LASER IRRADIATED IMPACT EXPERIMENTS SHOW THAT NANOPHASE IRON PARTICLES FORMED BY SHOCK-INDUCED MELTING RATHER THAN VAPOR DEPOSITION

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Introduction: Nanophase iron particles (np-Fe^0) are rather common in the mature lunar soil grains as well as agglutinatic glasses [1, 2, 3]. Np-Fe^0 has been proposed as the main cause of the change in the optical properties produced by space weathering processes, and has been invoked to explain the mismatched spectra of lunar rocks and regolith, and between those of asteroids and meteorites [4, 5]. Previous studies suggest that the origin of np-Fe^0 in lunar soil rims was due to the deposition of micrometeorite impacted vapor [6, 7]. The ultimate origin of np-Fe^0 in agglutinatic glasses were also believed as vapor-deposited np-Fe^0 in mature soil grains, which were subsequently melted, became part of the overall glass component [3, 8]. Here, we proposed another formation mechanism of nanophase iron particles, impact melting fractionation as major origin, rather than vapor deposition origin only.

Experimental Methods: We irradiated polished Huaxi H5 ordinary chondrite with 1, 5 and 10 pulses of an Nd:YAG laser, respectively. The calculated power density is 1×10^8 W/cm^2 at 532nm wavelength. The irradiated surface of the sample was characterized by FE-SEM imaging. FIB cross sections were prepared by FEI Scios dual-beam and characterized using a FEI Tecnai F20 field-emission scanning transmission electron microscope (FE-STEM).

Results: The FIB sites located at the junctions of olivine, plagioclase and orthopyroxene in the bottom of the impact crater. Two amorphous layers bearing nanophase iron particles were found above crater surface which were formed by the laser irradiating impact. Upper layer is continuous covering whole FIB section with thickness of 10 nm thick. Bottom layer close to the host silicates is not continuous containing iron particles with thickness of around 100 nm. Np-Fe^0 in bottom layer were only discovered close to Fe-bearing silicates, above olivine grain or pyroxene grain. The bottom layer above plagioclase is amorphous but no iron particles were found.

Discussion: Upper layer with similar size of nanophase iron particles continuous occur in amorphous layer demonstrate that it is the vapor deposition layer. While bottom layer with different size of nano iron particles and much thick thickness suggest that they are likely formed in melting zone under extreme high pressure and temperature. The melting zone do not have time and space to evaporate. However, the high temperature in the melting zone induce the fractionation of Fe-bearing silicate, and nano iron were formed, and other staff were vitrified. The fractionation of Fe-not-bearing plagioclase can melt and verified, but no iron particle were formed due to no Fe resources. The results of this experiment suggests that the origin of those np-Fe^0 relates to the shock-induced melting high temperature during the impacts of meteorites [9, 10]. It proves that the reduction of ferromagnesian silicates can take place in-situ in impact melts, and the deposition of vapor phase may not be necessary for the origin of np-Fe^0 in space weathering events, especially for np-Fe^0 in agglutinatic glasses.

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