THE INFLUENCE OF ABRASION ON MARTIAN DUST GRAINS: EVIDENCE FROM A STUDY OF ANTIGORITE GRAINS. Janice L. Bishop[1], Ahmed Drief[2], and M. Darby Dyar[3], [1]SETI Institute/NASA-ARC, Mail Stop 239-4, Moffett Field, CA 94035, [2]Dept. of Geology, Univ. of Calif., Davis, CA, 95616, [3]Dept. of Earth and Environment, Mount Holyoke College, South Hadley, MA 01075. (contact: jbishop@mail.arc.nasa.gov)

Introduction: Grinding was shown to greatly affect the structure and a number of properties of antigorite grains in a study by Drief and Nieto [1]. Grinding is likely to influence the structure of most clay mineral grains and has been shown recently to influence the structure of kaolinite [2]. The antigorite structure includes curved waves of layered sillicate as shown by D dony et al. [3]. Our study was performed in order to characterize in detail changes in the mineral grains resulting from grinding and to assess the influence of physical processes on clay minerals on the surface of Mars. This project includes a combination of SEM, reflectance spectroscopy and Mössbauer spectroscopy.

Methods and Results: Reflectance spectra measured in this study indicate that grinding has a profound influence on both the shape of the spectral features and the spectral continuum in the visible/near-infrared (NIR) and mid-IR regions. Biconical, off-axis FTIR data were scaled to bidirectional data at 1.2 µm and corrected for absolute reflectance as in previous studies [4]. The antigorite sample in this study is a weathering product of an olivine rock with magnetite inclusions from Mulhacen, Spain, and was freshly prepared following procedures outlined in [1]. 30 g of this antigorite, $Si_{2.01}Al_{0.12}Fe_{0.08}Mg_{2.70}O_5(OH)_4$, sample (including a few % magnetite) was initially ground in an HSM vibration grinder for 30 sec. to produce sufficient particulate material for the study and was termed An-0. Subsequent samples are labeled according to the number of minutes ground, i.e. An-1 was ground for 1 min. and An-30 for 30 min. SEM was performed at UC Davis and shows aggregates of ultrafine grains in the ground samples. Mössbauer data were measured at room temperature as in [5] and show reductions in the amount of antigorite and magnetite in these samples with grinding.

SEM: The image of antigorite particles ground for 30 minutes in Fig. 1 illustrates the ultrafine particle sizes produced by grinding. These tend to adhere to each other and form larger aggregates (e.g. as indicated by the white arrow). The increased surface energy due to the mechanical stress caused by grinding plays an important role in their adhesion.

Mössbauer Spectra: The room temperature spectra are characteristic of a mixture of antigorite and magnetite (Fig. 2). The antigorite Fe^{2+} peaks (which lie at roughly -0.2 and 2.45 mm/s) decrease in intensity with grinding, but there is no related increase in the region where Fe^{3+} peaks should occur in antigorite (0.10 and 0.75 mm/s). All the magnetite peaks decrease with increased grinding, and there is no apparent change in peak intensity/line asymmetry that would signal significant changes in grain size or the creation of nonstoichiometric magnetite or maghemite. Thus, the observed changes in both antigorite and magnetite spectra suggest that neither phase is becoming more oxidized; rather, the decreasing intensities suggest a change to an amorphous material.

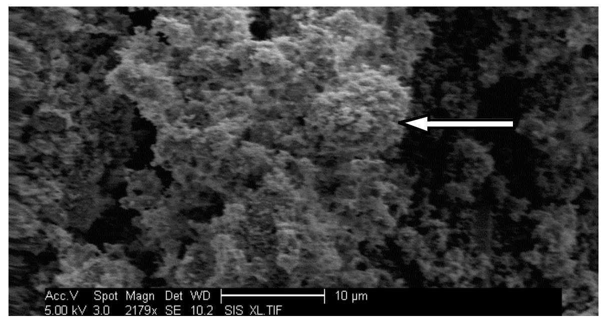

Fig. 1 SEM image of antigorite (ground for 30 min. and sieved to <125 µm) showing aggregates (white arrow) of ultrafine particles.

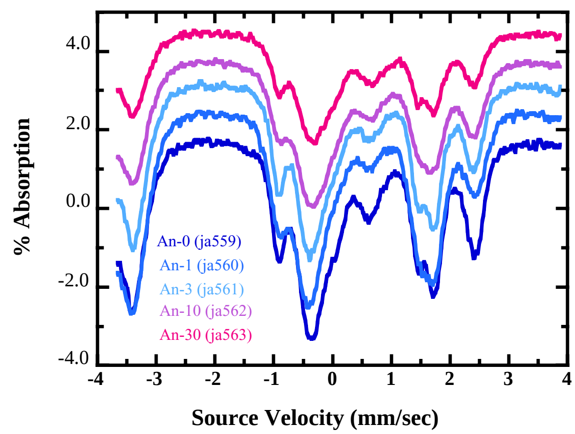

Fig. 2 Mössbauer spectra (278 K) of ground antigorites. The spectra are offset for clarity. An-0 was ground for 30 s, An-1 for an additional 1 min., An-2 for an additional 2 min., An-10 for 10 more min., and An-30 for 30 more min.

Reflectance Spectra: Visible/NIR reflectance spectra are shown in Fig. 3, where the color varies from dark blue for the freshest samples to pink for the most altered. These spectra show that grinding of antigorite grains induces a spectral slope, darkens the spectra, reduces the intensity of the OH features, and changes the character of the Fe bands from 0.6 to 1.0 µm. Mid-IR reflectance spectra show a decrease in the intensity of the silicate bands near 490, 675, 890, and 1050 cm^{-1}, shifts in some band centers, creation of new features near 820, 870, 1350, 1480 and 1600 cm^{-1}, and a reduction in the spectral contrast above 1200 cm^{-1} with grinding. Arrows in Fig. 4 indicate the position of the new bands formed with grinding; these are most obvious in the pink spectrum (ground for 30 min.). Some of these new bands may be related to features in the Martian dust spectrum.

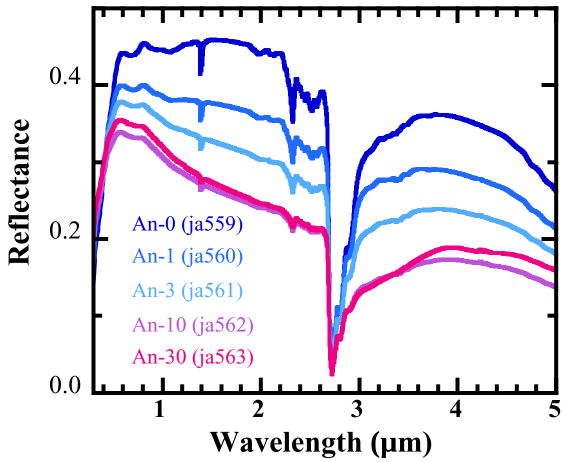

Fig. 3 Visible/NIR reflectance spectra of the antigorites.

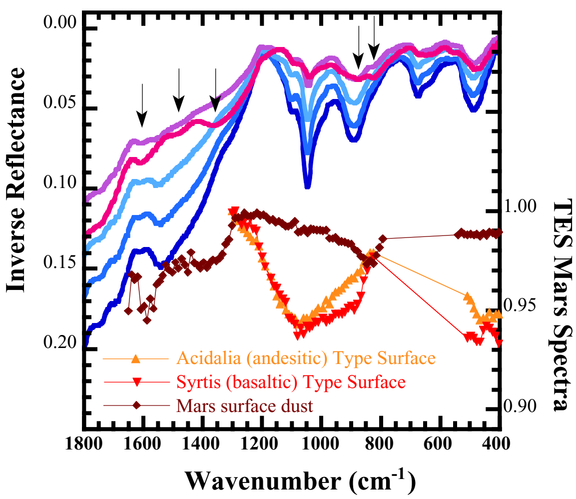

Fig. 4 Mid-IR reflectance spectra of the ground antigorite samples and TES spectra of Mars. The Acidalia and Syrtis spectra are from Bandfield et al. [6] and the average surface dust spectrum is from Bandfield and Smith [7]. The arrows indicate new bands that appear after grinding.

Applications to Mars: NIR spectral studies of Mars have shown evidence for weak features near 2.2-2.3 µm in some regions (e.g. Lunae Planum) that are attributed to octahedrally bound OH in clays or other minerals [8], although the features are too weak for mineral identification in existing spectral datasets of Mars. Upcoming OMEGA and CRISM spectrometers will measure NIR spectra at higher spatial and spectral resolution and will be able to provide closer inspection of any putative OH features present in the alteration products on the surface of Mars.

Previous studies have suggested chemical alteration as a mechanism for reducing the ~2.2-2.3 µm OH species in layer silicates on Mars [9, 10, 11]. This study shows that physical alteration can also reduce the OH species in layer silicates and may thus diminish this species in spectra of the dust on Mars. The Mössbauer and visible spectra suggest that grinding also reduces the amount of magnetite in the sample and produces some nanophase/amorphous iron oxides. As seen in Fig. 5 the spectral changes observed due to grinding of our samples are on a scale similar to the spectral changes observed on Mars. Further characterization of the amorphous species is underway. Changes in the Fe and OH species in our samples due to aeolian-like processes may have applications to data the MERs will see with mini-TES, Pancam and the mini Mössbauer.

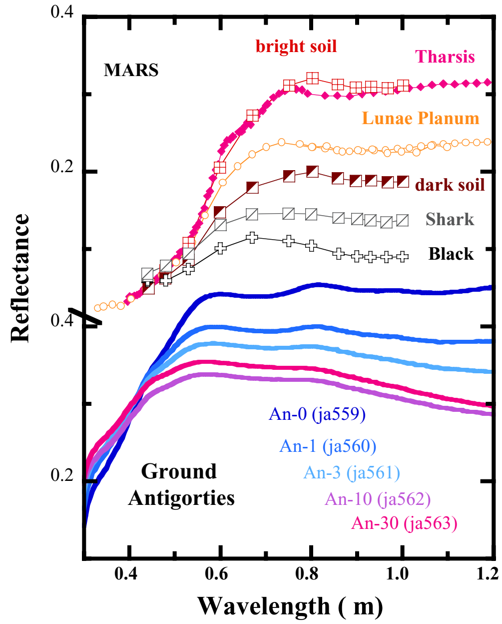

Figure 5 Extended visible region reflectance spectra of the ground antigorites and Mars. The Tharsis telescopic and ISM spectrum is from Mustard and Bell [12], the Lunae Planum telescopic and ISM spectrum are from McCord et al [13] and Murchie et al. [8].

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