

INNOVATIVE INSTRUMENTATION FOR MINERALOGICAL AND ELEMENTAL ANALYSES OF SOLID EXTRATERRESTRIAL SURFACES: THE BACKSCATTER MÖSSBAUER SPECTROMETER/X-RAY FLUORESCENCE ANALYZER (BaMS/XRF); T.D. Shelfer (NRC), R.V. Morris, Code SN4, NASA Johnson Space Center, Houston, TX, 77058, T. Nguyen, Lockheed Engineering and Sciences Co., Houston, 2400 Nasa Rd. 1, TX, 77058, D.G. Agresti, and E.L. Wills, Department of Physics, University of Alabama at Birmingham, Birmingham, AL, 35294.

SUMMARY. We have developed a four-detector research-grade backscatter Mössbauer spectrometer (BaMS) instrument with low resolution x-ray fluorescence analysis (XRF) capability. A flight-qualified instrument based on this design would be suitable for use on missions to the surfaces of solid solar-system objects (Moon, Mars, asteroids, etc.). Target specifications for the flight instrument are mass < 500 g, volume < 300 cm³, and power < 2 W. The BaMS/XRF instrument would provide data on the oxidation state of iron and its distribution among iron-bearing mineralogies and elemental composition information. This data is a primary concern for the characterization of extraterrestrial surface materials.

INTRODUCTION AND BACKGROUND. A primary concern for future missions to solid planetary surfaces is the development of instrumentation for *in-situ* mineralogical and elemental analyses. Such analyses would provide the fundamental data required for the characterization and identification of surface materials and offer insights into their origins and subsequent modification processes. In terms of naturally occurring materials, the element iron is particularly important due to its abundance and multivalent nature (primarily 0, +2, +3 oxidation states).

Mössbauer spectroscopy is a nuclear resonance technique which provides detailed information about the local electromagnetic environment of individual ⁵⁷Fe nuclei. The resulting resonance pattern (Mössbauer spectrum) provides diagnostic information on the oxidation state of iron and its distribution among iron-bearing mineralogies, which tightly constrains the types of materials present. For remote use, backscatter geometry (Mössbauer source and detector(s) on same side of sample) is preferable over transmission geometry (Mössbauer source and detector on opposite sides of sample, commonly used in the laboratory) because no sample preparation is required. Backscatter geometry also allows energy-dispersive x-ray fluorescence elemental analysis to be performed simultaneously with the Mössbauer analysis requiring no additional hardware.

In 1988 we proposed and began an instrument development project designed to produce a flight-qualified combined backscatter Mössbauer spectrometer/x-ray fluorescence analyzer (BaMS/XRF) instrument [1]. Here we present our work on the BaMS/XRF project to date. A similar instrument development project is underway in Europe [2].

RESULTS AND DISCUSSION. This instrument development project has been divided into three distinct phases: 1) Design and construct a prototype two-detector brassboard BaMS/XRF instrument to demonstrate proof-of-concept. 2) Design and build a research-grade laboratory-quality four-detector instrument based on data gathered in phase one. 3) Develop a flight-qualified BaMS/XRF instrument suitable for use on upcoming lander missions. Last year we reported the results of our completion of the first phase of this project [3].

The second phase required research efforts in three main areas to make the step from brassboard to research-grade instruments. The first area of work was to optimize the detector preamplifier/shaping amplifier and the velocity transducer electronics to maximize the signal-to-noise ratio and velocity linearity of the instrument respectively. This step was accomplished through unique circuit designs, specially selected components, and carefully designed printed circuit board layouts.

The second area of research completed for phase two was the optimization of the Mössbauer source-collimator-sample-detector(s) geometry. This was a critical step in maximizing the signal-to-noise ratio of the instrument. An aluminum instrument chassis and graded collimator were designed and machined based on these considerations. A cross-sectional view of the phase two research-grade BaMS/XRF instrument design is shown in Figure 1.

INNOVATIVE INSTRUMENTATION: BaMS/XRF: Shelfer T.D. et al.

The final area of research completed on the research-grade instrument was the development of a computer-based control and data storage unit. Due to wide availability and speed of software implementation using C/C++ programming, we are using a transputer (INMOS T805-20) for the heart of this unit. The transputer has been programmed to operate as a multichannel analyzer (MCA) with up to 16 separate detector input channels. Each detector channel has its own single channel analyzer (SCA) capable of multiple window settings. For a given input channel, two Mössbauer spectra and one pulse height analysis (PHA) spectrum will be stored in separate memory groups. The two Mössbauer spectra represent the data gathered from the 6.4 keV Fe x-ray SCA window and the 14.4 keV Mössbauer γ -ray window. Due to the different escape depths of these two energies, a limited amount of depth selective BaMS is possible, which should allow investigation of weathering rinds and other thin-coating phenomena. The PHA spectrum will contain the XRF data collected.

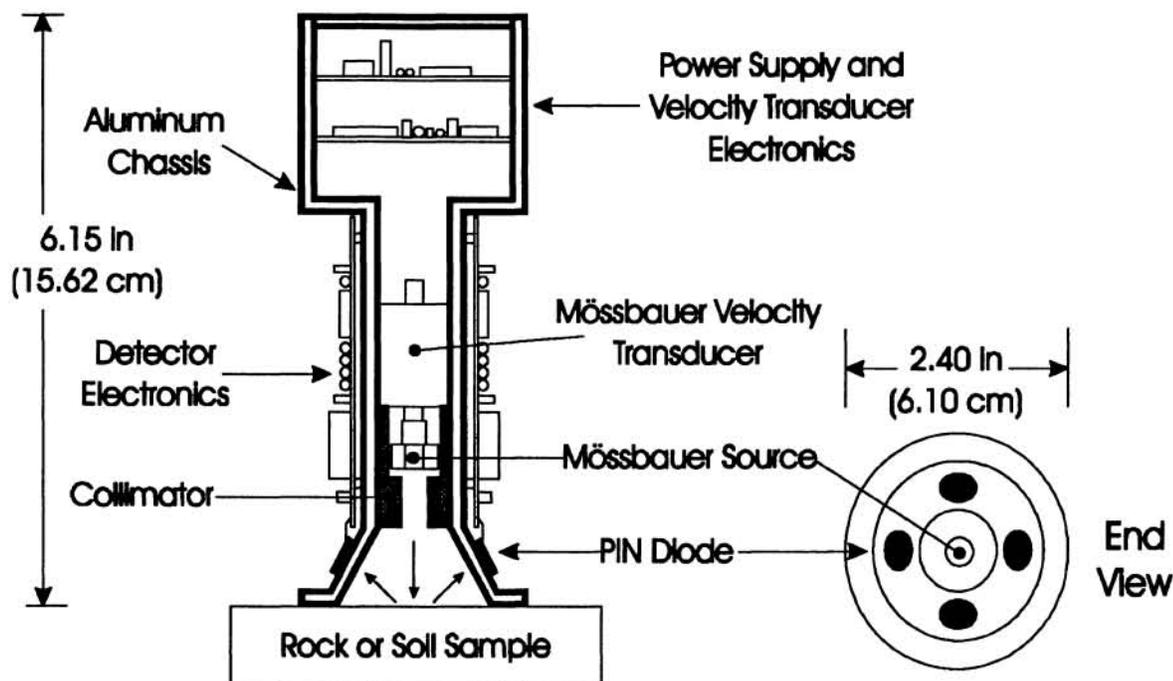


Figure 1. Cross-section and end view of research-grade BaMS/XRF instrument.

ACKNOWLEDGMENTS: This work was done while T.D. Shelfer held a National Research Council-NASA/JSC Research Associateship and support was provided by a grant from the NASA Planetary Instrument Definition and Development Program. We would also like to thank Jerry Sewell (Scientific instrument maker and machinist, Physics Dept., U.A.B.).

REFERENCES: [1] Morris R.V. et al. (Nov. 14-16, 1988) *SAAP Instr. Tech. Workshop*, Houston, TX. [2] Klingelhöfer G. et al. (1992) *Hyp. Int.*, 71, 1449. [3] Shelfer T.D. et al. (1993) *Lunar Planet. Sci. XXIV*, 1291.