feature

Understanding Martian geology with X-ray spectroscopy

How a University of Guelph team is piecing together Martian geochemistry

BY **DAVID NATAF**

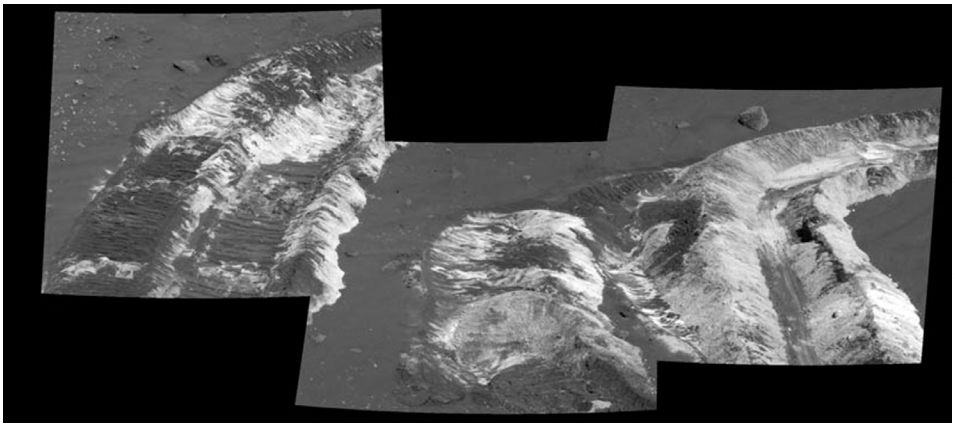
It's now been several years since the NASA-designed Mars rovers Spirit and Opportunity landed on the Red Planet and began their scientific missions. While providing a boost to the public perception of science, some real science was performed as the rovers conducted surveys of the Martian landscape and geology. A Canadian team, the Guelph PIXE Group, has been involved with the analysis of data from the rovers.

Based at the University of Guelph's department of physics, the group studies particle-induced X-ray emission (PIXE). Their work was used to analyze the readings of the Alpha-Particle X-Ray Spectrometer (APXS), which each of the rovers have. The APXS contains a sample of Cm-244, an isotope of curium, which excites X-ray emission in situ from Martian rock and soil samples, and a silicon drift detector which produces the X-ray spectra. Due to various modes of excitation, APXS has excellent sensitivity to most of the types of minerals that one might expect to find in Martian rock. The inherent complexity of such tasks combined with the group's expertise led to its selection to perform the work, according to University of Guelph professor Iain Campbell. "Together PIXE and XRF [X-ray fluorescence] provide a uniform sensitivity to the entire range of elements in Martian rocks. Rieder [the principal investigator for the APXS on the Mars Exploration Rovers] had looked at all available PIXE and XRF software packages (they differ a lot) and chose GUPIX as the one that he preferred as the base for creating a unique code that could handle the APXS spectra," says Campbell.

Prelimenary work included Monte Carlo simulations of the interactions in the sample. The simulations allowed predictions of expected X-ray intensities. These simulations have been tested against results of measurements using geochemical reference standards. Now, these computed sensitivities are helping the analyses of spectra from Mars. Three elements which have been clearly detected from the spectra of Martian rock are chlorine, bromine and sulphur. It is thought these may be the residues of salts that were once dissolved in large bodies of flowing water. One hope would be that APXS could detect bound water within the rocks being analyzed. The X-rays of hydrogen and oxygen cannot be directly detected by the instrument, and as such an indirect detection is what is aimed for.

The method is to deduce elemental concentrations from the observed elemental X-rays, and to convert these to oxide concentrations. This is followed by a comparison of predicted properties of the rocks from Monte Carlo simulations with what is actually observed, and if there is disagreemant, then "invisible" matter such as water must be present. Campbell elaborated, "the only other candidate is carbon—but there is very little carbon in materials of the type we are looking at. And we have several other pieces of evidence from the MER [Mars Exploration Rovers] to bring to bear on the formations we are examining on Mars." Currently, the equipment and software is good enough to detect water concentrations down to the 10% level, and the necessary analyses have been made so that future missions could make detections feasible down to the 5% level. The 10% threshhold is considered adequate for detecting water in salty formations. At *CUPJ*'s press time, the results of the Guelph team's analysis were not yet available.

Ralf Gellert, a faculty member at the University of Guelph, is principle investigator for the new APXS for the Mars Science Laboratory mission, which expected to launch in 2009 and land in 2010[2]. In the end, only the future will tell what the Martian past was like.



COURTESY OF NASA/JPL-CALTECH/CORNELL

A view of some sulphur-rich soil churned up recently by the Spirit rover. Sulphur-rich soils are suspected of having high levels of bound water on the Martian surface, and so are of great interest. BELOW: A panorama view of Cape Verde composed of hundreds of individual images taken by the Opportunity Rover.

REFERENCES

[1] *PIXE and XRF on Mars*, http://pixe.physics.uoguelph.ca/mars/. 2006.

[2] *Mars Science Laboratory*, http://marsprogram.jpl.nasa.gov/msl/. 2006.

COURTESY OF NASA/JPL-CALTECH/CORNELL