COMBINED BACKSCATTER MÖSSBAUER SPECTROMETER/X-RAY FLUORESCENCE ANALYZER (BaMS/XRF) FOR EXTRATERRESTRIAL SURFACES; T.D. Shelfer, E.L. Wills, D.G. Agresti, M.M. Pimperl, M.H. Shen, Department of Physics, University of Alabama at Birmingham, Birmingham, AL 35294, R.V. Morris, Code SN2, NASA Johnson Space Center, Houston, TX 77058, and T. Nguyen, Lockheed Engineering and Sciences Co., Houston, TX 77058.

Introduction. We have designed and tested a prototype combined backscatter Mössbauer spectrometer and x-ray fluorescence analyzer (BaMS/XRF). A space qualified instrument based on this design would be suitable for *in-situ* use on planetary missions to the surfaces of the Moon (Artemis and lunar outpost), Mars (MESUR), asteroids, or other solid solar system objects. The BaMS/XRF instrument is designed to be capable of concurrent sample analyses for the mineralogy of iron-bearing phases and elemental composition without the need for sample preparation.

BaMS/XRF Instrument. For this proof-of-concept prototype design we have split the instrument into two separate logical units: the probe unit and body unit. The probe unit contains a miniature (~20 g) Mössbauer drive [1], ^{57}Co source, collimator, PIN diode radiation detector, and the detector preamplifier and amplifier circuitry all mounted to an aluminum chassis as shown in figure 1. The body unit is a portable 80386-33MHz computer with a multichannel analyzer card (Nucleus PCA-II-4k) and the Mössbauer drive feedback circuitry mounted internally. With this arrangement, all that is needed to perform both analytical techniques (Mössbauer and XRF) is to present the unprepared sample (soil, rock, etc.) to the source/detector end of the probe unit.

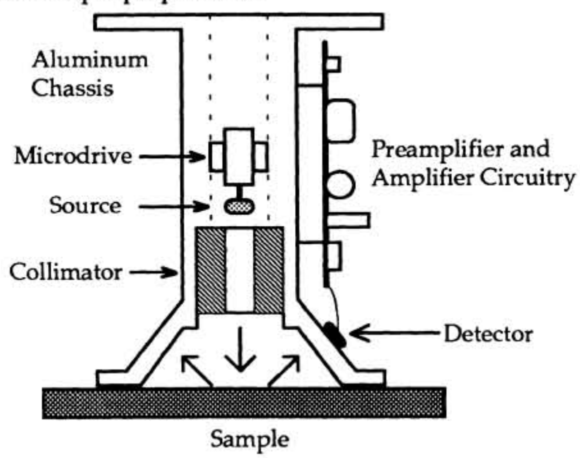

Figure 1. Probe unit schematic design.

Results and Discussion. The completed BaMS/XRF prototype instrument has been tested with a variety of standard Mössbauer and XRF samples. In particular, the BaMS capability has been applied to a Martian infrared spectrum analogue soil, Hawaiian palagonite PN9 [2]. Figure 2 shows a comparison between a transmission Mössbauer spectrum of PN9 and the backscatter spectrum obtained with the BaMS prototype. The general structure of the backscatter spectrum shows the central doublet and additional resonance to its right; however, the quality of the spectrum suffers due to the relatively weak ^{57}Co source used (~15 mCi vs ~50 mCi for the transmission spectrum) and the small solid angle of backscattered radiation collected by the single PIN diode (2.8% of the total 2π solid angle). Under these conditions (~100 hr collection time) the long-term drifts of the initial drive circuitry employed leads to a loss of resolution in the spectrum. The final BaMS design will include a stronger source (≥ 100 mCi), an array of backscatter detectors (~75% of total solid angle), and improved detector and drive circuitry which should result in a backscatter spectrum of adequate quality in ~30 minutes.

To test the XRF capabilities of the instrument, a variety of pure metal foil samples were analyzed at room temperature (~20 °C) by placing the foils on an aluminum target at the source/detector end of the BaMS/XRF probe head. The pulse height spectrum for each was taken for a preset length of time and stored. A blank (aluminum) spectrum was then subtracted from the foil spectrum to remove the noise contributions. The difference spectra for a number of metal foils (ranging in atomic number from Z=29 to Z=82) are shown in figure 3. Figure 4 is a pulse height spectrum of the ^{57}Co source taken with the PIN diode at 12 °C. To improve the range and sensativity of the XRF capability, the flight instrument might include several higher resolution radiation detectors or shutter in different excitation sources. Cold extraterrestrial temperatures will also improve the resolution of the PIN diode/preamplifier detector system.

A similar instrument development program is underway in Europe [3].

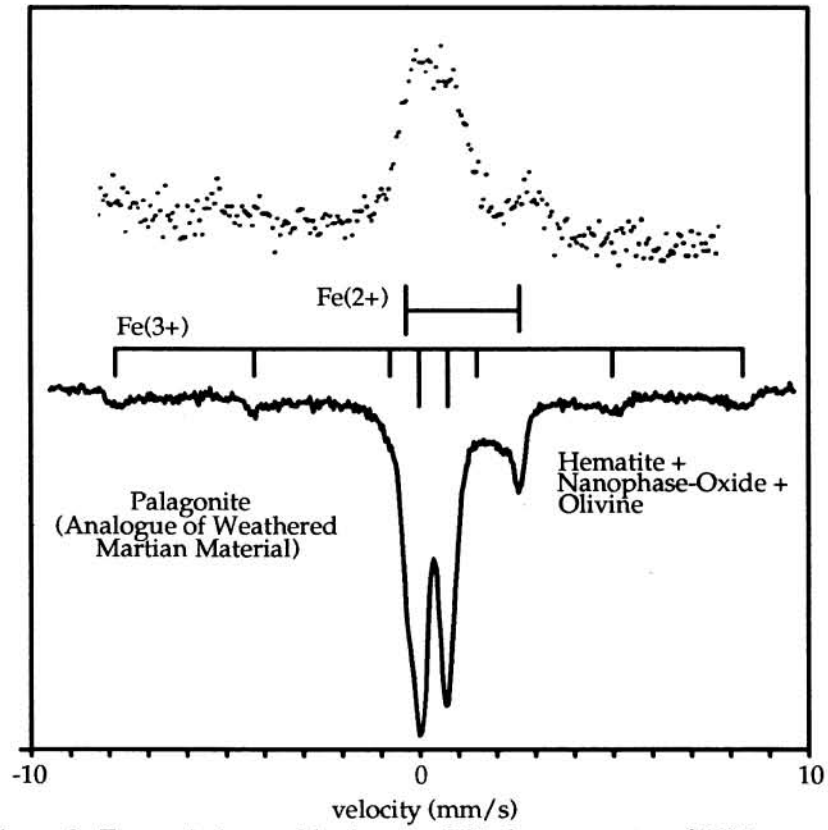

Figure 2. Transmission and backscatter Mössbauer spectra of PN9.

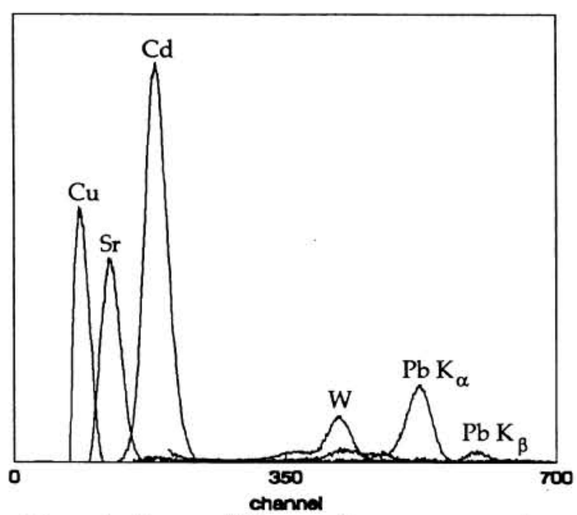

Figure 3. K x-ray difference fluorescence spectra.

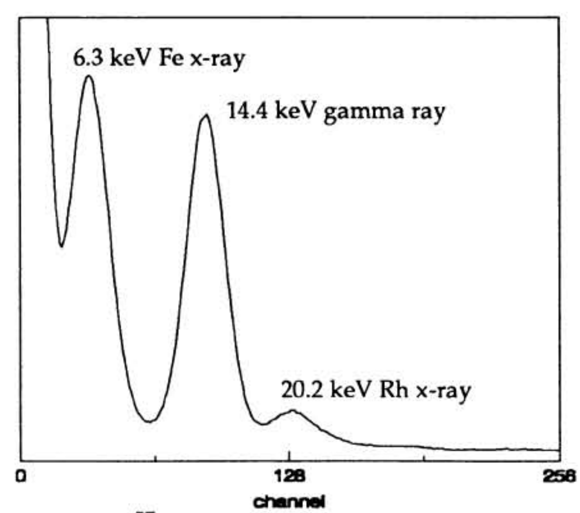

Figure 4. ^{57}Co PHA spectrum using PIN diode.

References: [1] Shelfer *et al.* (1992) *Lunar Planet. Sci. XXIII*, 1283; [2] Morris *et al.* (1989) *Lunar Planet. Sci. XX*, 723; [3] Klingelhöfer *et al.*(1992) *Hyperfine Interactions, 71*, 1449.