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Shocked quartz: A ^{29}Si magic-angle-spinning nuclear magnetic resonance study

PETER S. FISKE,[1,]* WILLIAM J. NELLIS,[1] ZHI XU,[2] and JONATHAN F. STEBBINS[2]

[1]Physics and Space Technology Directorate, L-045, Lawrence Livermore National Laboratory, Livermore, California 94550, U.S.A.
[2]Department of Geological and Environmental Sciences, Stanford University, Stanford, California 94305-2115, U.S.A.

ABSTRACT

Quantitative ^{29}Si NMR spectra of single-crystal α-quartz, shock compressed to 12–38 GPa and recovered, provide new information about the complex response of quartz to shock loading. Spectra from samples recovered from shock pressures of 12–20 GPa show a broadening of the ^{29}Si NMR peak and the development of asymmetry toward lower NMR frequency (indicating an increase in the mean Si-O-Si intertetrahedral bond angle). NMR spectra of samples shock compressed above ~25 GPa show increasing amounts of a separate amorphous phase of SiO_2 with a mean Si-O-Si bond angle roughly 5° narrower, and 10–15% denser, than fused SiO_2. Small amounts of crystalline material remain with a mean Si-O-Si bond angle up to 3° larger than unshocked α-quartz. The recovery of dense glass indicates that post-shock temperatures were sufficiently low to also preserve stishovite, had any been created in our experiments. The paucity of stishovite or $^{[6]}$Si in an amorphous phase in our recovered samples suggests that the formation of stable, high-coordinated Si is kinetically hindered in shock compression experiments up to about 35–40 GPa, except in regions of high temperature, such as planar deformation features (PDFs), microfaults (pseudotachylites), or voids.