MÖSSBAUER SPECTROSCOPY OF MARS-ANALOG ROCKS FROM AN ACID SALINE SEDIMENTARY ENVIRONMENT. M. W. Schaefer[1], M. D. Dyar[2], and K. C. Benison[3], [1]Center for Space Research, The University of Texas at Austin, 3925 W. Braker Lane Suite 200, Austin, TX 78795; mschaefer@csr.utexas.edu. [2]Department of Astronomy, Kendade Hall, Mount Holyoke College, 50 College St., South Hadley, MA 01075; mdyar@mtholyoke.edu. [3]Department of Geology, Central Michigan University, 314 Brooks Hall, Mt. Pleasant, MI 48858; benis1kc@cmich.edu.

Introduction: There is increasing evidence that some parts of Mars may at one time have been covered by a layer of water [1, 2, 3, 4]. Some efforts have been made to model the geochemical interaction of this layer of water with the atmosphere and the rocks of the surface [5, 6], but the abundant carbonates produced by a simple system of water under a thick carbon dioxide atmosphere have not been observed to exist on the present-day surface of Mars [7 and others]. There are two possible reasons for this discrepancy. First, the deposited carbonates may have been altered or covered up in the eons since their deposition, or second, the simple model does not accurately describe the weathering and depositional environment in the early Martian seas. We will here discuss a new analog for Martian rock-water interactions.

Extremely Acid Saline Deposits: It has recently been suggested that extremely acid to moderately acid (-1 - +4 pH) saline lakes, such as those that existed in the mid-Permian of the mid-continent of North America and exist today in southern Western Australia and northwest Victoria, may be good analogs for possible environments on Mars [8, 9, 10].

These systems are characterized by: (1) saline H_2SO_4-rich lake and ground waters with pH between 4 and –1; (2) bedded and displacive evaporite minerals hosted by red siliciclastic sediments; (3) common sulfate minerals, such as gypsum and anhydrite, and less abundant "acid" sulfate minerals, such as alunite and jarosite; (4) possible acidophilic microorganisms; and (5) lack of carbonate minerals.

Clark [11, 12] has suggested that the sulfur-rich lithosphere, relatively high soil SO_4/H_2O, and lack of carbonates indicate the presence of acid waters on Mars. Burns [13] suggested that jarosite could have formed near the surface of Mars in cold, acidic groundwater, and that remote-sensed reflectance spectra of Mars are not inconsistent with the presence of jarosite. Burns [14] and Bishop and Murad [15] suggested the presence of schwertmannite on Mars, deposited from acidic saline water. Burns [14] also drew an analogy to the acid saline groundwater and playas of the southeastern part of Western Australia.

Present study: Samples have been collected from Twin Lake West, an acid saline lake in Western Australia (Fig. 1) for a Mössbauer study of the weathering products produced on Archean rocks in this environment. This lake is one of at least nine acid saline lakes between the towns of Norseman and Grass Patch, Western Australia. The depths of these lakes were only several centimeters, with diameters of between a few hundred meters to a kilometer. The waters were saline (over 100 ppt TDS), and had pH values from 2.4 to 3.7. The lake beds were most commonly made of red muds, with halite and/or gypsum bottom-growth crystal crusts. Some lakes were hosted by highly weathered Precambrian metamorphic and sedimentary rocks, including gneisses, quartzites, ironstones, and sandstones. Groundwater in the vicinity had salinity and pH similar to lake waters. Rare beds of alunite and jarosite were found in some cases. Preliminary lab work has shown that both lake and ground waters are Na-Cl-Mg-Ca-SO_4 brines [10]. Al, Fe, and Si have not yet been analyzed.

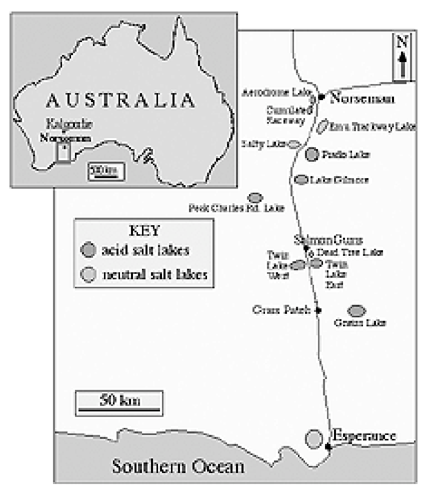

Figure 1. Map showing localities of modern acid saline systems in Western Australia. Samples in this study were collected from Twin Lake West.

Preliminary results: Samples from this locality that are being measured with Mössbauer spectroscopy include gneiss, schist, quartzite, and ironstone, as well as separate measurements of the weathering rinds from each of these samples. Rocks such as gneiss and schist are not here being suggested as being major components of the Martian surface, only that the processes that are altering these rocks in Australia may possibly act or have acted on Mars as well. It is the change in surface mineralogy through weathering that interests us here, not the mineralogy of the starting materials, *per se*. The ironstone, with its large proportion of hematite, may be the most similar of these materials to what we may expect to see on Mars [15].

*Schist and gneiss***.** Schist and gneiss samples appeared quite similar to one another (Fig. 2). The starting materials consist of feldspar, quartz and micas as shown in the spectrum of KCB9; the micas are roughly 30% Fe^{3+}. The spectrum of the orange weathering rind shows a shift from dominantly Fe^{2+} in the micas to roughly 60% Fe^{3+} in clay minerals. Note that the weathering products do not appear to be Fe oxides, which would be magnetically ordered unless they have extremely small grain sizes. The Mössbauer spectra of the micas are similar to those of the clay minerals because the Fe sites are structurally similar.

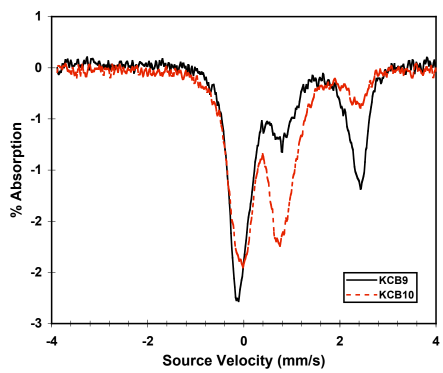

Figure 2. Mössbauer spectrum of schist (KCB9) and its orange weathering rind (KCB10). Preliminary thin section analysis shows orthoclase, biotite, quartz, and a small amount of muscovite.

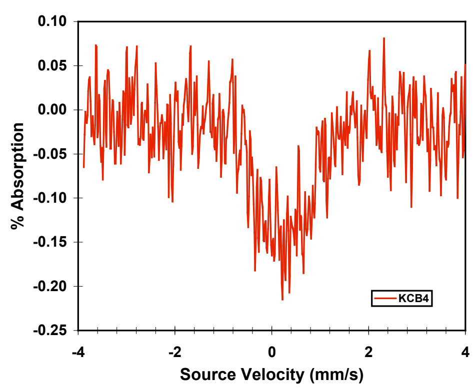

Figure 3. Mössbauer spectrum of orange weathered surface on quartzite. Preliminary thin section analysis shows quartz with a tiny amount of hematite.

Quartzite. The unweathered quartzite was not analyzed with Mössbauer spectroscopy because it is colorless and has an extremely low Fe concentration. Its weathered equivalent is reddish pink in color, suggestive of interaction with Fe-rich waters. The Mössbauer spectrum of the weathered sample, although it has only a little iron (Fig. 3), has an isomer shift of approximately 0.3 mm/s, not inconsistent with nanophase hematite. This sample will be rerun at low temperatures to confirm this identification.

*Ironstone***.** This sample shows a strong hematite sextet in the unaltered starting material, which is being altered in the weathering rind to another phase (Fig. 4). Although jarosite is not seen in bulk at this lake, the Mössbauer parameters of jarosite provide a good fit to the new doublet.

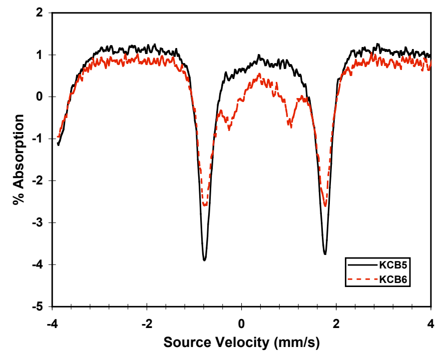

Figure 4. Mössbauer spectrum of ironstone (KCB5) and its red and yellow weathering rind (KCB6). Preliminary thin section analysis shows quartz and hematite.

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