



## The first “On-the-Spot Determination of Water Content of Martian Soils

**J. L. Campbell**, R. Gellert, J.A. Maxwell, J. M. O’Meara

Guelph-Waterloo Physics Institute, University of Guelph, Canada (jlc@physics.uoguelph.ca)

The alpha-particle X-ray spectrometers (APXS) on board the Mars Exploration Rovers (MER) employ two X-ray emission methods simultaneously for elemental analysis of Martian soils and rocks. These methods are X-ray fluorescence (XRF) and particle-induce X-ray emission (PIXE), using respectively the plutonium L X-rays and the 5.8 MeV alpha particles from a  $^{244}\text{Cm}$  source. We are developing a spectrum analysis code that combines the XRF and PIXE databases to fit the APXS spectra and hence provides the elemental concentrations in the range  $11 \leq Z \leq 39$ . From these concentrations we predict, using a Monte Carlo approach, the intensity ratio of the elastic and inelastic X-ray scatter peaks. By comparing this predicted ratio with the value derived from the spectrum fit, we are able to determine the contribution, if any, of elements having  $Z < 11$  in the sample, thereby enabling an estimate of water content. For any individual sample, the water detection limits ( $\sim 6$  wt%) and error estimates are high due to the low counting statistics in the spectrum, but integrating the data over a set of similar samples improves the error bars and lowers the limit.

This methodology has enabled us to determine the total water content of surface and sub-surface Martian soils encountered by the Spirit rover. We show that typical red-brown basaltic surface soils from the Gusev crater are essentially dry ( $< 1$  wt% water), as would be expected. In contrast, for several bright sub-surface soils churned up by the rover wheels, we find water content in the range 6 – 18 wt%; our analyses cover material analyzed in situ and one case of material actually adhering to a wheel.

These bright soils contain sulfur at unusually high levels (30 wt%  $\text{SO}_3$ ) relative to the common Martian basaltic soils. Mass balance mixing calculations of available cations

infer the presence of Fe-, Mg-, and Ca-sulfates. Together with constraints from mineralogy, our results imply that highly hydrated ferric sulfates are the most important carrier of the bound water found in the five spots studied and in the material carried away by the wheel. These results appear to fit with the available chemical and mineralogical information, and contribute to a growing understanding of present bound water reservoirs on Mars.

This new approach to determination of water has led to design changes in the APXS for the Mars Science Laboratory such that the detection limits for water will be significantly improved.