MIMOS II ON MER - ONE YEAR OF MÖSSBAUER SPECTROSCOPY ON THE SURFACE OF MARS: FROM JAROSITE AT MERIDIANI PLANUM TO GOETHITE AT GUSEV CRATER. G. Klingelhöfer[1], D.S. Rodionov[1,3], R.V. Morris[2], C. Schröder[1], P.A. de Souza[4], D.W. Ming[2], A.S. Yen[5], B. Bernhardt[1], F. Renz[1], I. Fleischer[1], T. Wdowiak[6], S.W. Squyres[7], and the Athena Science Team. [1]Institut für Anorganische und Analytische Chemie, Johannes Gutenberg-Universität, Staudinger Weg 9, D-55128 Mainz, Germany, klingel@mail.uni-mainz.de , [2]NASA Johnson Space Center, Houston, TX 77058, USA, [3]Space Research Institute IKI, 117997 Moscow, Russia, [4]Companhia Vale do Rio Doce (CVRD) Group, Vitoria, Brazil, [5]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA, [6]University of Alabama, Birmingham, AL, USA, [7]Cornell University, Ithaca, NY, USA.

Introduction: The miniaturized Mössbauer (MB) spectrometer MIMOS II [1] is part of the Athena payload of NASA's twin Mars Exploration Rovers "Spirit" (MER-A) and "Opportunity" (MER-B). It determines the Fe-bearing mineralogy of Martian soils and rocks at the Rovers' respective landing sites, Gusev crater and Meridiani Planum. Both spectrometers performed successfully during first year of operation. Total integration time is about 49 days for MER-A (79 samples) and 34 days for MER-B (85 samples). For curiosity it might be interesting to mention that the total odometry of the oscillating part of the MB drive exceeds 35 km for both rovers.

Gusev crater: During the first year of operation at the Gusev crater landing site the *Spirit* Mössbauer instrument analyzed rocks and soils at Bonneville crater and the ejecta plains between Bonneville and the Columbia Hills before entering the hills. As determined by MB already in the very first spectrum and confirmed by many others [2], the rocks around Bonneville and in the cratered plains have a basaltic MB signature, and their Mössbauer spectra are dominated by an olivine doublet [2]. The presence of abundant olivine in rocks and in surrounding soil as determined by MB suggests that physical rather than chemical weathering processes currently dominate the plains at Gusev crater.

The MB signature for the Columbia Hills is very different. Instead of relatively fresh olivine basalt, the MB signataure was characteristic of highly altered rocks. In particular, one of the rocks named *Clovis* contained, the Fe oxyhydroxide goethite. Like jarosite at Meridiani Planum, this mineral is a marker for aqueous processes as goethite forms only in the presence of water.

Another striking feature of Columbia Hill's outcrop is a variability of Fe-oxide phases for different places. For example, Clovis has no magnetite component. Ebenezer, however, has substantial magnetite contribution in addition to hematite and goethite.

Meridiani Planum: The Mössbauer spectra from Meridiani Planum are very diverse [3]. They can be divided into several main categories: outcrop spectra that are dominated by doublets and magnetic sextets from octahedrally coordinated Fe^{3+}; soil spectra dominated by oct. Fe^{2+} doublets; soil spectra that are dominated by a sextet from oct- Fe^{3+}, and spectra of *Bounce rock,* the very single rock present in this area. Representative MB spectra are shown on Fig.3 for comparison.

Outcrop spectra (e.g. *McKiitrick* at the landing site Eagle Crater) are characterized by an Fe^{3+} doublet with unusually high quadrouple splitting (~1.22 mm/s). The only reasonable assignment is the iron hydroxide sulphate mineral jarosite $(K,Na)(Fe,Al)_3(SO_4)_2(OH)_6$. Jarosite has the equivalent of ~10% weight H_2O present in its structure and thus is direct mineralogical evidence for the presence of water on Mars and for aqueous, acid sulfate processes under oxidizing conditions in the distant past.

Outcrop spectra have additional components: another Fe^{3+} doublet with lower quadrouple splittings (it is not specific and could result from a variety of phases (e.g. superparamagneric goethite and hematite)), Fe^{2+} doublet, whose parameters are consistent with pyroxene, and hematite. Outcrop measurements performed during Opportunitys traverse over the plains and inside Endurance crater have the same spectral signature as outcrops in Eagle Crater.

The sextet observed in the spectra of the spherule-rich targets (e.g. BerrySurvey) is assigned to hematite (a-Fe_2O_3). Mössbauer investigation show, that hematite is the major iron-bearing mineral in those spherules. Hematite assignment is also consistent with temperature dependencies of Mössbauer parameters because hematite Morin transition is observed.

The spectra of Bounce Rock are unique compared to all other Mössbauer spectra acquired on the Martian surface so far. It is dominated by two overlapping oct-Fe^{2+} doublets that are the fingerprint of pyroxene. Absence of olivine and ferric iron a clearly distinguishes MB Bounce rock spectrum from the predominant basaltic rocks and soils at Gusev crater plains and also from basaltic soils at Meridiani Planum. Though unique among Mössbauer spectra acquired from the surface of Mars, spectra from Bounce Rock are similar to spectra from Martian meteorites. The Mössbauer parameters of pyroxene in Bounce Rock are consistent with parameters for pyroxene in basaltic shergottites. The best match is pyroxene parameters reported for the meteorite QUE 94201 [5].

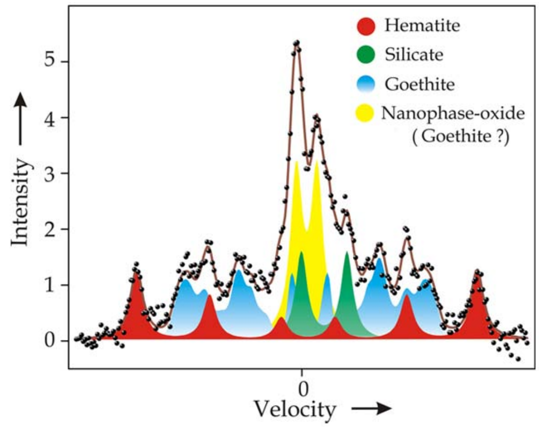

Figure 1. MB spectrum of Clovis (200-220 K)

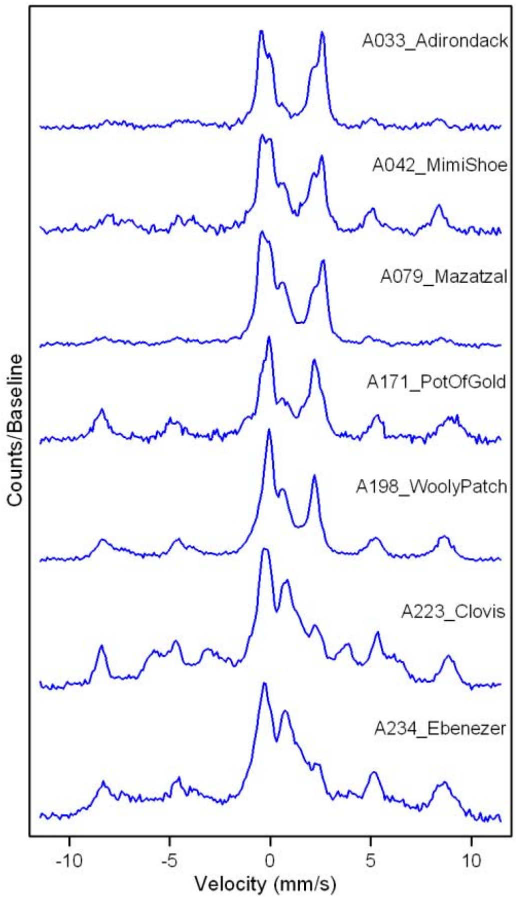

Figure 2. Representative MB spectra. Gusev crater.

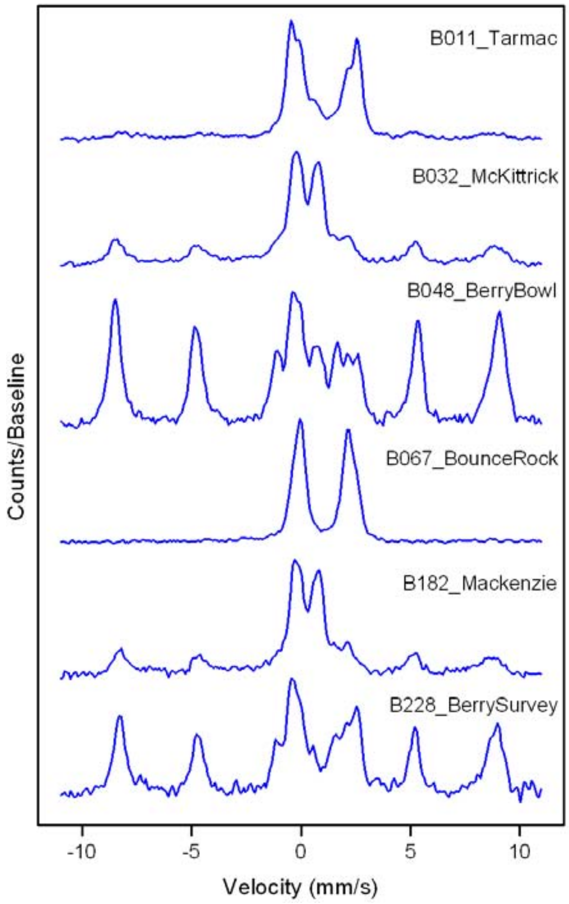

Figure 3. Representative MB spectra. Meridiani Planum.

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