarios in which some of the short-lived nuclides are produced by energetic particles from the early sun. Such a scenario is further supported by the finding that young stellar objects often emit significant amounts of their material as stellar winds and/or bipolar outflows (e.g., Feigelson et al. 2002). Here we simultaneously model the production of ^{7}Be, ^{10}Be, ^{22}Na, ^{26}Al, ^{41}Ca, and ^{53}Mn by spallation reactions induced by solar energetic particles (SEP) from the early sun.

Results and Discussion: Assuming solar chemistry for the hypothetical proto-CAIs and a particle fluence of $\sim 1\times10^{23}$ cm^{-2} for the SEP events explains the initial ^{7}Be/^{9}Be, ^{10}Be/^{9}Be, ^{26}Al/^{27}Al, ^{41}Ca/^{40}Ca, and ^{53}Mn/^{55}Mn ratios simultaneously. Therefore, the inferred abundances for most of the light short-lived radionuclides can be described simultaneously with the local production scenario. The concordance of modeled and measured initial ratios appears to provide strong evidence for a spallogenic origin of these isotopes. If so, this concordance and the remarkable homogeneity of the initial abundances, particularly of ^{26}Al, place stringent constraints on the CAI production mechanism. For example, the material now forming a large part of all CAIs would have seen surprisingly homogeneous particle fluences, despite probably variable irradiation times and shielding conditions. This in turn would require fast and efficient mixing of the irradiated material, either during or directly after irradiation. With an estimated irradiation time the heating of the CAIs as well as the cooling rates can be inferred.

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