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Estimation of shock pressure and post shock temperature from silica polymorphs in the lunar meteorite (DEW 12007)

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Shock-induced mineralogical and chemical transformations in meteorites provide crucial constraints on the pressure-temperature (P-T) conditions experienced during impact metamorphism. Compression and release during impact generate extreme P-T conditions within a short duration, leading to transitions in minerals, including amorphization. Silica, occasionally found in differentiated meteorites, exhibits polymorphic variations depending on P-T, making it a key indicator of post-shock P-T evolution. This study classifies silica polymorphs in the DEW 12007 using high-resolution backscattered electron (BSE) imaging and Raman spectroscopy to infer post-shock P-T conditions.

BSE imaging and Raman spectroscopic analysis reveal three different zones differentiated by mineralogical characteristics. We estimate shock conditions of each zone, based on the Hugoniot of quartz, with an assumption of isentropic release path [1]. Zone 1 shows a glass-like surface and minimal fractures, and is dominated by amorphous silica and feldspar, indicating post-shock temperatures exceeding 1973 K and peak pressures of at least 42 GPa. Zone 2 shows irregular internal brightness in BSE image and contains mixtures of amorphous silica, quartz, tridymite, and partially amorphized feldspar, reflecting intermediate shock conditions (approximately 1143–1743 K and 30–36 GPa). Zone 3 is characterized by darker grains with abundant internal fractures, dominated by quartz and crystalline feldspar, suggesting relatively lower peak temperatures (below 1143 K) and pressures (near or below 30 GPa).

These mineralogical transitions suggest that shock-wave reverberation and heterogeneous stress distributions played key roles in generating the observed variability in silica polymorphs and feldspar textures. The formation of amorphous regions alongside crystalline and partially crystalline phases highlights the complexity of shock-induced phase transitions, even within a single small clast. Our findings emphasize that even within a single meteorite fragment, shock pressures and temperatures can vary significantly due to local heterogeneities in mineralogy and shock-wave propagation. This study advances our understanding of lunar impact processes and emphasizes the need for careful interpretation when estimating impact pressures from meteorite samples.

[1] Luo, Ahrens & Asimow (2003), *JGR: Solid Earth 108,* https://doi.org/10.1029/2002jb002317