PROTOTYPE BACKSCATTER MÖSSBAUER SPECTROMETER (BaMS); INSTRUMENTATION SUMMARY AND CONCLUSIONS; T.D. Shaffer, NRC Research Associate, Mail Code SN4, NASA Johnson Space Center, Houston, TX 77058, R.V. Morris, Mail Code SN3, NASA Johnson Space Center, Houston, TX 77058, T.Q. Nguyen, Lockheed Engineering and Sciences Co., 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 completed work on development of a miniature research-grade backscatter Mössbauer spectrometer (BaMS). The BaMS instrument, built completely from scratch, provides (non-destructively and with no sample preparation) high-quality Mössbauer spectra from which the distribution of Fe among both its oxidation states and its mineralogies can be calculated. A flight-qualified version of this design would provide future missions to the surfaces of the Moon, Mars, asteroids, and other solid-surface solar-system objects, with a highly-selective mineralogical tool.

INTRODUCTION. Mössbauer spectroscopy is a recoil-free nuclear resonance technique which can be used to precisely determine energy levels inside of a nucleus. These energy levels are very sensitive to the local electromagnetic environment of the nucleus, and the energy difference information can be used to determine the arrangement and oxidation state of atoms in the local environment. This data provides a unique fingerprinting tool useful in identifying mineralogical compositions and oxidation states. Of the 45 elements (91 nuclides) which exhibit the Mössbauer effect, $^{57}$Fe (2.2% natural abundance) is perhaps the most important in terms of mineralogical investigations due to its abundance in nature and multivalent character (primarily 0, +2, and +3 oxidation states) [1]. Diagnostic data on the oxidation state of iron and its distribution among iron-bearing mineralogies tightly constrains the types of materials which may be present in a sample.

There is a serious shortage of instrumentation capable of providing in situ mineralogical analysis for planetary lander missions due to the severe constraints on power, mass, data rate and storage, sample preparation/handling, and survivability limitations imposed by missions. In 1988 we proposed and began an instrument development project designed to produce a prototype for a flight-qualified backscatter Mössbauer spectrometer (BaMS) instrument for the purpose of mineralogical analyses on the surfaces of solar-system objects [2]. We have selected a backscatter geometry for our design, in which the Mössbauer source and detectors are on the same side of the sample, to eliminate the need for sample preparation [3]. A Mössbauer spectrum of a sample (rock, core, soil, etc.) is obtained simply by placing the source-detector end of the BaMS instrument in contact with or in close proximity to the target sample. A similar instrument development program is underway in Europe [4,5].

RESULTS AND DISCUSSION. A complete four detector prototype BaMS instrument, as illustrated in Figure 1, has been assembled and tested over a wide range of samples and environmental conditions [6-8]. With a 50 mCi $^{57}$Co source, an identifiable Mössbauer spectrum of a natural hematite rock was obtained in roughly five minutes. Work on assembling a library of BaMS spectra of iron-bearing minerals has begun at JSC. Additionally, a wide range of lunar samples, SNC meteorite samples, and Mars simulates will be analyzed and added to our library database.

The BaMS instrument has been successfully tested from room temperature down to approximately -100° C in an environmental chamber. The instrument has been used in a high
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Radiation environment (> 20 mR/hr) with high-level nuclear wastes at the DOE Westinghouse Hanford Site. To test potential vibration problems when mounted on a robotic arm, the BaMS instrument was attached to a robotic arm provided by McDonnell Douglas. There was no statistical difference between spectra taken on the arm versus benchtop spectra.

The BaMS instrument project is now ready to proceed to flight hardware development and deployment for future planetary lander missions.

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**ACKNOWLEDGMENTS.** This work was done while T.D. Sheller 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.


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