SPECTRAL PROPERTIES OF SHOCKED AND UNSHOCKED GRANITES: IMPLICATIONS FOR DETECTION ON MARS.

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Introduction: Recent evidence for granitoid rocks on Mars has been obtained through remotely sensed imagery of two craters near Syrtis Major. Data was acquired using the Thermal Emission Imagery System (THEMIS) on the Mars Odyssey spacecraft and the Thermal Emissivity Spectrometer (TES) on board the Mars Global Surveyor [1]. The spectra and images show materials in the crater central uplift with emissivity spectra that closely match the spectral properties of quartz monzonite [1]. These rocks are thought to have formed through the melting of metamorphosed basaltic rocks. This transformation to silica-rich materials would have occurred 3-4 km below the surface [1]. The effect of the impact was to bring these underlying granitic materials to the surface, which are exposed in the craters' central uplifts (Figure 1). The central uplifts show distinctly different spectral properties than the surrounding crater material that has spectral characteristics similar to the intercrater basaltic plains. The central uplift exposures of granitic material make up a small portion of the 30 km diameter craters, with roughly 1 by 3 km expanses [1].

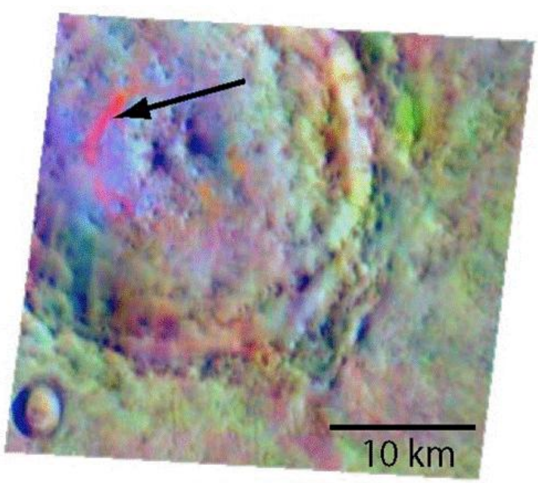

Figure 1: Exposed granitoid rocks at central uplift of crater (arrow). Source: http://themis.asu.edu/node/5395

Although quartz-bearing granitoid rocks have been detected on Mars, they remain a rare occurrence. Should cratering processes have formed these materials from basaltic precursors, they would be more common on the Martian surface, and it can then be deduced that the source rock of the grantioid material found in these two craters is unique [1]. Further investigation into identification of such materials using various remote sensing techniques can aid in the ability to recognize exposed granitoid and granitic outcrops. This information can increase the understanding of Martian geological processes including the possibilities of fractional crystallization, crustal assimilation, and crustal overturn. An improved ability to identify these rock types may reveal other occurrences of such outcrops and suggest the likelihood of Mars having more active geological processes than currently thought.

Study Site: To better understand possible evolutionary pathways for the formation of granitic rocks on Mars, and how impacts may play a role in their formation, alteration, and spectral properties, we have conducted a spectroscopic-structural-compositional study of shocked/melted and unshocked granites. Granite samples were collected from a variety of locations and depths of the Lake St Martin (LSM) impact structure in central Manitoba.

The LSM impact structure is located in Manitoba, Canada with a diameter of approximately 23 km and is ~230 million years old [2]. Prior to impact, the surficial geology of the site consisted of ~400-500 m thick Devonian and Ordovician carbonate deposits overlaying Precambrian granites [3]. The impact resulted in the formation of shocked and melted granites and carbonates. Major outcrops include unshocked but uplifted Precambrian granites, granitic melt rock, shock metamorphosed granitic gneiss, and recrystallized carbonate melt rocks. Due to the prevalence of accessible outcrops of various stages of shocked and melted granite, the LSM impact structure is a favorable analogue site for understanding how similar rock types may be identified on Mars. Understanding the variations in spectral properties of shocked or melted granites may provide insights into the non-detection of larger scale unaltered granite deposits on Mars.

Two unaltered Precambrian granites (country rock) were retrieved from the eastern rim of LSM impact structure. The granitic melt samples include one melt rock and samples of two drill cores from the southeastern crater edge. Shock-metamorphosed granitic gneiss samples were also retrieved.

Results: A thorough analysis of the LSM samples was conducted; this included X-ray diffraction and X-ray fluorescence analysis as well as collection of Raman, visible and near-infrared reflectance and thermal infrared emissivity spectra. The emissivity spectra are the focus for the purposes of comparison to the granitoid rocks identified on Mars. Similar to the granitoid rock spectra of the central uplift identified by THEMIS, the LSM samples show a similar high wavenumber absorption within the 800-1200 cm-1 Si-O absorption band. Preliminary emissivity data show a shift in this Si-O band to longer wavelengths in the shocked samples as well as a narrowing of the emissivity band; this is indicative of exposure to high pressures and shock respectively (Figure 2). This shift to longer wavelengths may be due to quartz and its doublet absorption losing its short wavelength when shocked to cristobalite or melted glass.

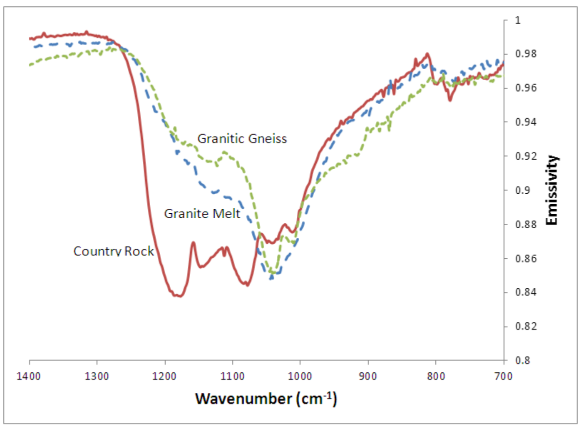

Figure 2: Whole rock emissivity spectra of granites from LSM

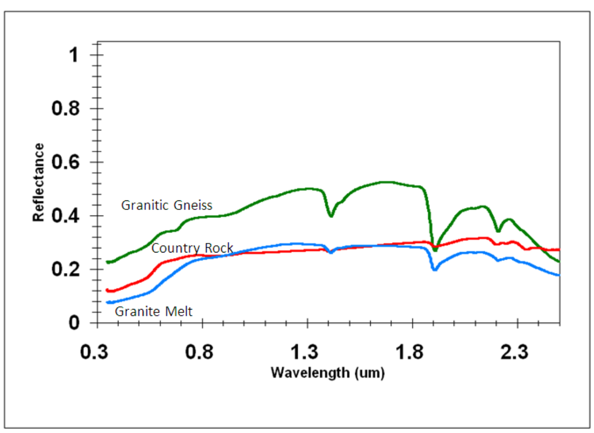

Figure 3: Whole rock reflectance spectra of granites from LSM

The reflectance spectra, which were obtained in the 0.35-2.5 µm range, also show evidence of shock in the gneiss and melt. This is evident in the widening of absorption bands in both the melt and gneiss when compared to the country rock (Figure 3).

The Raman spectra of these samples have proven to be difficult to analyze given the high degree of fluorescence which they exhibit using 532 nm excitation.

Conclusions: *Implications for Mars.* The data collected may be used to better understand which spectroscopic techniques are best suited for the identification of shocked granites and melted carbonates on Mars. Given the high fluorescence of granites when measuring Raman spectra it may not be a reliable method to use in identification of granites on the martian surface. However clear signs of shock were evident in both the reflectance and the emissivity spectra collected. Reflectance and emissivity spectra collection would be the most appropriate orbital or rover tool for further identification of granites on Mars.

References: [1] Bandfield J. L. et al. (2004) *JGR, 109, E10009* doi: 10.1029/2004JE002290. [2] Wartho J-A. et al. (2010) *LPS XXXXI #1930.* [3] McCabe H. R. and Bannatyne B. B. (1970) *Geol. Survey Manitoba. 3/70, 1-79.*