APXS ON MARS SCIENCE LABORATORY – FIRST RESULTS FROM POST-LANDING CHECKOUT.

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Introduction: The Alpha Particle X-ray Spectrometer (APXS) [1] is the Canadian payload contribution to the Mars Science Laboratory (MSL) mission, set to land at Gale crater (4°36′0″S 137°12′0″E) on August 6, 2012. Like its predecessors on Pathfinder and the Mars Exploration Rovers (MER) [2], the APXS will analyze the bulk chemistry of Martian materials. This is accomplished by employing ^{244}Cm sources and an x-ray detector, both housed within its sensor head (shown below), to provide x-ray excitation spectra from incident x-rays and alpha particles. The sensor ultimately provides the abundance of the elements Na through Sr within a 15 mm field of view on the Martian surface.

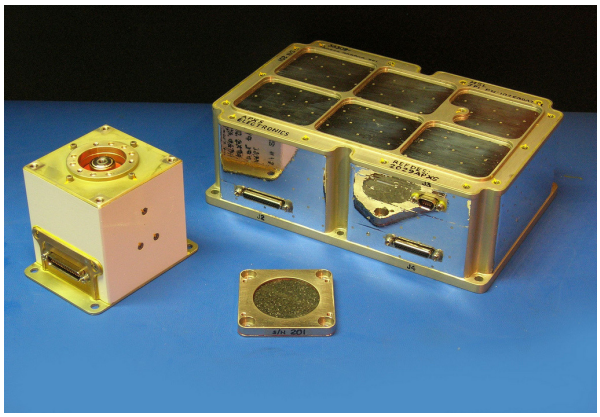

Figure 1: MSL APXS flight instrument. The sensor head (left), mounted on the MSL robotic arm; the electronics box (back right), located inside the rover, contains a microcontroller to process the analogue signals and to command the instrument; the basaltic calibration target (center).

Development of APXS: The APXS was developed by the Canadian Space Agency, with MacDonald Dettwiler & Associates as the prime contractor. The scientific design and technical support during the development was provided by the University of Guelph.

Several improvements have been made to the APXS sensor from previous versions, including:

- The usage of a Peltier-cooled detector to increase the operational upper temperature limit from -40° C to ~ -5° C, and thus allowing Martian daytime operation.
- A shorter sample-detector distance for higher sensitivity, thus decreasing the data acquisition times to 3 hours from 9.
- An on-board basaltic rock slab for calibration.
- Extended energy range from 0.7 to 25 keV.
- Addition of standard XRF ^{244}Cm sources to increase sensitivity for high z elements.

An illustration of the new APXS sensor head is shown in Figure 2 below.

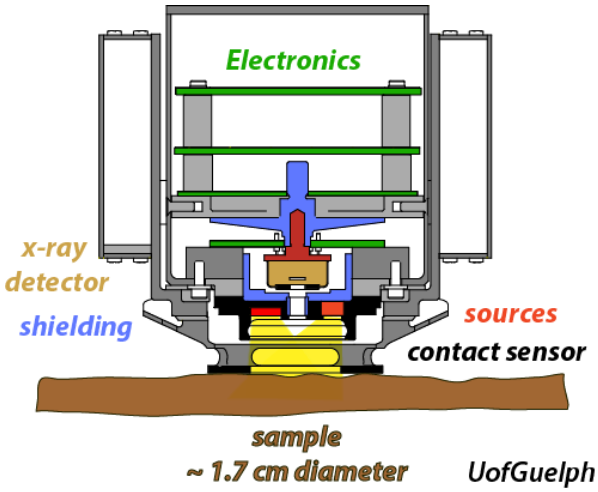

Figure 2: Sketch of the new APXS sensor head geometry. The opening of the JPL provided contact sensor plate is wide enough to measure either in contact or with a standoff.

Calibration: The methodology employed in calibration of the APXS sensor is nearly identical to that done for MER [e.g. 3,4,5]. About 100 geological reference powders, chemical compounds and mineral specimen were selected for calibration of the APXS sensor.

Using spectral fitting routines, the elemental signal is calibrated with the certified abundance of all the detectable elements. The signal response for each element is a smooth function of the x-ray energy, as illustrated in Figure 3, determined by the instrument properties and the Physics of the x-ray excitation processes in the sample.

The calibration provided a reliable cross calibration with other MSL lab instrument and MER instruments currently in use on Mars. A comparison of the perfor-

mance of the MSL and MER version of the sensor is shown in Figure 4.

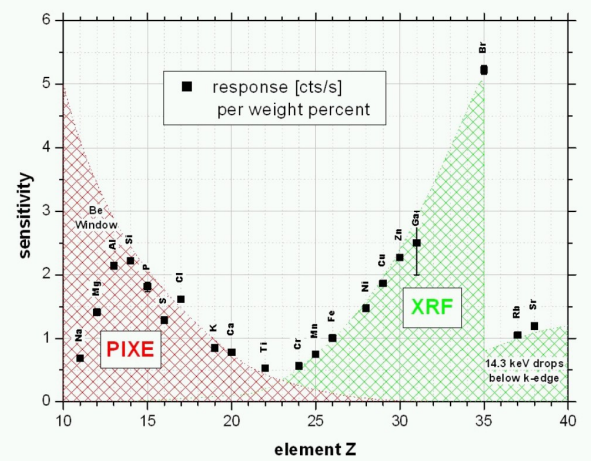

Figure 3: Signal sensitivity as a function of element for the APXS using both Particle Induced X-Ray Emission (PIXE) and X-Ray Fluorescence (XRF) excitation.

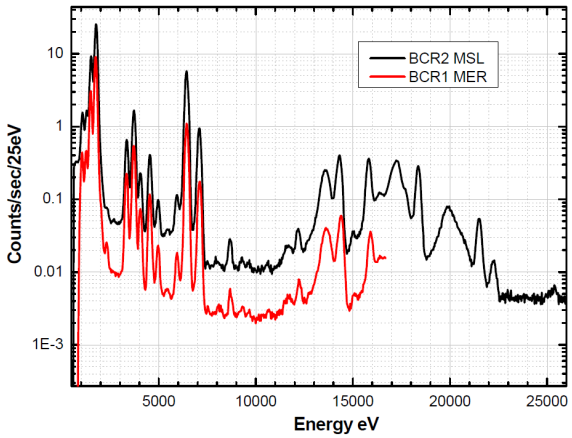

Figure 4: Comparison of fluorescence signal response employing the MER (red) and MSL (black) versions of APXS for the same integration time.

As described in [6,7] the instrument calibration was ultimately extended to create a database of expected Martian compositions, this included certified geostandards of igneous, sedimentary and mineral samples. Bulk sample effects, such as density, have also been investigated, as have surface and crystallographic effects such as sample homogeneity, grain size, crystal orientation and the effects of sample surface coating.

Finally, Campbell et al describe a novel method for estimating light element content within Martian samples using the elastic and inelastic scatter peaks at high energies in the APXS spectrum [8]. The extended energy range, as well as the additional signal from the ^{244}Cm XRF sources greatly enhances the sensitivity to detect excess light elements, like bound H_2O or Carbonates.

Results: After landing beginning in August the MSL rover will undergo a series of rover and instrument checkouts, before starting to explore the landing site. At the time of this writing it is expected that the APXS checkout results and first preliminary findings at Gale crater will be presented.

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References:

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