

XRD PATTERNS OF GLASSY IMPACTITES: AMORPHOUS CURVE FITTING AND COMPOSITION DETERMINATION WITH IMPLICATIONS FOR MARS. M. A. Craig¹, R. L. Flemming¹, G. R. Osinski¹, E. A. Cloutis², M. R. M. Izawa², H. M. Sapers³ and C. L. Marion¹, ¹Western University, Dept. of Earth Sciences/Centre for Planetary Science and Exploration, 1151 Richmond St., London, ON, Canada, N6A 5B7, (mcraig44@uwo.ca); ²University of Winnipeg, Dept. of Geography, 515 Portage Ave., Winnipeg, MB, Canada, R3B 2E9; ³McGill University, Dept. of Natural Resource Sciences, 2111 Lakeshore Rd., Ste. Anne de Bellevue, QC, Canada, H9X 3V9.

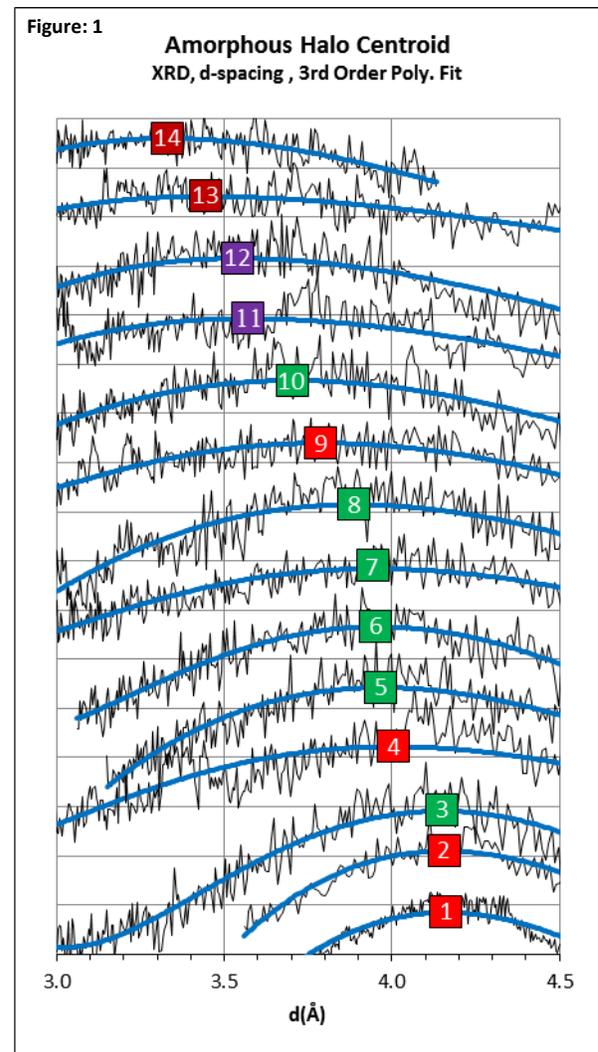
Introduction: Impact cratering is a ubiquitous process in the inner solar system, and continues to be the dominant geologic process shaping the surface of Mars. For some time, researchers have speculated about the types and volumes of amorphous material present on the surface of Mars [e.g., 1]. Probable “glassy” (referring to glasses and other amorphous phases) materials have been identified in the two major spectral windows used for remote observations of Mars, and some attempts have been made to describe their compositions via spectral techniques [2-4]. With the Mars Science Laboratory and its CheMin instrument on the surface of Mars we have our first opportunity to quantitatively assess the mineralogy and composition of amorphous phases.

Experimental Procedure: A series of glassy impactites from the Haughton, Ries, Lonar and Mistastin impact craters and glass/glass-rich exemplars from a number of other terrestrial sources have been prepared by hand crushing and dry sieving to produce <45 μm powders. These powders were analyzed via UV-Vis-NIR and IR reflectance and transmission spectrometers, XRF, XRD and NMR techniques. Focusing on the XRD, sample patterns were collected using a Rigaku DMax-2A powder diffractometer. Patterns were collected using a step-scan method, from 5 to 90° 2 θ , with 0.05 degrees per step, and a 1.0 second dwell, using Co K α radiation, or, 0.02 degrees per step, and a 2.0 second dwell using Cu K α radiation.

Results: The results and a graphic depiction of methodology are presented in the following 3 figures. Figure 1 displays the cropped centroid of the amorphous halo of 14 individual XRD patterns (converted to d-spacing, offset and scaled for clarity). The central portion (approximately 20° 2 θ , 10° either side of the maxima) of each halo is extracted from the full pattern and crystalline features, if present, are removed from the centroid and replaced with a section of randomly generated pattern bound by the standard deviation of the XRD pattern of the entire centroid. One can see the procedure in Figure 2, A through C. Using the sample from Mistastin (Figure 1: #12, top most purple), Figure 2:A is the full 5 to 90°, 2 θ pattern, from which the centroid of the amorphous halo is extracted. In 2:B we can see the 20 to 40° 2 θ centroid with crystalline features at ~ 24, 25.5 and 31° 2 θ , respectively. Each of these crystalline features is then cut out, and appropri-

ate sections are replaced with the bound random pattern. A 3rd order polynomial is then fit to this extracted section of the pattern (both illustrated in Figure 2:C) and the 2 θ and/or d-spacing maximum of the halo is computed. Full XRD patterns in Figure 3 are for reference so one can see the differences on a more familiar scale and displays patterns of Darwin Glass, 3 and Basaltic Glass, 14 (offset +250 counts for clarity).

Discussion and Conclusions: Figure 1, displays the 14 selected XRD patterns of glassy material. From bottom to top, 1 and 2 are both samples from Haughton that retain their macroscopic structures and shock features despite being nearly completely glass, i.e., they



are mixed diaplectic and melt glasses. **3** is Darwin glass. **4** is also from Haughton, this time a melt derived from sandstone. **5**, **6**, **7** and **8**, are Moldavite, Apache Tears, Trinitite (glass from the Trinity nuclear test site) and obsidian respectively. **9** is an impact melt glass from Haughton, and **10**, a fulgurite. **11** and **12** are melt glasses from Ries and Mistastin respectively, both featuring devitrification via weathering, i.e., phyllosilicate formation. Finally, **13** and **14** are both basaltic glasses containing minor amounts of various crystalline pyroxenes and quartz, from the Lonar crater and Hawaii respectively.

The series of amorphous halos in Figure 1 are grouped by colour to denote their formation mechanism, compositions, (Note: the maxima of the centroid does not correlate with silica content) and to a lesser extent location. The **reds** from the Haughton impact event are either mixed diaplectic/melt glasses, as in **1** and **2**, or melt glasses, **4** and **9**. The **greens** from various locales, all rapidly cooled in air; either impact related, **3** and **5**, pyroclastics, **6**, explosion, **7**, extrusive volcanism, **8** or via flash heating produced by lightning strike, **10**. The **purple** and **burgundy** samples are basaltic melts, either from impacts, **11** and **12**, each mid-devitrification, **13** which is a pristine impactite, or **14** which is extrusive.

The amorphous halo in question is a result of a series of linkages akin to polymerization within the glassy material or a series a nano-crystalline versions of the crystals that would make up the material should it have been afforded the time to recrystallize. Either scenario is equally plausible (We suggest the halo is a combination of the two). Via the procedure laid out in the results we can derive a metric from the XRD that we can then use to compare with other samples. The technique of [4] relies on this comparison. We prefer this method to the more complicated calculation based method of [5] which requires a glassy material of a known initial composition, from which bonds can be assigned and amorphous linkages/makeup established.

We further suggest that one could take glasses from known locales and compare them with those that either contain crystallites or do not, but have known progenitors, i.e., samples **13** and **14**. These two, a glassy impactite from Lonar, and an extrusive basaltic glass have very similar compositions which result in very similar amorphous halos. One could then extrapolate to unknown samples, for example those recently, and to be analyzed by CheMin on Mars. Should those amorphous materials have halos similar to basaltic glass, one could safely conclude the amorphous material is likely to share a similar origin. Initial composition is not the only result one might look for, though. Comparing all samples, there are three stand outs, #s **1**, **2**

and **3** are without question different from all others, and could only have been produced by impact.

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