MICRO-RAMAN SPECTROSCOPY OF EXPERIMENTALLY SHOCKED ALBITE. S. J. Jaret[1], J. R. Johnson[2], M. Sims[1], and T. D. Glotch[1] [1]Department of Geosciences, Stony Brook University, Stony Brook, NY 11790, [2]Applied Physics Laboratory, Johns Hopkins University Steven.jaret@stonybrook.edu

Introduction: Shocked feldspars commonly occur in meteorites and presumably are a commonly occurring phase on the surfaces of rocky planetary bodies such as Mars, the Moon, and asteroids. Shocked feldspars are used commonly as an index mineral for shock metamorphism [1] and serve as the basis for determining impact conditions (primarily peak pressures) on parent bodies. The manifestations of shock effects in feldspars are complex and vary depending upon specific composition and on analytical technique. This has led to several slightly different shock barometric classification schemes [1-11]. Here, we present micro-Raman spectra of experimentally shocked albite as part of an ongoing effort to reexamine the vibrational spectroscopic (Raman and infrared) response of feldspars to shock. Our goal is to add resolution to existing barometric classifications and to further our understanding of compositional effects on shock metamorphism processes.

Methods: Samples were shocked experimentally at Johnson Space Center's Flat Plate Accelerator as described in [6-7]. Optical petrography and micro-Raman spectroscopy were conducted on standard polished thin sections of recovered samples. All analyses were conducted in the Vibrational Spectroscopy Laboratory at Stony Brook University. Micro-Raman spectra were collected using a WiTec alpha300R confocal imaging system equipped with 532 nm Nd YAG laser with 2.24 mW nominal power at the sample surface, and a 50X objective (spot size of 763 nm). Each analysis consisted of 240 1-second integrations.

Samples: All experiments used target discs of the fine grained albite from serpentine massif in Szklary Lower Silesia, Poland. The sample is 97% albite (Ab_{98}) with accessory quartz, k-spar and amphibole [7]. Samples included in this study were shocked to 17.0, 24.0, 25.5, 27.8, 29.0, 31.4, 34.8, 38.0, 44.6, 50.0, and 55.8 GPa. These were also compared to an unshocked sample.

Petrography Results: Samples between 0 and 44.6 GPa show no traditional shock fabrics in plane- or cross-polarized light. However, in plane-light, these samples show a high degree of fracturing that is not present in the unshocked sample. Additionally, samples shocked to 38.0, 44.6, 46.8, 50.0 and 55.8 GPa show a "darkening" in plane-polarized light that does appear to increase in pervasiveness with increased pressure.

Micro-Raman Results: With the exception of the most highly shocked sample (55.8 GPa) all samples show characteristic feldspar peaks at 290, 478, and 507 Δ cm^{-1}. Additional peaks at 112, 251, 761 and 208 Δ cm^{-1} are present in some samples, but these likely reflect slight structural or chemical variation in individual grains. Between 17 and 50 GPa shock effects are manifested as a decrease in spectral contrast, loss of low-energy peaks (below 450 Δ cm^{-1}) and an increase in intensity ratio of 479 to 507 Δ cm^{-1}, approaching 1 in the most highly shocked samples (Figures 1-3). Only the 55.8 GPa sample is fully amorphous, with a Raman spectrum showing a broad peak centered near 490 Δ cm^{-1}.

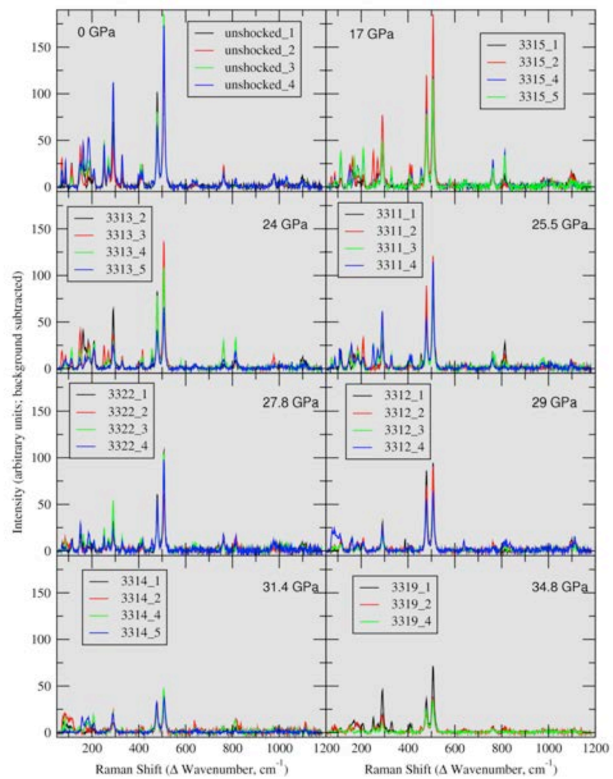

Figure 1a. Raman spectra for albite samples shocked between 0 and 34.8 GPa. Spectra were taken at multiple locations across each sample. Although there is variability within individual samples, there is a general trend of decreasing intensity of peaks and loss of low wavenumber peaks with increasing pressure. Sample numbers reflect experimental shock run numbers [7].

Discussion and Implications: Our results suggest that albite retains some degree of crystallinity up to 50 GPa, consistent with previous Raman analysis of albite [12] and with emission spectroscopy [7]. Low-wavenumber peaks (<450 Δ cm^{-1}) decrease steadily over the pressure range of 0 to 50.0 GPa, also consistent with previous work [12]. This could reflect structural disturbance of Na during shock [13], as these peaks correspond to complex lattice vibrations involving cations [14]. These results are different from Raman spectroscopy of andesine feldspars, which show the transition from crystalline feldspar to an amorphous material occurs between 28 and 29 GPa [15]. This is consistent with known strong compositional effects from shock among feldspars.

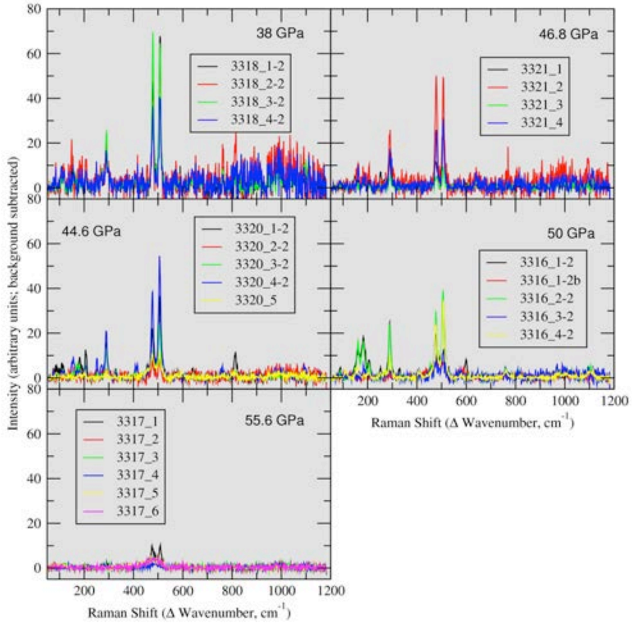

Figure 1b. Raman spectra for samples shocked between 38 and 55.6 GPa. Only the 55.6 GPa sample has become completely amorphous. Spectrum 3317_1 shows peaks at 479 and 508 Δ cm^{-1}, but this was collected along the edge of the sample and is not representative of the full sample.

Interestingly, no samples show traditional petrographic shock textures in feldspars such as planar deformation features or alternate twin deformation lamellae. They do, however, show heavy fracturing and an overall "darkening" in plane-polarized light, neither of which are currently recognized as uniquely diagnostic of shock events. The lack of petrographic shock indicators in samples exhibiting pressure-dependent spectroscopic changes highlights the importance of a multi-technique approach when dealing with complex processes such as shock events.

Future work. Micro-FTIR reflectance spectra (715-7000 cm^{-1}) are also being acquired of these samples for comparison to the Raman spectra and to experimentally shocked andesine and bytownite samples [cf. 15]. Diamond Anvil Cell (DAC) static compression experiments on these samples are also underway [cf. 16].

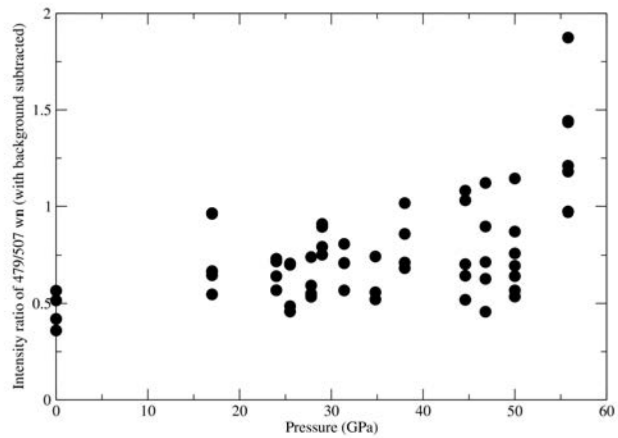

Figure 2: Intensity ratio of 479 to 507 Δ cm^{-1} peaks. With increased shock, this ratio approaches 1 as the peaks disappear, similar to the experimentally shocked andesine samples from [15].

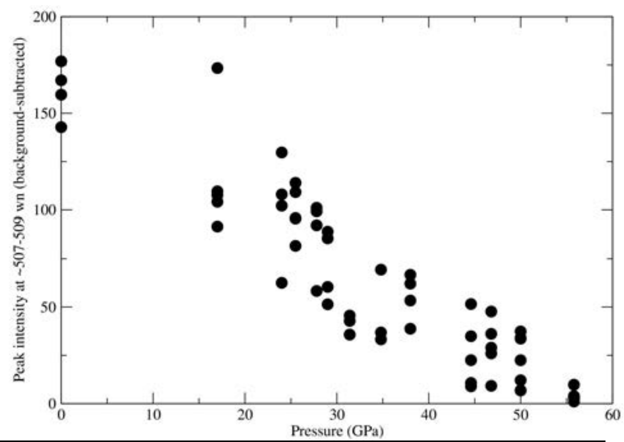

Figure 3. Variation of peak intensity near 507 Δ cm^{-1} as a function of pressure in albite samples, calculated from spectra shown in Figure 1.

References: [1] Stöffler et al., 1991. GCA 55:3845–3867. [2] Stöffler, 1971. JGR 76, 5541-5551. [3] Kieffer et al., 1976. Proc. Lunar Sci. Conf. 1391-1412. [4] Hörz and Quaide, 1973. The Moon 6, 45-82. [5] Ostertag, 1983. Lunar Sci. Conf. J. Geophy. Res. 88 Supplement, B364-B376 [6] Johnson et al., 2002. JGR 107(E10) 5073. [7] Johnson et al., 2003. Am. Min., 88, 1575-1582. [8] Singleton et al., 2011. MAPS 46, 1774-1786. [9] Johnson, 2012. Icarus 221 359–364. [10] Jaret et al., 2015 JGR 120, 570–587. [11] Pickersgill et al., 2011. MAPS 50, 1546–1561. [12] Velde et al., 1989. Chem. Min. Phys. 16, 436-441. [13] Yamaguchi and Sekine, 2000. EPSL175 289^296 [14] Iiishi et al., Neues Jahrb. Mineral. Abh., 115, 98–119. [15] Jaret et al., 2015. LPSC abstract 2056. [16] Jaret et al., 2015 GSA p.355.

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