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TERRESTRIAL IMPACT MELTS AS ANALOGUES FOR THE HEMATIZATION OF MARTIAN SURFACE MATERIALS;

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Abstract. Visible and near-IR reflectivity and Mössbauer data were obtained on powders of hydrothermally-altered impact melt sheets from West Clearwater Lake, Manicouagan, and Ries (Polsingen) impact structures. The data support previous interpretations that Martian bright regions spectra can be interpreted by a ferric-bearing phase that has a relatively featureless absorption edge together with some well-crystalline (bulk) hematite to account for the 860 nm hematite band. The data also show that bands at wavelengths longer than 900 nm, which are characteristic of Martian dark regions, occur when both hematite and pyroxene are present. It thus follows that hematization of Mars can be attributed, at least in part, to hydrothermal alterations of impact melt sheets. Impact heating could also form bulk-Hm from nanophase ferric oxides.

INTRODUCTION. Hydrothermal alteration of impact melt sheets is reported at many terrestrial impact structures, including West Clearwater Lake [1] and Manicouagan [2], both in Quebec, Canada, and the Ries basin [3,4] in Germany. The alteration apparently occurs shortly after the impact by influx of groundwater while the rocks are still hot but below solidus temperatures [1]. The alteration products of glass and mafic minerals at West Clearwater and Manicougan are montmorillonitic clays with hematite and possibly hydrous ferric oxides [1,2]. The reddish, coherent impact melt rock from the Ries basin has been less studied; [3] describe the melts as fine-grained aggregates of predominantly feldspar with minor pyroxene, hematite, and cristobalite. A number of studies [e.g., 5, 6, 7] have advocated that a significant fraction of Martian soil may consist of erosional products of hydrothermally-altered impact melt sheets. This process is consistent with the recent identification of hematite in visible and near-IR spectral data for martian bright regions [e.g., 8, 9, 10].

If erosional products of hydrothermally-altered impact melt sheets are volumetrically important on Mars, their signature may be present in reflectance spectra of Martian bright regions. To investigate this possibility, we have obtained visible and near-IR reflectance spectra for samples from their terrestrial analogues at West Clearwater Lake, Manicouagan, and the Ries Crater (Polsingen). Data were obtained on fine powders ($<90\ \mu m$) derived from coherent rock samples. To characterize the iron mineralogy and chemistry of the samples, we also obtained Mössbauer and INAA data.

RESULTS AND DISCUSSION. Reflectivity and Mössbauer data (293 K) for five samples are shown in Figure 1. The two samples from West Clearwater Lake (WCW) are red and purple regions from the same rock. The Mössbauer spectra of the samples can be fit by three components: a sextet (IS=0.37 mm/s, QS=-0.21 mm/s, and B_{hf}=51.0 T), a ferric doublet (IS=0.36 mm/s and QS=0.55 mm/s), and a ferrous doublet (IS=1.15 mm/s and QS=2.03 mm/s). The sextet results from well-crystalline hematite (bulk-Hm); the asymmetry of the lines implies impurities (e.g., Ti or Al) are present. The ferrous doublet is reasonably assigned to pyroxene. The assignment of the ferric doublet is uncertain. The Mössbauer parameters imply octahedrally-coordinated ferric iron. The value of QS is significantly smaller than that observed for nanophase ferric oxide particles (np-Ox) in palagonitic soils [e.g., 11, 12]; however, this may result from different formation conditions. It is possible that the doublet results from inherently paramagnetic phases such as lepidocrocite, pseudobrookite, and Fe-bearing clay minerals. Lepidocrocite is not likely, however, because the doublet is not magnetically split at 16 K. The relative contributions of the three components to the individual Mössbauer spectra are highly variable, although bulk-Hm is present in major proportions in all samples. The WCW and Ries samples contain essentially no pyroxene; for the WCW samples, bulk-Hm dominates over the ferric-doublet phase and vice versa for the Ries sample. The two Manicouagan (MAN) samples contain all three phases; MAN-74-125 has the most pyroxene.

The reflectivity spectra of all samples are characterized by an inflection (Ries and MAN) or strong bend (WCW) near 520 nm, an inflection near 620 nm, a relative reflectivity maximum near 750 nm, and, except for MAN-74-217, a band minimum near 860 nm. All off these features are characteristic of bulk-Hm [e.g., 13]. The bend near 520 nm in the WCW samples is stronger because they have the highest relative proportions of bulk-Hm. The band minimum for MAN-74-217 is near 910 nm, which is more characteristic of goethite. However, this assignment is inconsistent with the Mössbauer data. Because Mössbauer data show that this sample has the highest proportion of ferrous iron as pyroxene, the 910 nm minimum is interpreted as a composite feature of ferric and ferrous bands of hematite and pyroxene, respectively.

The spectra of RIES-POL-01 and especially MAN-74-125 are reasonable analogues of Martian bright region spectra. This is additional support for previous interpretations [8, 9, 10] that the Martian bright regions spectra can be interpreted by a ferric-bearing phase that has a relatively featureless absorption edge together with some bulk-Hm to account for the bulk-hematite features. The spectrum for MAN-74-217 is similar to other Martian spectra that have a ferrous-like band minimum longward of 900 nm and a ferric absorption edge [10, 14]. It thus follows that hematization of Mars is, at least in part, a consequence of hydrothermal alterations of impact melt sheets. Impact heating could also form bulk-Hm from nanophase ferric oxides [e.g., 12]. It thus follows that hematization of Mars is, at least in part, a consequence of hydrothermal alterations of impact melt sheets. Impact heating could also form bulk-Hm from nanophase ferric oxides [e.g., 12].

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