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One year of Mössbauer spectroscopy on Mars: Highlights and experiences

G. Klingelhöfer (1), R.V. Morris (2), D.S. Rodionov (1,3), C. Schröder (1) , P.A. de Souza Jr. (1,4), 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.

The miniaturized Mössbauer (MB) spectrometer MIMOS II [1] as part of the Athena payload of NASA's Mars Exploration Rovers "Spirit" and "Opportunity" determined definitively the Fe-bearing mineralogy of Martian soils and rocks at the Rovers' respective landing sites, Gusev Crater and Meridiani Planum. Both spectrometers performed extremely well and successful during first year of operation. At Gusev Crater the rocks and soil around Bonneville crater and in the cratered plains have been identified by MB to be basaltic, with their MB spectra dominated by an olivine doublet [2]. The clear presence of abundant olivine in rocks and in surrounding soil suggests that physical rather than chemical weathering processes currently dominate the plains at Gusev crater. In contrast, the MB mineral signature for the Columbia Hills was characteristic of highly altered rocks. In particular the Fe-oxyhydroxide Goethite (a-FeOOH) has been identified by MIMOS II [3].

At Meridiani Planum the mineralogy definitively determined by Mössbauer can be divided into several main categories [4]: evaporitic outcrop, characterized by the presence of the Fe-sulfate-hydroxide Jarosite, thus providing the first direct evidence on Mars for water interaction; soil spectra dominated by basaltic silicate signatures; soil spectra dominated by the signature of hematite; spectra of the rock Bounce, revealing a pyroxene signature identical to some Martian meteorites discovered on Earth.

The ubiquitous mm-sized spherules dubbed "Blueberries" were determined by MB to consist mainly of hematite.

Operational experience: The operation of the MB instrument was adjusted during the mission acting on gained experience. Integration times ranged from a minimum of 30 min in "touch-and-goes" to overnight measurements lasting more than 20 hours to obtain the best possible statistics. The spectral sampling range (MB drive velocity) was adjusted to get the best resolution for different spectral signatures. Martian diurnal temperatures were employed in the identification of minerals.

References: [1] Klingelhöfer G. et al. (2003) JGR 108(E12), 8067; [2] Morris R.V. et al. (2004) Science, 305, 833-836; [3] Schröder C., Klingelhöfer G. et al., this issue; [4] Klingelhoefer G. et al. (2004) Science 306, 1740-1745.