

NMR SPECTROSCOPY OF QUARTZ FROM THE K/T BOUNDARY: SHOCK-INDUCED PEAK BROADENING, DENSE GLASS, AND COESITE; M.B. Boslough¹, R.T. Cygan¹, and G.A. Izett², ¹Sandia National Laboratories, Albuquerque, NM 87185; ²U.S. Geological Survey, Emeritus, Williamsburg, VA 23185.

We have obtained solid state ²⁹Si nuclear magnetic resonance (NMR) spectra for quartz samples collected from K/T boundary sites in the Raton Basin, Colorado, as part of a project to evaluate the use of NMR as a quantitative tool to identify and characterize naturally-shocked minerals. This work follows our group's demonstration of a strong correspondence between NMR spectra and Kieffer's classification levels for shocked quartz from Meteor Crater (MC), Arizona. The insoluble residue of a sample from the Clear Creek North (CCN) location was analyzed using both magic-angle spinning (MAS) and cross-polarization magic-angle spinning (CPMAS) methods. The MAS spectrum for CCN consists of a single strong peak with a chemical shift consistent with crystalline quartz. The peak width is 0.96 ppm, significantly greater than would be expected for unshocked natural quartz. The CPMAS spectrum shows three distinct peaks that are consistent with a densified amorphous phase similar to that found in Class 3 quartz sandstone from MC. A sample from Berwind Canyon (BER) that was subjected to strong acid treatment was also analyzed by MAS NMR. The quartz resonance is strongly broadened, and the spectrum is remarkably similar to that of Class 2 quartz from MC. Identification of coesite in the BER sample has been confirmed by x-ray diffraction. There is no evidence for stishovite in either sample.

We have previously shown [1] that NMR spectra from shocked Coconino Sandstone correlates with the classification scheme of Kieffer [2]. In that work, we also tentatively identified a new densified amorphous phase. We later confirmed that identification [3] by use of CPMAS techniques, which enhance silicon resonances near protons, and suppress silica peaks to allow analysis of hydrated phases. We inferred that the phase is a unique product of shock chemistry, and that its presence is diagnostic of impact.

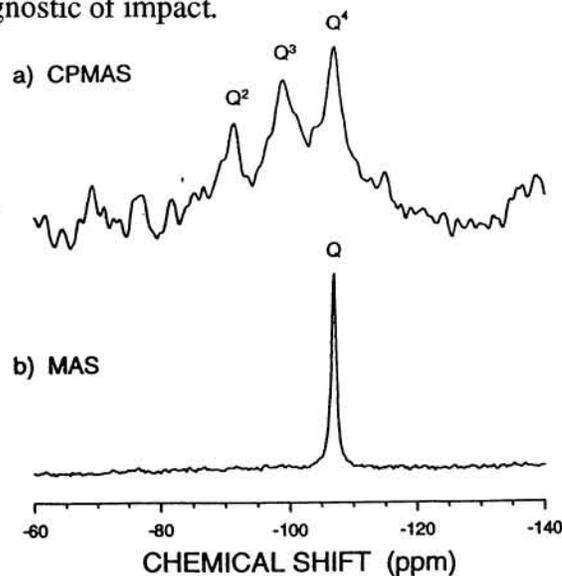


Figure 1. ²⁹Si NMR spectra of CCN samples. (a) CPMAS spectrum, (b) MAS spectrum.

The MAS and CPMAS spectra of the CCN samples [4] are shown in Figure 1. The MAS spectrum shows no evidence for high-pressure silica phases, but the peak at about -107 ppm is significantly broader than that usually exhibited by unshocked natural quartz. Deconvolution of

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this spectrum demonstrates that it consists of a superposition of narrow and broad components as has been observed for experimentally shocked quartz [5, 6]. However, because the sample has been acid-processed, and because it is likely to be an admixture of shocked and unshocked quartz, it may be difficult to extract information about shock pressure from the deconvolution.

The CPMAS spectrum has three resonances at about -107, -99, and -91 ppm. A tentative interpretation is that these are Q^4 , Q^3 , and Q^2 resonances, respectively, in a dense hydroxylated amorphous silica similar to the phase we found in Class 3 MC samples. Observation of Q^4 resonances would require spin transfer from neighboring protons; we did not observe this peak in the MC CPMAS spectra.

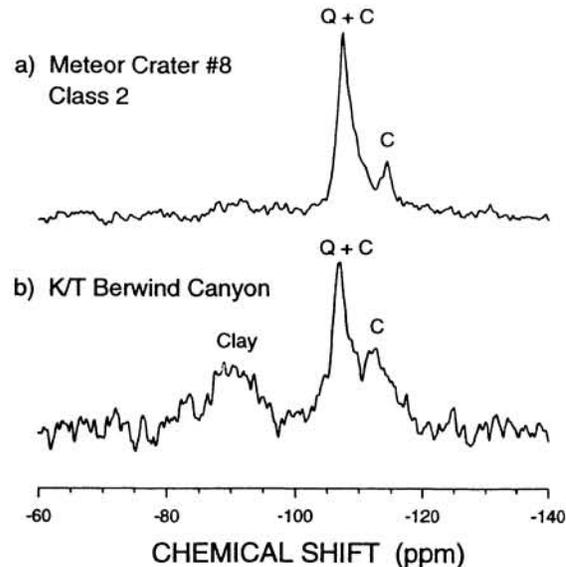


Figure 2. ^{29}Si MAS NMR spectra of (a) MC sample #8 (Class 2), (b) BER sample.

The BER spectrum is shown with the MC Class 2 spectrum (Kieffer sample #8) in Figure 2. The BER sample was heavily processed by repeated etching with fresh 5% solutions of HF, leaving a small residue of the original sample. Nevertheless, the apparent similarity to the MC spectrum is striking. The signal-to-noise ratio is not as good, but the peak at about -113 ppm is consistent with a coesite resonance. Several coesite diffraction peaks appear in the x-ray pattern for the BER sample residue, confirming the presence of this high pressure silica polymorph.

We will continue this work by performing deconvolution analysis of the spectra. We also plan to carry out NMR relaxation studies in an attempt to provide fractal dimensions for the amorphous material, which may be another diagnostic of shocked quartz [7].

References: [1] Boslough *et al.* (1993) in *Lunar Planet Sci. XXIV*, 149-150. [2] Kieffer (1971) *J. Geophys. Res.* 76, 5449-5473. [3] Cygan *et al.* (1994) In *High-Pressure Science and Technology--1993*, 807-810. [4] Izett (1990) *GSA Special Paper 249*. [5] Cygan *et al.* (1992) *Proc. Lunar Planet Sci. 22nd*, 127-136. [6] Fiske *et al.* (1993) in *Lunar Planet Sci. XXIV*, 491-492. [7] Assink *et al.* (1994) In *High-Pressure Science and Technology--1993*, 383-386.

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