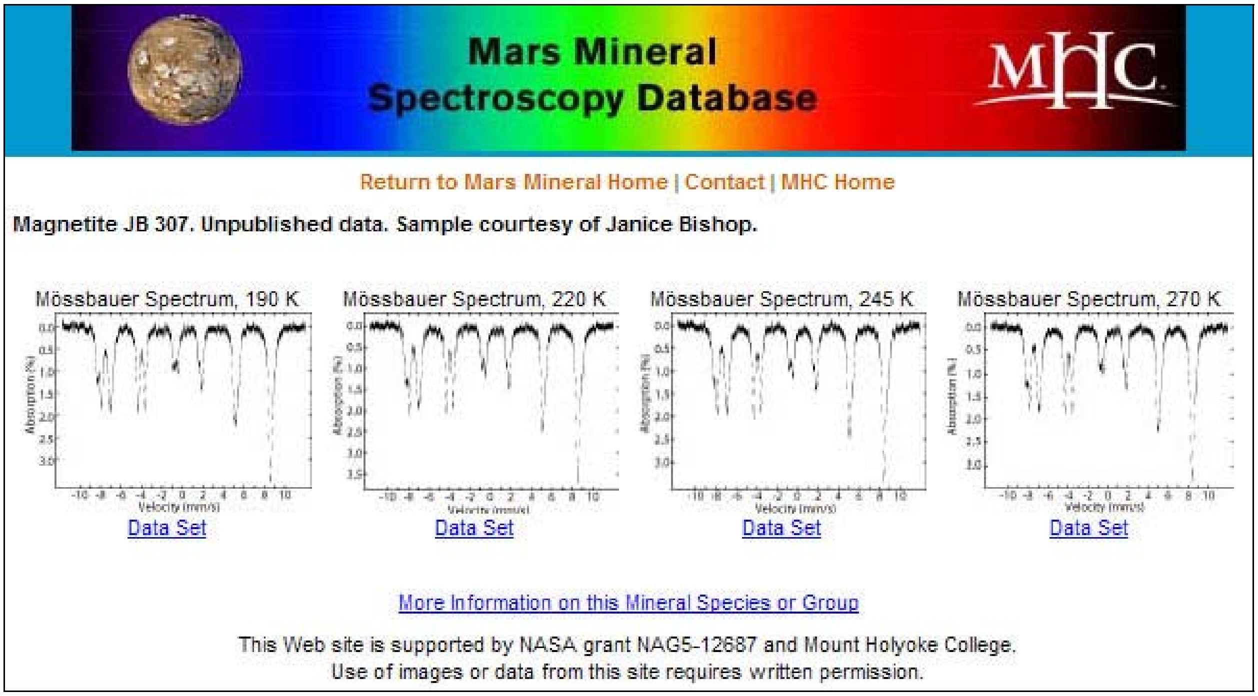
MARS MINERAL SPECTROSCOPY WEB SITE: A RESOURCE FOR REMOTE PLANETARY SPECTROSCOPY. M.D. Dyar[1], M.W. Schaefer[2], J.L. Griswold[1], K.M. Hanify[1], and Y. Rothstein[1]. [1]Dept. of Astronomy, Mount Holyoke College, 50 College St., South Hadley, MA 01075 USA, mdyar@mtholyoke.edu; [2]Dept. of Geology and Geophysics, Louisiana State University, Baton Rouge, LA 70803-4101, USA., schaefer@geol.lsu.edu.



Introduction: A web site dedicated to Mars Mineral Spectroscopy has been established at http://www.mtholyoke.edu/go/mars. Its goal is to provide an easily accessible data set of Mössbauer spectra of minerals collected over a range of temperatures, to provide suitable analog spectra for data acquired on remote surfaces such as Mars. Complementing these data (eventually) will be both reflectance FTIR data, collected at Brown University's RELAB facility, and Raman spectra to be collected by Jill Pasteris at Washigton University St. Louis. Through our Education link, we provide information for those wishing to learn about how Mössbauer and other types of spectroscopy work. Our emphasis is to study only well-characterized mineral samples that represent typical rock-forming occurrences such as might exist on Mars and other terrestrial bodies in our solar system.

Background: When instrument packages that included Mössbauer spectrometers were selected for the Beagle 2 and MER lander/rovers, it became clear to us that mineral spectra of rock-forming minerals, acquired at mars surface temperatures, would be necessary for interpretation of remotely-acquired spectra. At that time, these authors looked for and could not find systematic sets of published Mössbauer spectra of rock-forming minerals in the appropriate temperature range from 140-270K. Data acquired at 300 K, 77 K, and 12 K (corresponding to room, liquid nitrogen, and liquid helium temperatures, as acquired with traditional cryostats) were, however, available. From these it was apparent that many of the minerals suggested to be present on the surface of Mars [1] undergo transitions in the range of temperatures present there. Thus, it became critically important to characterize the changes in Mössbauer spectra over a temperature range that is applicable to Mars surface conditions. The availability of a helium closed cycle refrigerator in the Mineral Spectroscopuy Lab at Mount Holyoke permits acquisition of Mossbauer spectra at any temperture between 12 and 300K, including variable temperature runs.

Methods: In the fall of 2002, we visited the Harvard Mineralogical Museum and selected a suite of specimens to be used to this study. Those samples were augmented with minerals from our lab collections and with samples generously loaned to us by Janice Bishop and by NASA. The assembled samples comprise a comprehensive list of mineral species (and representative grain sizes) likely to be found on the martian surface (Table 1). Criteria for this selection process and complete references are described in [1]. These minerals have all now been characterized by electron microprobe, and further chemical characterizations are under way to determine their hydrogen and other light element contents.

Results: To date, the Mössbauer spectroscopy portion of the database now contains roughly 350 mineral spectra. At present, more than two-thirds of the spectra posted represent data acquired between 12 and 300 K, with an emphasis on the range from 140-270K; the remaining spectra were acquired at 300 K. For each spectrum, both a jpg file displaying the spectrum and a text file containing the raw data are posted. This should allow anyone to download the raw data and mix spectra to simulate martian rocks.

Uses: A single example is useful to show why this database is needed (Fig. 1). The composite figure below shows four spectra of a natural ferrihydrite acquired over a range of Mars surface temperatures. The spectrum of this sample is a simple doublet at 300 K, and a complicated set of sextets at lower temperatures as it orders magnetically. In order to correctly interpret a spectrum from the Mars surface of this mineral, it is absolutely essential that such comparative spectra be available, because the degree of ordering at any given temperature cannot be predicted theoretically.

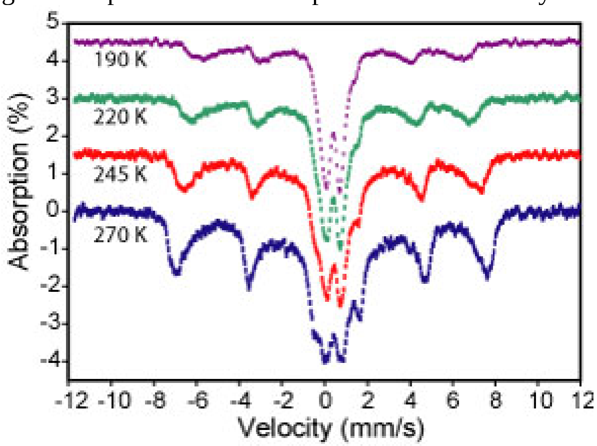


Fig. 1. Variable temperature Mössbauer spectra of ferrihydrite from Smedley's Iron Mine, Middletown, Delaware, Co., Harvard sample #96214.

Concluding Remarks: We are already experiencing heavy use of the site, and plan to maintain it indefinitely. It is certainly a work in progress. New Mössbauer spectra are being collected every 8-12 hours in our lab here at Mount Holyoke, and we are posting spectra as fast as we can process them. FTIR and Raman spectra will also be collected through 2004-05. This spectral library of Mössbauer spectra will provide the critical starting place for interpretation of martian Mössbauer results for current and future missions.

Acknowledgments: NASA grants NAG5-10424, NAG5-12848, and NAG5-12687.

References: [1] Dyar M.D. and Schaefer M.W. (2003) *LPS XXXIII*, Abstract #1329; and Dyar M.D. amd Schaefer M.W. (2003) *EPSL*, *in press*.

Table 1. Mineral Species Included in Database

Mineral Species	Mineral Formula
pentlandite	$(Fe,Ni)_9S_8$
pyrrhotite	$Fe_{1-x}S$
pyrite	FeS_2
hematite (nanophase)	α-Fe_2O_3
hematite and titanohematite	α-Fe_2O_3
ferrihydrite	$5Fe_2O_8{\cdot}9H_2O$
perovskite	$CaTiO_3$ $[(Ca,Na)(Nb,Ti,Fe)O_3]$
maghemite	γ-Fe_2O_3
goethite	α-FeO(OH)
lepidocrocite	γ-FeO(OH)
feroxyhyte	δ-FeO(OH)
akaganéite	β-FeO(OH)
schwertmannite	$Fe_{16}O_{16}(OH)_y(SO4)_z{\cdot}nH_2O$
hercynite	$Fe^{2+}Al_2O_4$
magnesioferrite	$MgFe^{3+}{}_2O_4$
magnetite	$Fe^{2+}Fe^{3+}{}_2O_4$
siderite	$Fe^{2+}CO_3$
ankerite	$Ca(Fe^{2+},Mg,Mn)(CO_3)_2$
hydromagnesite	$Mg_5(CO_3)_4(OH)_2{\cdot}4H_2O$
rhomboclase	$HFe^{3+}(SO_4)_2{\cdot}4H2O$
melanterite	$Fe^{2+}SO_4{\cdot}7H_2O$
hydronium jarosite, natro-jarosite	$(H_3O^+)_2Fe^{3+}{}_6(SO_4)_4(OH)_{12}Na_2Fe^{3+}{}_6(SO_4)_4(OH)_{12}$
fayalite	$Fe^{2+}{}_2SiO_4$
laihunite	$Fe^{2+}Fe^{3+}{}_2(SiO_4)_2$
almandine	$Fe^{3+}{}_2Al_2(SiO_4)_3$
andradite	$Ca_3Fe^{3+}{}_2(SiO_4)_3$
pigeonite	$(Mg,Fe^{2+},Ca)(Mg,Fe^{2+})Si_2O_6$
enstatite/ ferrosilite	$(Mg,Fe^{2+})_2Si_2O_6$
hedenbergite	$CaFe^{2+}Si_2O_6$
augite	$(Ca,Na)(Mg,Fe^{2+},Al,Ti)(Si,Al)_2O_6$
anthophyllite	$(Mg,Fe^{2+})_7Si_8O_{22}(OH)_2$
actinolite	$Ca_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$
kaersutite	$NaCa_2(Mg,Fe^{2+})_4Ti(Si_6Al_2)O_{22}(OH)_2$
kaolinite	$Al_2Si_2O_5(OH)_4$
antigorite, chrysotile, and lizardite	$(Mg,Fe^{2+})_3Si_2O_5(OH)_4$
muscovite	$KAl_2(Si_3Al)O_{10}(OH,F)_2$
glauconite	$(K,Na)(Fe^{3+},Al,Mg)_2(Si,Al)_4O_{10}(OH)_2$
biotite	$K(Mg,Fe^{2+})_3(Al,Fe^{3+})Si_3O_{10}(OH,F)_2$
annite	$KFe^{2+}{}_3AlSi_3O_{10}(OH,F)_2$
"illite"	$(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,H_2O]$
"smectite"	
montmorillonite	$(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2{\cdot}nH_2O$
nontronite	$Na_{0.33}Fe_2(Si,Al)_4O_{10}{\cdot}nH_2O$
chamosite	$(Fe^{2+}Mg,Fe^{3+})_5Al(Si_3Al)O_{10}(OH)_8$
anorthite-albite	$CaAl_2Si_2O_8$-$NaAlSi_3O_8$