NEAR-INFRARED SPECTRA OF GLASSY IMPACTITES FROM TERRESTRIAL IMPACT STRUCTURES.
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Introduction: Hypervelocity impacts ranging in scale from large events involving asteroidal and cometary projectiles down to micrometeoroid impact are ubiquitous occurrences that have been shaping the surfaces of the rocky bodies of the inner solar system throughout geological time. A characteristic feature of the impact process is the creation of glasses. Impact glasses are likely to be a significant portion of the material comprising the uppermost surface of Mars [1]. They comprise a portion of the materials responsible for the suppression of spectral contrast and red slopes in asteroid near-infrared spectra, and, finally, they contribute to the spectral properties of the lunar soil [2]. Glassy materials have been proposed to be responsible for features observed across varying regions of the Martian surface in the near-infrared by [3, 4] and used in spectral deconvolutions to explain infrared spectral features by [5, 6]. On the Moon, the near-infrared spectral features of space weathering are attributed to glassy materials with imbedded minute iron grains [e.g., 2, 7 and references therein].

Experimental Procedure: Biconical absolute reflectance spectra, i=30°and e=0°, were collected with an Analytical Spectral Devices Inc. FieldSpec Pro HR spectrometer at the HOSERLab facility at the University of Winnipeg from 0.35–2.5 µm. The spectral resolution varies between 2 and 7 nm. Spectra were measured relative to Spectralon®. Periodic measurements of a holmium oxide doped Spectralon® wavelength standard ensured wavelength accuracy, and 200 spectra were averaged to increase the signal-to-noise ratio. The spectrometer uses a bundle of fibre-optic cables for spectral collection which split internally to the three detectors, as such, the ~ 5 mm field-of-view of the instrument is approximate as each detector is not viewing the same area of the sample and as a result, the spectra often have breaks at the detector junctions which are corrected for by scaling the 0.35–1.0 and 1.83–2.5 µm ranges either up or down such that they meet smoothly with the wavelength range of the thermally stabilized central detector. Other than correction for breaks in the spectra, the presented spectra are unaltered.

Samples were crushed by hand and dry sieved to produce splits with grain sizes of <45 µm; the **Lonar** and **Mistastin** crater samples shown in Fig. 3, 45–90 µm; the **Ries** and **Mistastin** samples shown in Fig. 1 and 2, 500–1000 µm; the **acid leached basaltic glass** from Fig. 1 and 2 and an unsorted sample (<1 mm fraction), **mature lunar soil 15041** as discussed by [8, 9], shown in Fig. 3. The acid leached basaltic glass sample in Fig. 1 and 2 was immersed in acid for 43 days prior to the measurement of this particular spectrum following the procedures discussed in [4]. Spectra of this sample were collected over a period of 220 days and the sample continued to alter over the course of the experiment, though less so after the 43 day mark, see [3, 4] for examples of earlier and later spectra.

In addition to the near-infrared spectra presented herein, the samples have also had transmission and reflectance infrared spectra measured using the HOSERLab facility and X-Ray diffraction patterns collected at the Micro X-Ray Diffraction Facility at the University of Western Ontario.

Discussion: When envisioning both lunar-style space weathering, and the acid leaching of basaltic glassy rinds, one considers comminuted particles with acid-leached rinds or vapor-deposited coatings (i.e., microscopic surficial alteration). This stands in stark contrast to the macroscopic nature of samples produced by hypervelocity impact, where iron is mobilized in such a fashion that it produces similar spectra, but is not within microscopic surficial coatings. With reference to Mars, the spectra in Fig. 1 show two examples of with high concavities and shifted band centres as discussed by [3, 4]. While their spectra are similar, these two samples have vastly different physical properties. The sample from **Ries** is a white-coloured, highly vesiculated melt glass, partially devitrified into hydrous phyllosilicates (see Fig. 2d in [10]), while the sample from **Mistastin** is an impact breccia with interspersed black vesiculated glassy clasts similar in appearance to the sample shown in Fig. 2a in [10]. These are spectrally similar not because of their morphology or constituents, but because the iron in the glassy component has been mobilized in such a fashion as to produce similar spectra. Figure 2 shows that for the same samples, the addition of non-glassy components makes a substantial difference to the overall reflectance of these samples.

Referring to the lunar soil and the two impactites shown in Fig. 3 we see much the same sort of effect. Again, the driver the spectra here is the fashion in which the iron has been mobilized. In both the **Lonar** and **Mistastin** impactites the red slope and overall suppression of spectral contrast is due to the glassy and nanophase iron components just as they are in the spectra of the lunar agglutinates in the split of **15041**. But unlike the lunar agglutinates which have vapour-deposited glassy coatings with imbedded minute particles of iron metal, these samples are a vesiculated pyroxene-bearing glass (Lonar) and an example of obsidian-like impact melt glass (Mistastin).

Conclusion: The near-infrared reflectance spectra of the majority of the rock-forming minerals are driven by the coordination environment, dispersion and abundance of iron in the minerals, and as most rocks, so too are the absorption features of glassy iron bearing impactites. In the examples provided, we have shown that morphology is not a significant contributing factor and that the mobilization of iron in glassy impactites on the macroscopic scale can mimic that on the microscopic scale that is currently used to describe similar spectral features on the Moon, Mars and asteroids. Glass-bearing impactite lithologies can mimic the spectral properties of glassy rinds produced by micrometeoroid impact and acidic leaching. Because hypervelocity impact is a ubiquitous process, it is possible that simple admixture of impact melt glass is responsible for some spectral properties heretofore attributed to space weathering or acidic leaching processes.

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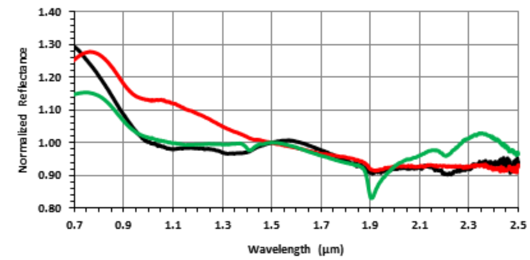

Figure 1: Normalized near-infrared biconical absolute reflectance spectra of two glassy impactites, a sample from the **Ries** impact crater and a sample from the **Mistastin** impact crater, compared with an **Acid Leached Basaltic Glass** sample from [4]. The grain size of the samples is dissimilar, i.e., the impactites are splits with a grain size of 45–90 µm, while the leached basaltic glass is a split from 500–1000 µm. As such, the spectral contrast of the impactite samples is muted when compared with that of the basaltic leached glass sample. Spectra have been normalized to 1 and 1.5 µm.

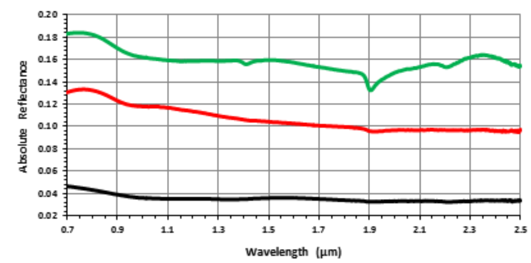

Figure 2: The same **Ries**, **Mistastin** and **Acid Leached Basaltic Glass** samples as fig. 1 presented in absolute reflectance.

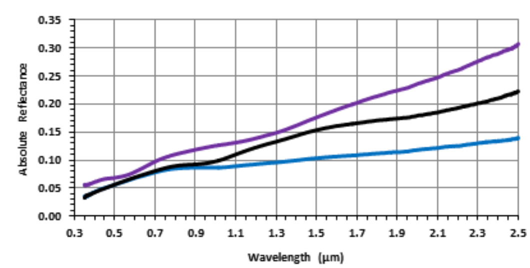

Figure 3: Biconical near-infrared absolute reflectance spectra of a sample from the **Lonar** impact crater and a sample from the **Mistastin** impact crater, compared with **Mature Lunar Soil 15041**. The Lonar and Mistastin spits are 45–90 µm while 15041 is unsorted, though, in this instance, grain size is not a significant factor, rather here, it is the variance in the relative amounts of lunar agglutinate-like glass in the samples which is subtly altering the spectral slopes.