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High Pressure Polymorphs of Silica in shocked lunar meteorites and impact events in lunar surface

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Microcrystals of coesite and stishovite were discovered as inclusions in amorphous silica grains in shocked melt pockets of a lunar meteorite Asuka-881757 by micro-Raman spectrometry, scanning electron microscopy (SEM), electron back-scatter diffraction (EBSD), and transmission electron microscopy (TEM). These high pressure polymorphs of SiO₂ in amorphous silica indicate that the meteorite experienced an equilibrium shock-pressure of at least 8-30 GPa. Secondary quartz grains are also observed in separate amorphous silica grains in the meteorite. The estimated age reported by the ³⁹Ar/⁴⁰Ar chronology indicates that the source basalt of this meteorite was impacted at 3800 Ma ago, time of Lunar Cataclysm, i.e., the heavy bombardment in the lunar surface. Observation of coesite and stishovite formed in the lunar breccias suggests that high pressure impact metamorphism and formation of high pressure minerals are common phenomena in brecciated lunar surface altered by the heavy meteoritic bombardment. We also confirmed existence of a post-stishovite polymorph, seifertite alpha-PbO₂ type structure, in a different lunar meteorite, NWA4734, by X-ray diffraction using synchrotron radiation at BL10XU of SPring-8. Although this phase was previously suggested in the same meteorite only based on the cathode luminescence (CL) spectrum, it was never confirmed since there is no reference of seiferite in CL spectra. The present X-ray diffraction measurements confirmed existence of seifertite in this meteorite. The lattice parameter of this phase was consistent with that reported from a Martian meteorite (ElGoresy et al., 2008). The condition of the shock event in this lunar meteorite was more intense compared to Asuka-881757 lunar meteorite.

Keywords: High pressure, Polymorph, Silica, Lunar meteorite, Lunar Cataclysm, Asuka-881757