NMR SPECTROSCOPY OF SHOCKED QUARTZ FROM EXPERIMENTAL IMPACT CRATERS; M. B. Boslough, R. T. Cygan, and D. A. Crawford, Sandia National Laboratories, Albuquerque, NM 87185, and R. J. Kirkpatrick, University of Illinois, Urbana, IL 61801

To quantify the extent of shock modification associated with the impact of projectiles into quartz targets, we used the NASA Ames Vertical Gun Range (AVGR) to generate impact craters and applied nuclear magnetic resonance (NMR) spectroscopy to recovered samples. Two cratering experiments were performed by using the two-stage gun to launch copper projectiles into target materials comprised of unconsolidated quartz powder and a block of Coconino Sandstone. The velocities of the 0.32 cm-diameter spherical impactors were 4.61 km/sec for the unconsolidated quartz and 4.97 km/sec for the sandstone block. The resulting impact craters have diameters of approximately 22 cm and 9 cm, respectively, for the quartz sand and solid sandstone targets. ^{29}Si NMR spectroscopy of recovered target material from each impact experiment provides a useful method for comparing samples and degree of shock loading. The ^{29}Si MAS (magic angle spinning) NMR spectra from samples collected across most of the crater in the quartz powder target exhibit relatively little variation in the quartz resonance. However, the shocked quartz collected from the central part of the crater exhibits extreme broadening of the NMR peak, indicating significant shock metamorphism. The samples from the impact crater formed in the sandstone block are characterized by broadened NMR peaks; the most significant broadening occurs for the material from the center of the crater and from the crater edge.

We previously demonstrated a strong correlation of ^{29}Si MAS NMR peak widths with shock pressure for quartz powders [1,2]. To investigate the relevance of these results to actual cratering events, we performed two experiments at the AVGR. Targets were comprised of 15 kg of quartz powder and a 25 kg block of Coconino Sandstone, the latter being a target rock associated with

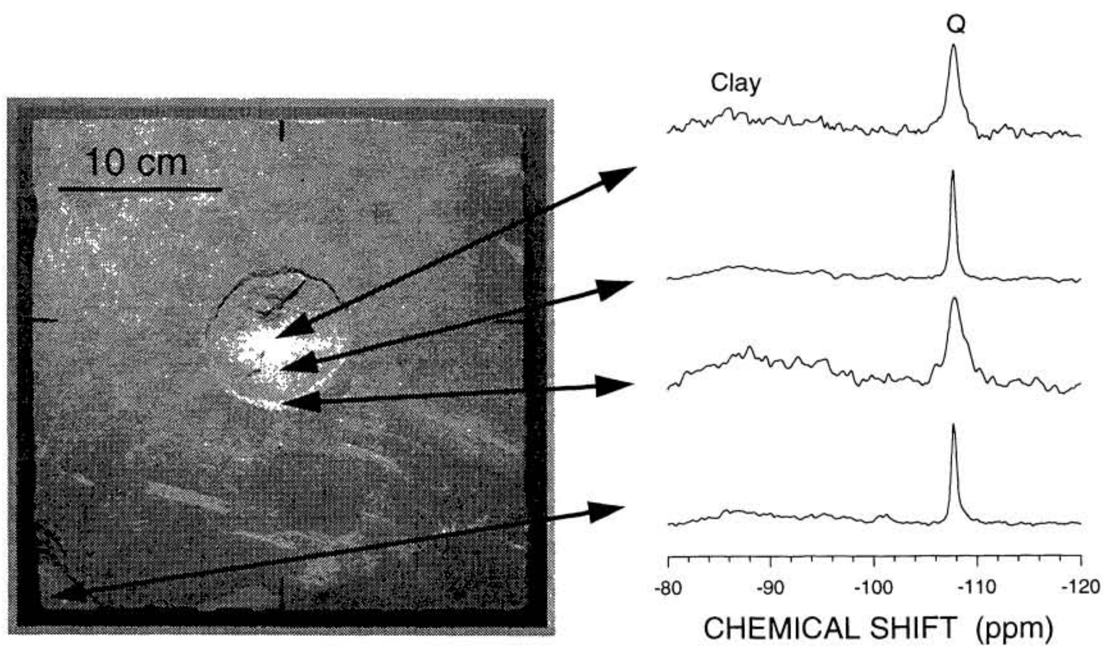

Figure 1. Sampling sites from crater in Coconino Sandstone block, and the corresponding ^{29}Si MAS NMR spectra. Q denotes the tetrahedrally-coordinated silicon site of quartz that is broadened as a result of the impact and crater formation.

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Meteor Crater, Arizona. We used high speed video photography to monitor the formation of the impact craters, and the spatial and temporal distribution of ejecta. Figures 1 and 2 present the ^{29}Si MAS NMR spectra. The most significant shock modification of the sandstone occurs at the crater bottom and at the crater edge. The extent of NMR broadening of the four-coordinated ^{29}Si resonance (-108 ppm) in the Coconino Sandstone samples is comparable to that observed in our previous studies [1,2] for shock pressures up to 22 GPa. All but one of the spectra, for samples collected from five locations within the impact crater created in the quartz powder, exhibit slight peak broadening compared to the unshocked starting material. In contrast, the shocked quartz from the center of the crater provides a spectrum with extreme broadening of the same peak, indicating significant deformation of the crystalline quartz and the formation of an amorphous phase.

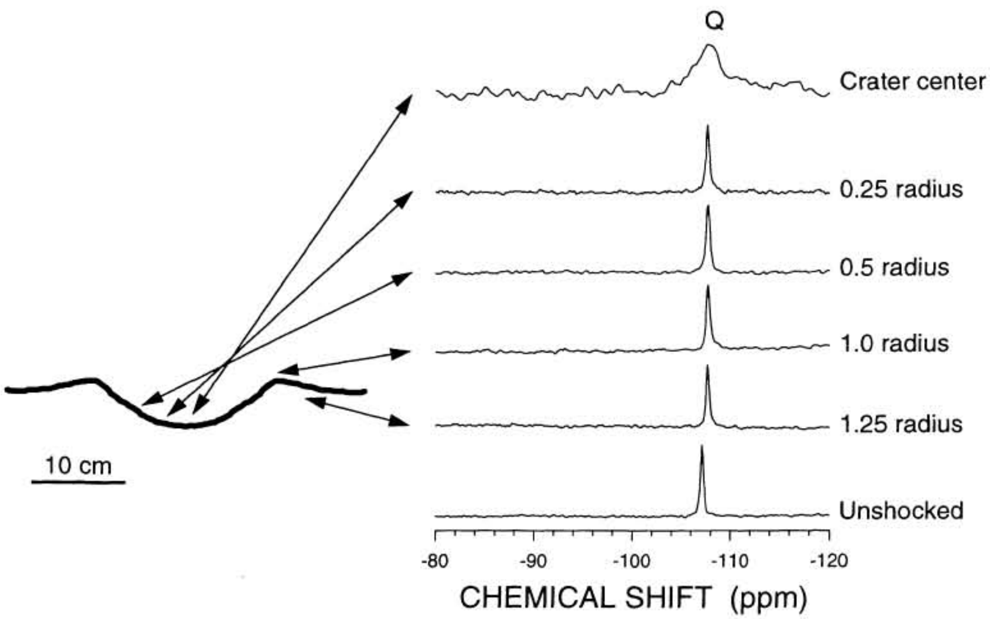

Figure 2. Schematic cross-section of crater in quartz powder target with sampling sites, and the corresponding ^{29}Si MAS NMR spectra.

References: [1] Cygan *et al.* (1990) In *Proc. Lunar Planet Sci. Conf. 20th*, 451-457. [2] Cygan *et al.* (1992) In *Proc. Lunar Planet Sci. Conf. 22nd*, 127-136.

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