

MOSSBAUER MINERALOGY OF A MARTIAN SPECTRAL ANALOGUE (HAWAII 34): IMPLICATIONS FOR THE IRON OXIDE PIGMENT OF MARS. Richard V. Morris¹, D. G. Agresti², T. D. Shelfer², and J. B. Adams³. ¹Code SN4, NASA-JSC, Houston, TX 77058; ²University of Alabama at Birmingham, Birmingham AL 35294; ³University of Washington, Seattle, WA 98195.

INTRODUCTION

Visible and near-IR spectral data for a number of palagonites (mafic volcanic weathering products) from Hawaii, Iceland, and Antarctica [1-3] are similar to spectral data for the bright regions of Mars [4]. The correspondence is particularly good for Hawaiian palagonite Hawaii 34 (H34) [1,5] and other samples collected from its type location (VOL02, [3]), which is given by [1]. H34 is described as X-ray amorphous [1], and spectral data are published by [1,5]. It is important to understand the composition, distribution, and mineralogy of the ferric-bearing phases for samples like H34 because their close correspondence in spectral properties with the martian bright regions implies the nature of ferric-bearing phases may also correspond. The purpose of this study is to investigate the Mossbauer mineralogy of sample PN-3-23-87-9 which was collected from the type location of Hawaii 34 by J. Adams. The Mossbauer technique is particularly well-suited to study the ferric mineralogy of these samples because iron oxide phases can be identified at particle dimensions where they do not coherently scatter X-rays (X-ray amorphous) [e.g., 6].

RESULTS AND DISCUSSION

The Mossbauer spectra of PN-3-23-87-9 at 293 K and at broad and narrow velocity ranges are shown in the figure. The spectra are characterized by two weak ferrous doublets with quadrupole splittings (QS) of ~ 3.0 and ~ 2.1 mm/s, an intense ferric doublet with QS of ~ 0.70 mm/s, and a ferric sextet with an internal field strength (H_{int}) of ~ 51.0 T and QS of ~ 0.17 mm/s. The ferric doublet with QS ~ 3.0 mm/s is most likely due to high-Mg olivine (forsterite) that has not been weathered. This assignment is consistent with [7] who find weak lines due to olivine in the XRD data of the same sample. The assignment for the other ferrous doublet is uncertain with available data. It could be due to pyroxene or to a ferrous weathering product.

The fractional areas of the Mossbauer lines show that most of the iron present in PN-3-23-87-9 is ferric iron. Of the common ferric oxide/oxyhydroxide phases, hematite (Hm) is the most reasonable assignment for the sextet. The values of H_{int} and QS for PN-3-23-87-9 are in good agreement with the corresponding values of 51.2 T and -0.22 mm/s for bulk-Hm [e.g., 6]. Maghemite, goethite, and lepidocrocite are not reasonable assignments because at 293 K their bulk forms are characterized by QS = 0.0 mm/s, $H_{int} = 38.0$ T, $H_{int} = 0.0$ T, respectively [e.g., 6]. The existence of the Hm sextet for PN-3-23-87-9, the skewed shape of its lines, and the small reduction in the magnitude of its Mossbauer parameters as compared to bulk-Hm imply the hematite particles that contribute to the sextet have diameters predominantly in the range 20-140 nm [6, 8].

Based on Mossbauer studies of both synthetic and naturally-occurring materials [6 and references therein], the ferric doublet is best interpreted as due to superparamagnetic (sp) ferric oxide/oxyhydroxide particles as opposed to some paramagnetic species (e.g., ferric iron substitutionally incorporated in pyroxene). Low-temperature (to 22 K) Mossbauer measurements in progress will confirm this and also probably identify the phase. Based on assignment of hematite to the sextet, it seems likely that at least some of

the particles are sp-Hm. If so, hematite particle diameters less than ~10 nm are implied [6]. The absence of Hm lines in the XRD data [7] of this sample is consistent with the inability of such small particles to coherently scatter X-rays [6]. However, the analysis of [6] indicates that the particles which contribute to the sextet are sufficiently large to coherently scatter X-rays. Apparently, their concentration is too low to be detected or their lines are masked.

In summary, the pigment in PN-3-23-87-9 is ferric oxide/oxyhydroxide particles. Only hematite is currently identified, but other ferric oxide/oxyhydroxide phases may also be present. Available data indicate that the diameter range of the pigmentary hematite particles is from less than 10 nm up ~140 nm with the average diameter being closer to ~10 nm. [6] were able to match the martian spectral data (and, by inference, also its spectral analogue PN-3-23-87-9) with a mixture of synthetic samples containing a similar diameter range of hematite particles. Thus we conclude that PN-3-23-87-9 is good martian spectral analogue because both it and the martian surface contain pigmentary hematite particles.

REFERENCES: [1] Evans and Adams, *PLSC11*, 757, 1980; [2] Allen et al., *Icarus* 45, 347, 1981; [3] Singer, *JGR* 87, 10159, 1982; [4] Singer et al., *JGR* 84, 8415, 1979; [5] Adams et al., *JGR* 91, 8089, 1986; [6] Morris et al., submitted, 1988; [7] Ming et al., this volume; [8] Morris et al., *JGR* 90, 3126, 1985.

