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Ion irradiations in the laboratory to simulate pre-accretion irradiation of cometary dust minerals in the interplanetary medium

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Transmission electron microscopy observations of minerals in IDPs, ultracarbonaceous Antarctic micrometeorites (UCAMMs) [1, 2], and characterizations of the composition of dust from comet 67P/Churyumov-Gerasimenko [3, 4] suggest that pre-accretion irradiation is common in minerals of cometary origin. IDP and UCAMM minerals recorded damaged rims (<100 nm thick) at their surfaces, and irradiation tracks with a density of ~ 10^{10} tracks.cm^{-2}. The irradiation rims are caused by solar wind, and the tracks by solar energetic particles or galactic cosmic rays. These irradiations features could have occurred in these minerals before their accretion into the cometary dust [3, 4], and/or during the journey of the particles to Earth [5].

In order to better characterize these irradiation effects, we selected relevant mineral analogues (olivines, pyroxenes, feldspar, melilite, chromite, magnetite, pyrrhotite and pentlandite) that were prepared in polished sections or crushed in indium, and subsequently irradiated. High energy irradiation was performed at the GSI facility at 4.8 MeV/u with $^{197}Au^{25+}$ ions, with a fluence of 10^{10} ions.cm^{-2}. Low energy irradiation was performed at IJCLab on two sets of olivines and pyroxenes using He^{+} ions at 10 keV/u for a fluence of 10^{16} ions.cm^{-2}, and 1 MeV/u for a fluence of 10^{10} ions.cm^{-2}. FIB sections extracted from the high-energy irradiated olivine and pyroxenes (diopside and enstatite) were characterized by transmission electron microscopy. The measured track densities are ~2.6 x 10^{9} (olivine), ~7 x 10^{9} tracks.cm^{-2} (diopside) and ~9 x 10^{9} tracks.cm^{-2} (enstatite), with a mean diameter of ~12 nm. We did not identify induced changes in the chemical composition of the minerals. FIB section from minerals irradiated at lower energies at IJCLab will be examined to look for possible changes in the mineral compositions of the irradiated rims and to account for the track density recorded by the minerals.

References:
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