# MOSSBAUER BACKSCATTER SPECTROMETER: A NEW APPROACH FOR MINERALOGICAL ANALYSIS ON PLANETARY SURFACES,

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**THE TECHNIQUE.** Iron Mossbauer spectroscopy is specific for the element and sensitive to all its normal oxidation states (3+, 2+, and 0) and to its chemical environment. For a geological sample, the technique thus provides quantitative information on the distribution of iron among its oxidations states, the mineralogy of iron-bearing phases, and the relative proportions of those phases. As an example of the utility of the technique, we discuss next the Mossbauer spectra of two samples considered to be representative of some types of materials present on Mars.

Figure 1 shows the Mossbauer spectrum of meteorite EETA79001, which is one member of a class of meteorites (SNCs) thought to have originated from Mars [e.g., 1, 2]. This spectrum, which is essentially identical to ones published by [3,4], shows two strongly overlapping doublets which result from ferrous iron in olivine and pyroxene. The larger area for the pyroxene doublet means that there is more ferrous iron associated with pyroxene that with olivine. According to [3,4], only ~2 % of the total iron in EETA is present as ferric iron. Because of their spectral characteristics in the visible and near-IR, certain palagonites (mafic volcanic weathering products) are thought to be terrestrial analogues for material present in the bright regions of Mars [e.g., 5]. The Mossbauer spectrum of a particularly good spectral analogue has been published by [6] and is shown in Figure 2. Unlike the spectrum for EETA79001, this one is dominated by ferric-bearing phases. Hematite (sextet 1) and a superparamagnetic ferric phase (doublet 2), probably in part nanocrystalline hematite, are present. Smaller amounts of olivine (doublet 4) and probably pyroxene (doublet 3) are also present. Thus, Mossbauer spectroscopy can be used to provide remote mineralogical analysis and to select samples with different mineralogies, composition, weathering state, etc. for return to earth or for additional analysis on a spacecraft lander.

**THE LANDER INSTRUMENT.** Basically, a Mossbauer spectrometer consists of a multichannel analyzer, a $^{57}$Co source attached to vibrating rod, and a detector. To obtain Mossbauer spectra onboard a planetary lander, several modifications of the typical laboratory instrument will be required to conserve space, mass, power, and time required for a good experiment. Transmission geometry (sample between source and detector) is most widely used in laboratory instruments. However, backscatter geometry (source and detector on the same side of the sample) is more practical for an extraterrestrial field system because sample preparation is minimal or unnecessary. If the instrument is configured so that the source and detector are next to the outer skin (with a suitable window material) of the lander, sample need only be placed on the window for analysis. The instrument could be part of or moved by a robotic arm and placed on soil or rock surfaces for analysis thereof.

A lightweight, piezoelectric-based system would replace the bulky electromechanical transducer commonly used in laboratory instruments.

Velocity calibration could be done by a small diode-laser interferometer or by analyzing a known material (e.g., Fe metal, which could be part of the robotic arm). Recent advances in detector technology have made available solid-state detectors that are more suitable than the gas-filled proportional counters used in many laboratory instruments. With a annular array of small solid state detectors, the source-detector distance may be decreased, allowing a good Mossbauer spectrum to be recorded in a fraction of the time currently required in the laboratory (typically 1-24 hr depending on source strength, sample Fe content, and precision required). During data collection, spectra will be stored internally, placing no burden on the main computer of the lander. Based on the halflife of $^{57}$Co, the estimated useful instrument lifetime is a minimum of 3 years. The estimated size for the instrument is <700 cm$^3$.

References: [1] Bogard and Hirsch, *Science 221*, 651, 1983; [2] McSween, *Rev. Geophys 23*, 391, 1984; [3] Vieira *et al.*, *Physica Scripta 33*, 180, 1986; [4] Solberg and Burns, *PLPSC19*, in press, 1989; [5] Singer, *JGR 87*, 10159, 1982; [6] Morris *et al.*, *LPSC XIX*, 813, 1988.