REFLECTANCE AND EMITTANCE PROPERTIES OF SPRING-FORMED FERRICRETES AND ACID MINE DRAINAGE MATERIALS: RELEVANCE TO REMOTE SENSING OF MARS. W.H. Farrand[1] and M.D.Lane[2], [1]FarrView Consulting, 300 W. 123rd, #2816, Denver, CO 80234, farrand@rmi.net, [2]Code SN3, NASA Johnson Space Center, Houston, TX 77058.

Introduction: Minerals and mineral formation processes associated with the weathering of sulfide bearing ore deposits on Earth may have their analogs on Mars. Indeed, they may be important constituents of the Martian surface layer over large areas [1,2]. The presence of such minerals as jarosite, goethite and schwertmannite on the Martian surface would be indicative of their formative environment. They could indicate the presence of ground water systems equivalent to those that cause acid sulfate soils on Earth [3,4].

This paper reports on the 0.35 to 2.5 μm reflectance and 6.7 to 25 μm (1500 to 400 cm^{-1}) emittance properties of materials associated with the weathering of sulfide-bearing ore deposits. Specific materials examined here are spring-formed ferricretes and Fe^{3+} -bearing precipitates associated with acid mine drainage (AMD).

Iron-rich waters emanating from springs precipitate Fe^{3+} - bearing phases that can aggregate to form ferrosinters (nearly pure iron oxide, oxyhydroxide, and/or oxyhydroxysulfate) or cement surrounding sand and gravel to form a ferricrete. The streams coming from these springs and from the abandoned mine sites contain ferrous ions in solution which, when oxidized, precipitate into colloidal phases which include ferrihydrite, schwertmannite, jarosite and goethite. These precipitates accumulate on the banks and beds of acidic streams coursing from mine districts. These minerals can also be precipitated from waters emerging from acid sulfate soils.

Samples: The samples examined here were collected in the San Juan Mountains of southwestern Colorado at the headwaters of the Alamosa River. Mining has taken place at the Summitville district, now an EPA Superfund site. The region also hosts a large number of naturally occurring acidic mineralized springs.

The VNIR reflectance of the samples was measured in the laboratory using an ASD FieldSpec FR [5] and artificial illumination from a quartz halogen lamp. Small (1 cm diameter) spots can be measured with the FieldSpec and numerous spots were measured on each sample. The TIR emittance of the samples was measured at the TES laboratory at ASU using equipment and procedures described in [6].

Spectra: Figure 1 shows reflectance spectra of ferricretes and of precipitate coated rocks collected from along the Alamosa River and its tributaries. Figure 2 shows emittance spectra of these and related samples. The three lower spectra in Fig. 1 (Sv98-7, Svfc-big, and Sv98-10b) are ferricretes. The remaining spectrum is that of a schwertmannite precipitate. Most of the ferricretes examined had spectra characteristic of goethite (such as is seen for Sv98-10b); however, spectra representative of schwertmannite (Sv98-7) and ferrihydrite (Svfc-big) were seen as were patches of jarosite. The TIR spectra of Sv98-10c and Sv98-16b have features at 476, 540 and 800 cm^{-1} that are also indicative of the presence of goethite. The emissivity spectrum of Sv98-17 has features near 600 and 680 cm^{-1} that are tentatively assigned to schwertmannite.

Relevance of ferricretes and acid mine drainage materials to the study of Mars: Several regions on Mars, such as Arabia, Lunae Planum and Oxia Palus, have been shown to have reflectance spectra with an absorption centered at 0.88 to 0.92 μm with no corresponding 2.0 μm absorption- indicating that the asorption is caused by ferric and not ferrous iron (e.g., pyroxenes) [7,8,9]. Minerals such as goethite, ferrihydrite, jarosite, and schwertmannite have been suggested as candidate minerals with an absorption feature in the appropriate spectral region. Mustard [10] suggested that ferrihydrite might be a primary mineral in duricrusted soils in Oxia Palus and elsewhere. The $^6A_1 \rightarrow {}^4T_1$ feature has its longest band center in ferrihydrite (near 1 μm as in sample svfc-big) and this is inconsistent with the 0.88 μm band center observed for Lunae Planum [7] (although it could be consistent with the 0.92 μm band center observed for Arabia).

The emittance spectra shown here indicate that observations of regions such as Lunae Planum and Arabia could provide the required information on what minerals are in the duricrust in these regions. Additional laboratory studies of the emissivity properties of poorly crystalline materials such as ferrihydrite and schwertmannite are required to aid in the interpretation of TES data. Supporting information from the

0.4 to 2.5 μm region (as might be supplied by the ESA Mars Express spacecraft) will also prove vital in the characterization of the mineralogy of these areas.

References: [1] Burns, R., Proc. 18th LPSC, 713 (1988); [2] Burns, R., Proc. 17th LPSC, JGR, **92**, E570 (1987); [3] Doner,H. and Lynn, C. in *Minerals in Soil Environment*, (J. Dixon and S. Weed, ed.s) 75-98 (1977); [4] Schwertmann, U. and Taylor, R. *ibid*, 145-180, [5] Curtiss, B. and Goetz, A. ASD manual (1994) [6] Ruff et al., JGR, **102**, 14899 (1997); [7] Murchie et al., *Icarus*, **105**, 454 (1993); [8] Bishop et al., **117**, 101 (1995); [9] Morris and Golden, *Icarus*,**134**, 1 (1998); [10] Mustard, J., *Conf. Early Mars* (1997) .

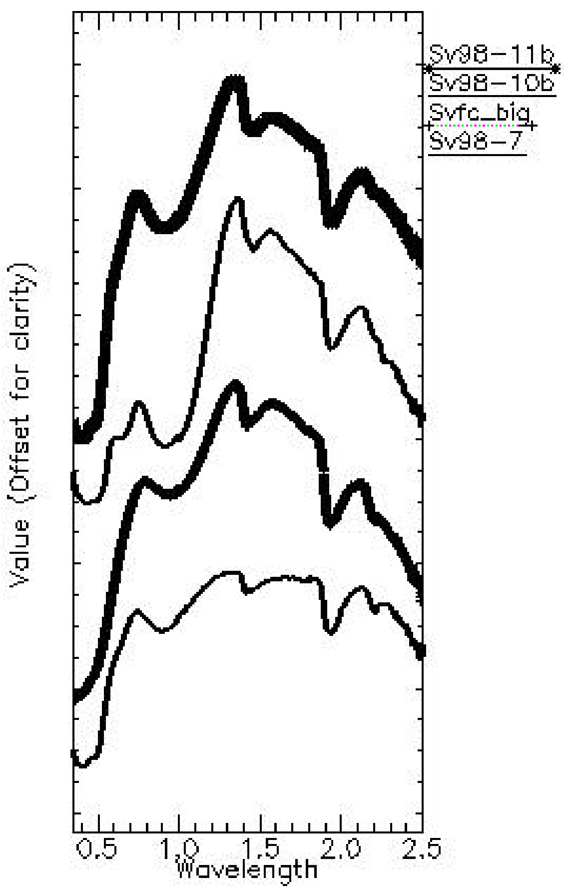

Figure 1. VNIR spectra of ferricretes and ferric iron precipates.

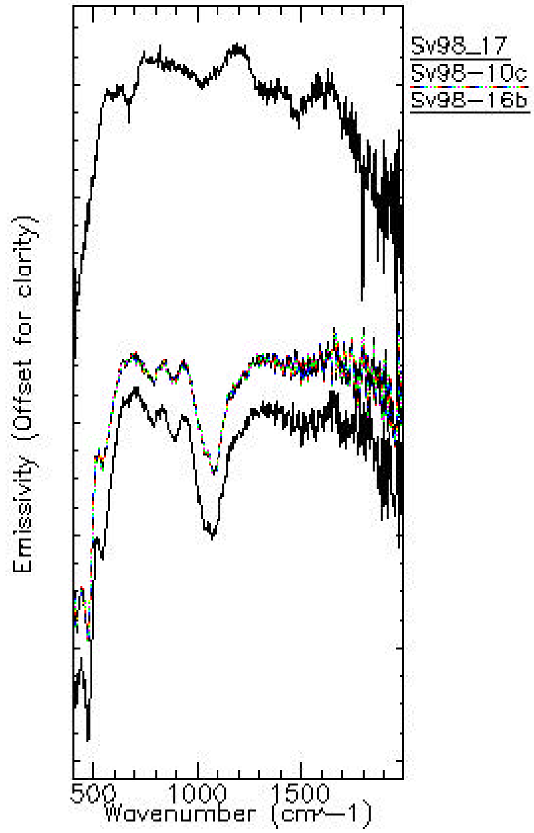

Figure 2. TIR spectra of ferricretes and ferric iron precipitates.