

**Backscatter Mössbauer Spectrometer (BaMS) for Extraterrestrial Applications.** D.G. AGRESTI, T.D. SHELFER, M.M. PIMPERL, E.L. WILLS, and M.H. SHEN, University of Alabama at Birmingham, and R.V. MORRIS, NASA-Johnson Space Center.

Mössbauer spectroscopy is a nuclear gamma resonance technique particularly well suited to the study of materials that contain iron ( $^{57}\text{Fe}$ ). It can provide information on the oxidation state of iron as well as the type and proportion of iron-containing mineral species in a sample of interest. Iron Mössbauer spectroscopy (FeMS) has been applied to samples believed to have come from Mars (SNC meteorites) and has been helpful in refining the choice among putative Martian surface materials by suggesting a likely nanophase component of the Martian regolith [1]. Figure 1 shows a FeMS spectrum of a Martian analogue material (Hawaiian palagonite); it is dominated by ferric-bearing phases and shows evidence of a nanophase component. FeMS has also been applied to lunar materials, an example of which is shown in Figure 2. It can be used to measure the maturity of lunar surface material and has been proposed as a prospector for lunar ilmenite, an oxygen resource mineral [2].

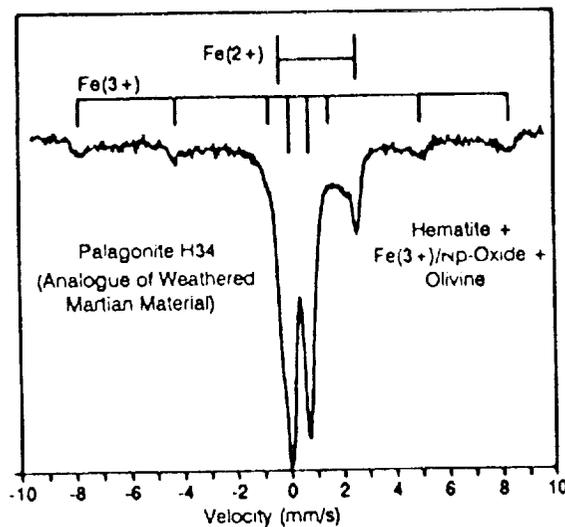


Fig. 1. Martian analogue.

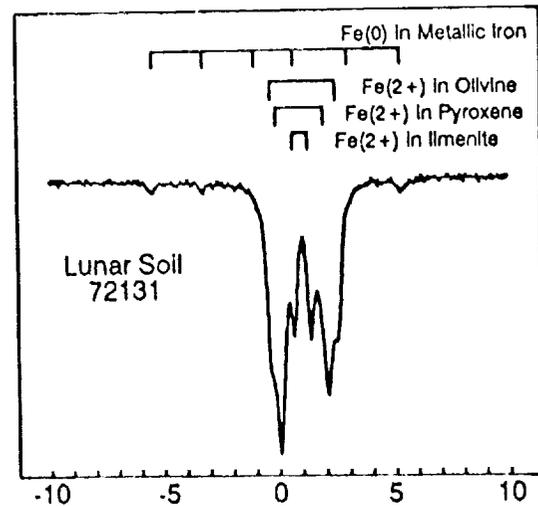


Fig. 2. Lunar sample.

Several years ago we suggested a backscatter Mössbauer spectrometer (BaMS) for a Mars rover mission [3]. Backscatter design was selected as most appropriate for *in-situ* application because no sample preparation is required. Since that time, we have continued to develop the BaMS instrument in anticipation that it would eventually find a home on a NASA planetary mission. Gooding proposed BaMS as a geochemistry instrument on MESUR [4]. More recently, an LPI workshop has recommended that BaMS be included in a three-instrument payload on the next (1996?) lunar lander [5].

The typical laboratory spectrometer contains as its principal elements a velocity transducer for modulating by Doppler effect the frequency of gamma rays emitted from a  $^{57}\text{Co}$  source, a detector for recording the radiation transmitted through or scattered by the sample being studied, and electronics to control the velocity of the source and record the resulting spectrum. For planetary applications, each of these components must be miniaturized and integrated into a single package suitable for a space instrument.

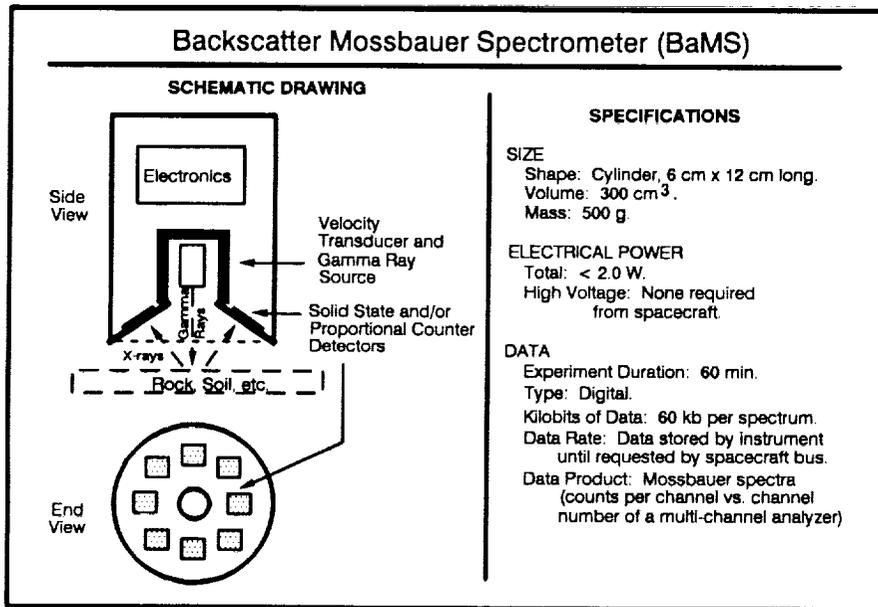


Figure 3. BaMS schematic.

We propose an instrument approximately the size and shape of a soft-drink can, as shown in Figure 3. For the velocity transducer we have constructed a version, shown in Figure 4, of the traditional two-coil (drive with feedback) design that operates with good linearity and is less than 1% the mass and volume of the typical laboratory transducer [6,7]. We have obtained Mössbauer spectra with room-temperature silicon-based PIN detectors, as have others [8]. The circuit design for a small electronics package including detector bias supply, analog pulse amplifier, pulse-height analyzer, drive control circuitry, and data storage has been completed. We are now assembling a prototype BaMS instrument of design appropriate for space applications that should be completed shortly. An instrument development program is also underway in Europe [8].

We have also tested piezoelectric and electrostrictive devices as velocity transducers as well as other solid-state detectors ( $\text{HgI}_2$ ) and a gas-filled proportional counter designed for backscatter application. X-ray fluorescence (XRF) capability can readily be incorporated into BaMS, resulting in a BaMS/XRF instrument. We refer the reader to a more comprehensive discussion of applications, principles of operation, and alternate technologies [9].

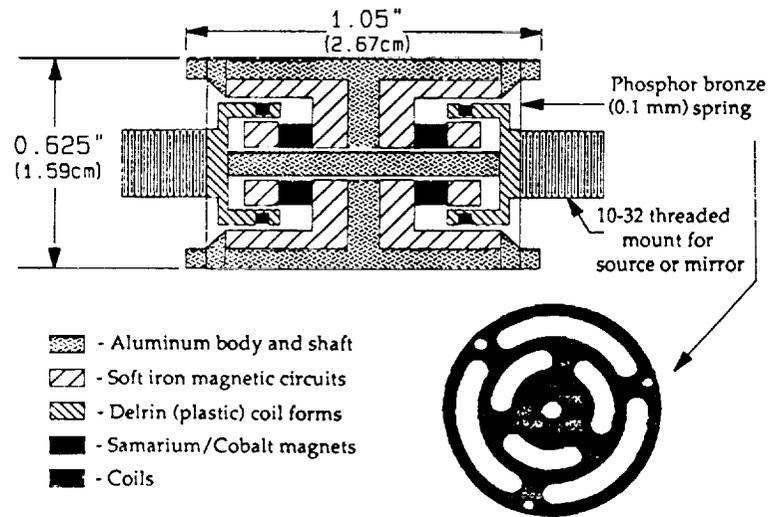


Fig. 4. Mini velocity transducer. Drive coil has 64 turns of 40-gauge magnet wire (11.4  $\Omega$ ). Pickup coil has 642 turns of 51-gauge wire (790  $\Omega$ ).

## References

- [1] "Evidence for pigmentary hematite on Mars based on optical, magnetic, and Mössbauer studies of superparamagnetic (nanocrystalline) hematite." R.V. Morris, D.G. Agresti, H.V. Lauer, Jr., J.A. Newcomb, T.D. Shelfer, and A.V. Murali. *J. Geophys. Res.* **94** (1989) 2760-2778.
- [2] "Mössbauer spectroscopy for lunar resource assessment: Measurement of mineralogy and soil maturity." R.V. Morris, D.G. Agresti, E.L. Wills, T.D. Shelfer, M.M. Pimperl, M.-H. Shen, and M.A. Gibson. In *Joint Workshop on New Technologies for Lunar Resource Assessment* (Santa Fe, April, 1992, Lunar and Planetary Institute), pp. 45-46.
- [3] "Mössbauer spectroscopy for mineralogical analysis on planetary surfaces," R.V. Morris, D.G. Agresti, T.D. Shelfer, and T.J. Wdowiak. In *Proceedings, Pathfinder Sample Acquisition, Analysis, and Preservation Instrument Technology Workshop* (Houston, November, 1988, pub. by NASA HQ).
- [4] "Geochemistry on the Mars Environmental Survey (MESUR) mission." J.L. Gooding. In *First MESUR Science Definition Team Meeting, Notes and Handouts* (NASA Ames Research Center, February, 1991).
- [5] "Conclusions and Recommendations." *Workshop on Early Robotic Missions to the Moon* (Lunar and Planetary Institute, Houston, February 1992).
- [6] "Backscatter Mössbauer spectrometer (BaMS) for planetary applications: Transducer design considerations." T.D. Shelfer, M.M. Pimperl, D.G. Agresti, E.L. Wills, and R.V. Morris. *Lunar Planet. Sci.* **22** (1991) 1229-1230.
- [7] "Development of a backscatter Mössbauer spectrometer (BaMS) for planetary applications." T.D. Shelfer, M.M. Pimperl, E.L. Wills, D.G. Agresti, and R.V. Morris. *Lunar Planet. Sci.* **23** (1992) 1283-1284.
- [8] "Mössbauer backscattering spectrometer for mineralogical analysis of the Mars surface." G. Klingelhöfer, J. Foh, P. Held, H. Jäger, E. Kankeleit, and R. Teucher. *Hyperfine Interactions* (1992), in press.
- [9] "Extraterrestrial Mössbauer spectrometry." D.G. Agresti, R.V. Morris, E.L. Wills, T.D. Shelfer, M.M. Pimperl, M.H. Shen, B.C. Clark, and B.D. Ramsey, *Hyperfine Interactions* (1992), in press.

