SUITABILITY OF AN APXS FOR PHOBOS AND DEIMOS MISSIONS

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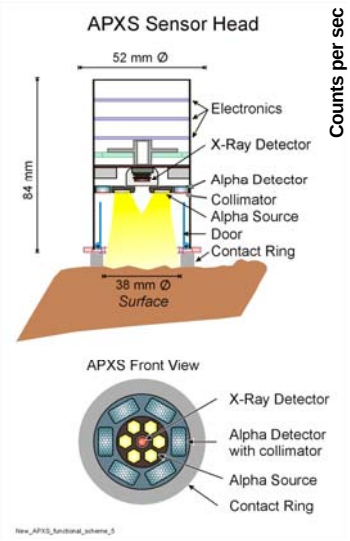
Introduction: The Alpha-Particle-X-ray Spectrometer (APXS) is part of the MER rover payload [1]. An earlier version was on board the Sojourner rover on the Pathfinder mission in 97. Here the suitability for an APXS on a Phobos/Deimos lander shall be discussed.

Method: The APXS is a contact instrument to determine the elemental composition of rocks and soils. It uses two modes simultaneously; x-ray spectroscopy for elements from Na to Br and beyond and Rutherford backscattering (RBS) for light elements. The APXS uses Curium244 sources emitting Pu x-rays and ~ 5 MeV alpha particles onto the sample. The x-ray part is a combination of the terrestrial standard methods PIXE and XRF determining the abundances of trace elements like Ni, Zn, Ge and Br down to a couple of 10 ppms. Element identification is unambiguous. The abundance extraction is theoretically well understood, precise and accurate [2]. Typically, accuracy from 3-15%, limited only by sample heterogeneity and a precision of some percents is achieved within in a few hours of data acquisition.



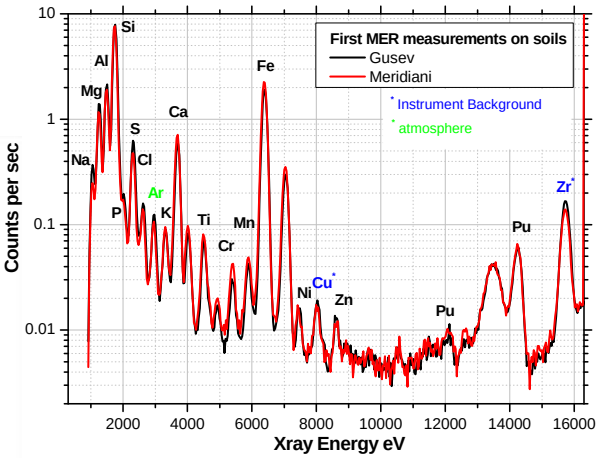
The alpha part is based on the z dependant energy loss of backscattered high energetic alpha particles and very sensitive to low z elements like Carbon and Oxygen. On Mars RBS is of limited usage due to interferences with the 10 mbar CO_2 atmosphere. Therefore the MSL APXS – competitively selected by NASA, endorsed by CSA – will not entertain RBS and instead use a close up geometry to speed up the x-ray spectra collection by a factor of ~4. However, in vacuum a Carbon detection limit of ~ 1% by weight is achievable within ~ 10 hours as demonstrated during MER calibration.

Science Objectives: The APXS can address several major science objectives of a Phobos mission:

- to determine if the moons are of Martian origin or if they are captured asteroids
- the composition of its regolith and its distinction to bedrock (if accessible with a deployment device)
- the presence of H_2O and C on the surface

The small changes to be made to the MER APXS design based on lessons learned would be:

- activation of the build-in Peltier inside the x-ray detector for high quality spectra below ~ 20C
- extension of the x-ray energy range to capture more of the so called scatter features
- addition of a well known calibration target



The figure above shows the first two x-ray spectra taken of soils from both MER landing sites. The well balanced sensitivity for all elements, the low background and the superb energy resolution is the key for this instrument and the method. Recently Campbell et al developed a method to extract the abundance of x-ray invisible light elements like C and O from the Pu scatter peaks at ~ 14 keV [3]. This method – unexpected at the development of the instrument – plus the simultaneous RBS mode in vacuum promise to be able to address possible heterogeneity and abundance of C and excess Oxygen (presumably in H_2O or OH) with detection limits of 1% carbon and ~ 5 % water.

Summary: The APXS is a compact, sound and flight proven instrument that can be used to address major scientific objectives on the Martian moons. Its operation on MER over 3½ years delivered the standard for Martian Chemistry so far and showed the variability of igneous as well as altered chemistry. Many detectable elements or element ratios are indicative for mineralogy and to distinguish the two origin theories, e.g. Mg/Si, P, Fe/Mn, Ni, Ge,…

References: [1] Rieder, R., et al (2003*), JGR, 108(E12),8066*, [2] Gellert,R et al. (2006), *JGR*, 111, E02S05, [3] Campbell et al, JGR , submitted