Remarks on the Calibration of the Alpha-Particle-X-Ray Spectrometers on board the MER Rovers

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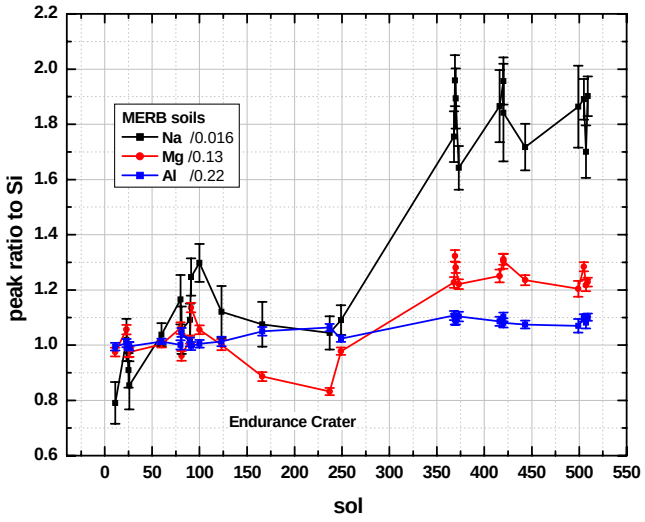
The APXS on both MER rovers don't carry a useful calibration target for the x-ray channel. The dedicated calibration target on the inner side of the dust protective doors consists mainly of a thin gold layer glued on top of the Copper doors. It was specially tailored to fulfill the needs for the calibration of the alpha particle channels. But the lowest x-ray lines for gold at around 2.2 keV are too high in energy to be sensitive to reveal unambiguously subtle changes in detector properties (either contamination or other changes in the detector properties). Furthermore it was decided early in the mission to leave the doors open due to a cumulative unreliable mechanism on the APXS sensor head.

Therefore the soils at both landing sites were used to monitor the performance and the calibration of each APXS instrument. This was triggered by the discovery that the soils on all five known Mars landing sites were very similar (due to global mixing by Aeolian processes) and the observation that the composition didn't change much along the traverse of both MER rovers (except for obvious soil anomalies mostly in disturbed subsurface soils).

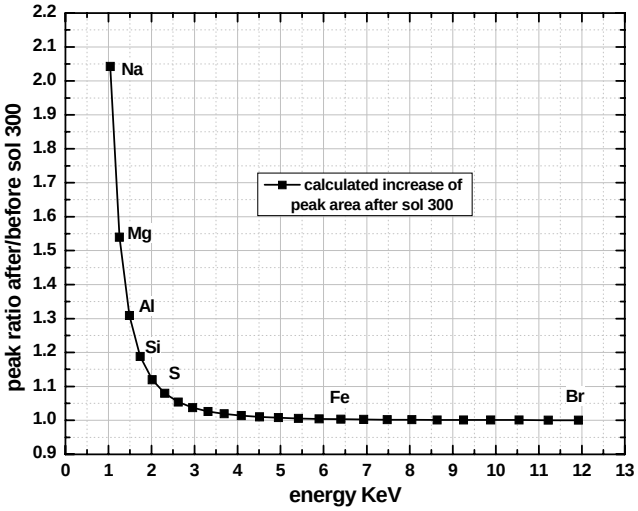


Recently it was discovered and proven that an obvious incident happened to the MERB APXS instrument sometime between sol 250 and sol 368. These were the dates when the APXS measured soils on MERB. The ratio between the low-z elements Na, Mg and Al and the Si peak areas are plotted in Figure 1. This ratio allows comparison despite the admixture of various amounts of Fe rich spherules in the soils of the MERB landing site.

It is obvious that in this timeframe a change in the properties of the detector occurred. Figure 1 shows that the light elements Na, Mg and Al are clearly enhanced after sol 250

versus Silicon. The enhancement shows a certain pattern. The enhancement is bigger for Na than for Mg. The Mg enhancement is in turn higher than Al. A pattern like this indicates a change in the detector properties, i.e., by removing an absorbing element in the path of the detected low energy x-rays. The fact that the ratios are nearly constant before and after sol 250 also points to a one time change of the detector properties. The constancy of the results before and after made it necessary to wait till enough spots were measured. Recent calculations revealed that the changes can be simply explained by the removal of 1 bar N_2 atmosphere within the detector assembly. The x-ray detector chip is sealed by glass feed-throughs and a Be window from the external environment. This compartment is filled, as a standard practice, with 1 bar of N_2 by the vendor after detector assembly. It seems that either an electrical feed-through, the housing, or the Beryllium window developed a gas leakage after sol 250. This incident removed the 1 bar of N_2 and filled the interior of the detector with martian atmosphere. The derived elemental ratios before and after the incident lead to a thickness of 1.9 mm of the N_2 column. This is in good agreement with the internal mechanical setup of the x-ray detector. A complete removal of the Be window can be excluded as it would have had a greater influence on the results with a different energy pattern.

Derived correction factors of the measured peak areas before and after the incident are given in Figure 2.



Taking these correction factors into account, the results of the outcrop analyses show that the composition of the outcrops did not change significantly after Opportunity left Endurance Crater, which was about the time when the incident happened. This conclusion is in good agreement with all other instruments on the MER rover. Without the correction a jump of approximately 80 % in Na and a significantly increased Si/Fe ratio would have been observed in the APXS results.

A final correction table of the peak areas is pending until all results of the science investigations on board the Opportunity Rover are taken into account.

The incident bears no challenge for the x-ray detector itself. The FWHM as well as the peak to background ratio of the APXS before and after the incident is constant. Because the martian atmosphere is very dry, no oxidation inside the detector is expected. The fact that measurements during the morning hours do not show excessive noise due to light indicates a very small gas leakage *only* in the x-ray detector housing.