

**SPECTROSCOPY OF IMPACTED SERPENTINE: IMPLICATIONS FOR ASTEROID SURFACES.** A. S. Rivkin, *Massachusetts Institute of Technology, Cambridge MA 02139, USA, (asrivkin@mit.edu)*, T. Hiroi, *Brown University, Providence RI, USA*, F. Horz, M. Cintala, *Johnson Space Center, Houston TX, USA*, E. Pierazzo, *Planetary Science Institute, Tucson AZ, USA*.

The presence of hydrated/hydroxylated minerals (hereafter “hydrated minerals”) in meteorites has been known for several decades [1]. Spectroscopically, they have been detected on asteroids beginning in the 1970s using a set of strong absorptions near 3  $\mu\text{m}$  [2,3]. While the presence of a 3- $\mu\text{m}$  band on an asteroid has been considered diagnostic for the presence of hydrated minerals on its surface, the interpretation of *no* feature is not as straightforward. Evidence for spectral changes in the 0.3–2.5  $\mu\text{m}$  region and maturation processes in asteroid regoliths has led to the idea that micrometeorite impacts could dehydrate the surfaces of small bodies, leading to a “false negative”. If true, abundant hydrated minerals could plausibly be hidden beneath a dehydrated veneer of old regolith. This issue is particularly important in the case of the martian satellites Phobos and Deimos. These have been found to have no detectable 3- $\mu\text{m}$  band, leading to the interpretation that these are largely anhydrous bodies. Because of the possibility that Phobos and Deimos could be used as staging areas for human exploration of Mars, the determination of their hydration state is crucial for proper planning.

We have begun a multi-stage program using impact experiments and numerical modeling to tackle the question of whether impacts can dehydrate asteroidal surfaces. We report the spectral results of five impact experiments into serpentine performed at NASA Johnson Space Center (JSC) at shock pressures from 22–41.4 GPa. The starting material for the impact experiments was a massive chunk of serpentinite from Rich Bar, CA, that contains some 12.5% water (LOI; courtesy of R.V. Morris, JSC). This sample was cored and wafered into a disk of 12 mm diameter and 1 mm thickness. The shock experiments employed a powder propellant gun to accelerate metal flyer plates into metal targets containing the specimen disks as summarized in [4], including other experimental details. Care was exercised during all sample coring and extraction so as not to heat the sample, and the samples were stored and shipped in desiccant-loaded containers.

The samples from these experiments along with an unshocked sample were analyzed using the bidirectional spectrometer and the FTIR spectrometer at RELAB in Providence to obtain their reflectances from 0.3–4.6  $\mu\text{m}$ . The samples were analyzed within 60 days of the experiments, and spent less than 2 hours outside of the vacuum-sealed bags they were placed into immediately following the shots. During preparation, the samples were ground into particles smaller than 125  $\mu\text{m}$  and dry-sieved, then were purged in dry air for 24 hours before their final spectra were taken. Spectra were also taken before the purge and can be compared to the post-purge versions. Sections of the spectra are shown in Figure 1, normalized to 1.7  $\mu\text{m}$ . As is obvious, there is no strong weakening of the 3- $\mu\text{m}$  band in these samples, and no consistent trend. The most striking difference is the lack of absorptions near 3.3–3.4  $\mu\text{m}$  in the shocked samples. These absorptions are

due to C-H bonds, probably originally present as contamination in the unshocked serpentine but destroyed by shock in the other samples. Their absence in shocked samples may help explain their absence in outer-belt asteroid spectra that have been studied by Cruikshank et al. [5].

The O-H stretch at 2.7  $\mu\text{m}$  is slightly weaker in the shocked samples, though unexpectedly, the H<sub>2</sub>O feature near 2.9  $\mu\text{m}$  is slightly stronger and the 3- $\mu\text{m}$  band as a whole is slightly broader. This has been observed before in kernite by Boslough et al. [6] who attributed the phenomenon to OH liberated by shock being immediately reincorporated as H<sub>2</sub>O. The overtones and other bands associated with hydrated minerals, near 1.4, 1.9, and 2.2–2.4  $\mu\text{m}$  also show no obvious changes.

Preliminary XRD analysis has also been performed at JSC. An aliquot of recovered sample mass was powdered to less than 63  $\mu\text{m}$  grain size for these studies. While there is evidence for line broadening with increasing shock stress due to mechanical disaggregation of the crystal lattice (consistent with previous studies [4,7]) and the possible formation of an additional oxide above 35 GPa, there is no evidence for measurable water loss.

We will present the spectra, and discuss them in terms of what this may mean for asteroid spectra as well as in terms of alternate, laboratory-based explanations for the results.

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*References:*

- [1] DuFresne and Anders *GCA* **26** (1962) 1084–1114.
- [2] Lebofsky *MNRAS* **182** (1978) 17–21.
- [3] Rivkin et al., in *Asteroids III* (2002)
- [4] Skala et al. *GSA Special Pub.* **356** (2002) 571–585.
- [5] Cruikshank et al. *Icarus* **156** (2002) 434–441.
- [6] Boslough et al. *LPSC* **11** (1980) 97–99.
- [7] Horz and Quaide *The Moon* **6** (1973) 45–82.

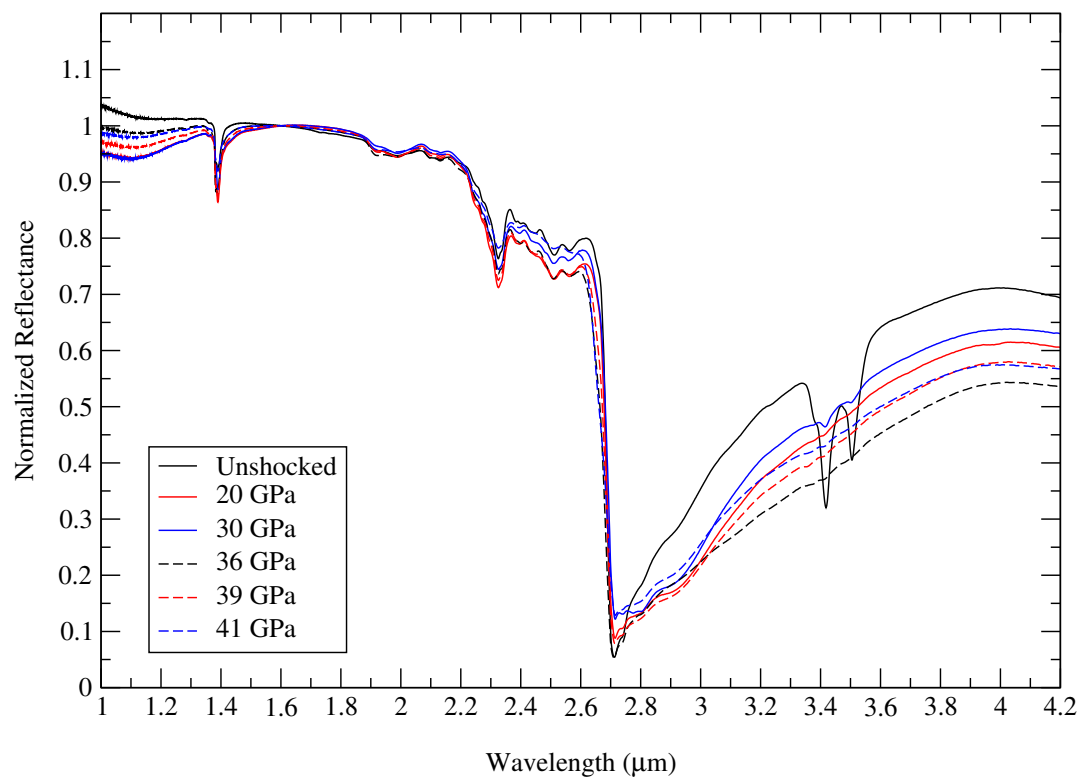


Figure 1: Spectra of serpentine samples, normalized to  $1.7 \mu\text{m}$ . The most obvious change in the spectra is the loss of the absorption bands near  $3.4 \mu\text{m}$ , due to C-H, with increased shock. The main, broad  $3\text{-}\mu\text{m}$  hydrated mineral band broadens with shock, and the  $2.7\text{-}\mu\text{m}$  band depth lessens, but the feature appears to broaden. We will discuss these data and possible interpretations.