GAMMA-RAY METHODS FOR THE MEASUREMENT OF ATMOSPHERIC THICKNESS AND SURFACE PRESSURE AT MARS: A. E. Metzger, Jet Propulsion Laboratory, Pasadena, CA 91109, and E. L. Haines, Sunrise Research, Inc., Eugene, OR 97402

The atmosphere at Mars absorbs a portion of the gamma-ray flux emitted from its surface, the proportion depending on the energy of the gamma ray and the thickness of the atmosphere. We have been studying the extent to which this effect may be applied to the measurement of atmospheric thickness and surface pressure by comparing the ratio of line pair intensities emitted by the same element observed at orbital altitudes above the atmosphere with the corresponding known initial ratio (1). Such measurements can provide values of the total mass of atmospheric material and its distribution over the surface of Mars as a function of season. This differential attenuation method has been found to permit long period (ca 100 hr) observations with expected sensitivities on the order of 2-3% (2), subject to two limitations. The regolith must be bare, i.e. allowable ice deposits may be no more than a couple of millimeters thick, and the regolith composition must either be generally uniform to a depth of about a meter, or the variation known. In order to generalize these atmospheric measurements to the entire planet, we have expanded the study with the addition of two other methods, designated as direct determination and single line attenuation.

Atmospheric components may be measured by gamma-ray spectroscopy in the same manner as surface material, the required observing time for a comparible sensitivity being much greater for the atmosphere due to the difference in density and thickness. If the constituent abundance is known, then a measurement of the corresponding gamma-ray line can be interpreted in terms of atmospheric thickness. Direct determination has been found to be applicable to carbon if carbon is absent from the surface, and to oxygen regardless of the surface composition because of the broadened shape of the principal oxygen gamma-ray line from the atmosphere.

Single line attenuation depends on establishing the presence of a surface layer about a meter or more in thickness, of known and reasonably uniform composition, within which a strong and uniformly distributed gamma-ray emitter is present. Seasonal polar caps of carbon dioxide ice and residual polar caps of CO_2 ice and H_2O ice are likely to meet these requirements over much of the area they cover, with 6.129 MeV oxygen and 2.223 MeV hydrogen as the line emitting elements of interest. Layered terrain may also be suitable. Source composition and a satisfactory production model permit calculation of the gamma-ray flux generated by the thick target from which a comparison with the actual signal observed in orbit can be made to yield values of the effective atmospheric thickness. The expected sensitivities based on single line attenuation are comparable to the best obtainable by differential attenuation.

With these three methods, differential attenuation, direct determination, and single line attenuation, atmospheric thickness can be measured over the entire planet. Where they can be used in combination, there is the prospect either of an improvement in sensitivity or obtaining other information. For example, applying both differential attenuation and direct determination over bare regolith should reveal the presence of

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significant concentrations of carbon as carbonates or adsorbed into the regolith.

The use of direct determination and single line attenuation circumvents the inability to apply differential attenuation to polar cap regions. Direct determination also ameliorates the other limitation of differential attenuation, that of stratigraphic variation. The effect of stratigraphic variation is to offset the differential attenuation relationship of count-rate ratio vs atmospheric thickness by a factor which is roughly independent of the atmospheric thickness. A direct determination of atmospheric thickness over the same region can provide a normalization point to define this relationship irrespective of stratification. The approach also holds promise as a means of deriving information about near surface stratigraphy.

REFERENCES: (1) Metzger, A.E., American Astronomical Society Bulletin 16, #3 (Part I), pp. 678-679, 1984. (2) Metzger, A.E. and E. Haines, Fourth International Conference on Mars, abstract, Jan, 1989.