VISIBLE-INFRARED REFLECTANCE OF THE TISSINT METEORITE: IMPACT MELT, MASKELYNITE, AND IMPLICATIONS FOR MARS REMOTE SENSING

J.F. Mustard[1], C. D. K. Herd[2], J. R. Skok[1], K. M. Cannon[1] [1]Dept. of Geological Sciences, Box 1846, Brown University, Providence, RI 02912, [2]Dept. of Earth and Atmospheric Science, University of Alberta, Edmonton, AB T6G 2E3 Canada (Contact: John_Mustard@brown.edu)

Introduction and Science Objectives: The Tissint martian meteorite, which was observed to fall in Morocco July 18, 2011 [1], has a number of compelling characteristics important for understanding remotely sensed data of Mars acquired from orbit and rovers. It is extremely fresh and because its fall was observed, there has been little to no terrestrial contamination or alteration. The meteorite has abundant maskelynite in the groundmass, and is shot through with numerous shock viens and patches filled with glassy material (Figure 1).

Figure 1. Photograph of the Tissint meteorite (Natural History Museum, London. The fresh interior shows large yellow/gren olivine macrocrysts and pockets and veins of black glass. The rock is 15 cm across.

The authors of the recent Science paper on the Tissint meteorite [1] note that the meteorite is petrographically similar to the other picritic shergottites, the group of olivine-rich martian basaltic rocks. This new meteorite has the strongest affinities petrographically to the lithologies A and C of EETA79001 [2]. One exciting aspect of Tissint is the possible presence of a martian weathering component [1]. This is in the form of weathering products incorporated into the melt phase along fractures. Another key aspect of Tissint is the abundant glass/melt components were likely formed during impact and launch from Mars. Therefore this is an excellent sample of impact melt formed on Mars incorportaing elements of the atmosphere and possible weathering products.

The relative freshness of the sample, presence of abundant melt, and incorporation of martian weathering makes this sample particularly valuable for comparision to orbital and landed science remotely sensed data. The goal of this abstract is to present the first spectral data of Tissint and to compare to orbital data.

Sample Measurement. A sample of the Tissint meteorite was provided by co-author Chris Herd (University of Alberta) to be measured in the visible-infrared spectrometer RELAB. Several hundred miligrams of powdered material were loaned to Brown University. This material is saw fines generated in the preparation of aliquots for measurement.

Visible to infrared reflectance from 0.3 to 2.65 μm was collected in RELAB using the 30° incidence and 0° emergence angle geometry. These data are then compared to similar measururements of EETA 79001 lithology A and B analyzed spectroscopically by [3]. These data are further compared to martian reflectance spectra acquired by the CRISM instrument [4]. Skok et al. [5] investigated central peak regions with CRISM and identified Alga crater as having strong mafic mineral signatures and impact melt/glass. Data from the Alga crater were corrected for viewing geometry and atmospheric absorptions. Spectra over key regions were acquired and ratioed to a spectrally neutral region in the same columns.

Results: The laboratory spectra of Tissint and EETA 79001 are shown in Figure 2 along with the CRISM relative reflectance spectra of pyroxene-rich and melt-rich outcrops in Alga crater. Sunshine et al. [3] modeled the crystal field absorption band at 1 and 2 μm in the spectra of EETA 79001 as a mixture of sub-equal amounts of low and high Ca pyroxene, consistent with petrographic analyses. Skok et al. [5] modeled the pyroxene rich regions of Alga crater as a similar mixture of subequal amounts of low and high Ca pyroxene. The laboratory and remotely acquired data show good general agreement in shape and modeled mineralogy.

The spectrum is Tissint is distinct from those of EETA 79001 by having a much lower spectral contrast (strength of absorption features). The presence of pyroxene crystal field absorptions at 1 and 2 μm is still evident, but the band strength has been reduced by a factor of 5. This is entirely consistent with the CRISM spectra of melt rich regions of Alga crater compared to the well exposed mafic regions rich in pyroxene. This is also similar to the effects of impact melt in lunar samples [6].

Conclusions: Tissint is an important sample for understanding remotely acquired data for Mars because of the presence of abundant maskelynite, impact melt, its extreme freshness, and the presence of weathering components.

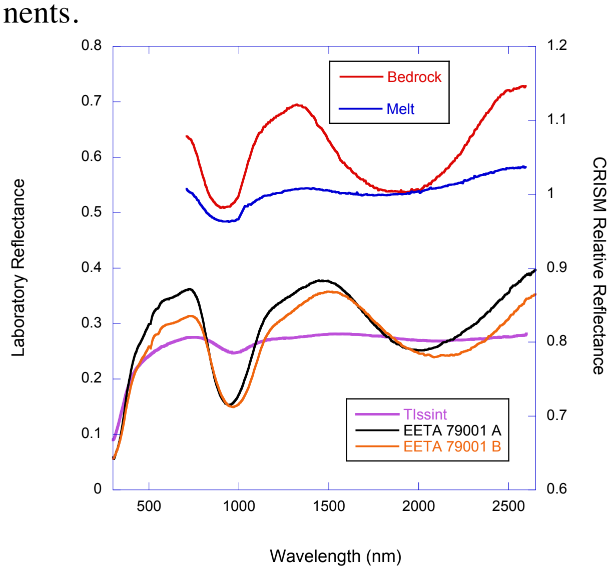

Figure 2. Top spectra are from the central peaks of Alga crater Mars. The bedrock spectrum shows typical

While the presence of pyroxene is evident in the Tissint spectrum, the presence of olivine, which is quite clear in hand samples and the petrographic analyses, is not from this initial analysis. This may be due to the particular region where the saw fines were derived, masking of its presence by impact melt and maskelynite, or suppression by spectral mixing with the other components (e.g pyroxene). The low spectral contrast has been observed in many mafic regions on Mars and with this new perspective from Tissint may be more confidently interpreted as due to the presence of melt components, as has been shown for the Moon [6]. Future work will seek to expand the analyses of Tissint samples to isolate some of the key components, including the impact melt formed in the martian environment.

References: [1] H. Chennaoui Aoudjehane et al., Science 338, 785 (2012) DOI: 10.1126/science.1224514. [2] R. H. Becker and R. O. Pepin, EPSL. 69, 225 (1984). [3] J. M. Sunshine et al., Icarus 105, 79-91 (1993). [4] Murchie et al. (2007) JGR DOI: 10.1029/2006JE002682. [5] J. R. Skok, et al., (2012) JGR, 117, E00J18. [6] S. Tompkins and C. M. Pieters (2010). , Meteor. Planet. Sci., 45, 1152-1169, doi: 10.1111/j.1945-5100.2010.01074.x.