APXS ON MARS: ANALYSES OF SOILS AND ROCKS AT GUSEV CRATER AND MERIDIANI PLANUM.

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Introduction: Newly developed APXS (Alpha Particle X-Ray Spectrometers) are part of the Athena payload of the Mars Exploration Rovers Spirit and Opportunity [1]. The APXS determines the chemical composition of soils and rocks along the traverse of the two rovers. Spirit and Opportunity operate at Gusev Crater and Meridiani Planum, respectively. First results of soil X-ray spectra at both landing sites support the hypothesis of a global homogenization of the soil by large dust storms and impact processes in the northern and southern hemisphere.

APXS Instrument: An APXS sensor head, which contains six Curium-244 alpha sources and a high-resolution X-ray detector, is mounted on the Instrument Deployment Device (IDD) of the MER rovers Spirit and Opportunity. The new APXS is an advanced version of the old Mars Pathfinder instrument [1]. The APXS together with the Mössbauer Spectrometer (MB), the Microscopic Imager (MI), and the Rock Abrasion Tool (RAT) [2] was and will be used to make in-situ measurements of soils and rocks to determine their chemical, mineralogical, and textural compositions. In addition to the major elements, the new APXS will also yield data of minor elements such as Na, P, S, Cl, K, Ti, Cr, Mn, and some trace elements such as Ni and Zn.

Expectation and preliminary results: It is thought that crater Gusev acted as settling pool for sediments carried by the water that cut Ma´adim Valley before it exited through the northern rim of the crater. However, it might well be that the expected fluvial sediments are overlain by younger volcanic units and their fragments, which are covered by aeolian layers.

The chemical composition of the soils analyzed by instruments of the Viking 1 and 2 Landers [3] and of the rover Sojourner of Mars Pathfinder [4] are very similar, indicating processes of an equatorially global homogenization. Soils from Gusev crater and Meridiani Planum – the first sites in the southern hemisphere – will add to or disprove this hypothesis.

Indeed, the first X-ray spectrum from rover Spirit (Fig. 1), measured for a period of 9.7 hours, shows intriguing similarities to the soil spectra of Pathfinder [5]. At Meridiani, the first APXS soil X-ray spectrum (Fig. 1) shows many similarities to the Gusev spectrum. Both soil measurements were carried out at a rather large distance between sensor head and sample surface. However, due to the excellent energy resolution (about 160 eV at 6.4 keV) at temperatures below -30 degree C and the rather long measurement times of several hours, peak areas for P, Ni and Zn could be well resolved.

Phosphorous could be evaluated with great difficulty in the Pathfinder soil spectra. A mean value of 0.4 ± 0.08 wt. % was calculated [5, 6]. The soils at Gusev and Meridiani have comparably high P contents (Fig. 2). Compared to Earth the Martian crust appears to be enriched in phosphorous. This is in agreement with the estimated high P content of the Martian mantle derived from the element correlation in basaltic shergottites [7].

The basaltic shergottites contain the moderately volatile element Zn in the range of 85 to 130 ppm. Because of the chemical similarity of basaltic shergottites and the Martian soil we expected a detectable Zn concentration in the soils of Gusev and Meridiani. Small Zn peaks were recorded at both landing sites.

The Gusev and Meridiani soil spectra reveal weak Ni peaks. Ni could be added to the Martian surface over time by impacts of meteorites. Lunar highland fines contain about 400 ppm Ni as a meteoritic component. However, Ni in the Gusev soil could also be derived from olivine, which was inferred from the Mössbauer spectra. During the last four years several olivine-phyric shergottites were recovered [8, 9, 10, 11, 12]. The Ni content of the olivine-phyric shergottites of about 250 ppm is enriched by a factor of 4 compared to the basaltic shergottites. On Earth the Ni content differs also between tholeiites and olivine basalts. However, the estimated Ni content of the Martian mantle of 400 ppm compared to the 2100 ppm Ni in the Earth mantle limits the Ni content in the Martian crust [7].

One feature of the Gusev soil X-ray spectrum is the obviously lower Ti content compared to the other known soils. This variable Ti content in the Martian soils is consistent with the proposition of McLennan

[13] of a fractionation of various titanium oxides (ilmenite, titanomagnetite) through sedimentological processes on the Martian surface. The lower content of Ti, Cr, Mn, and Fe in the Gusev soil could be explained by a fractionation of heavy minerals (ilmenite, chromite, titanomagnetite, magnetite) in the soil during the fluvial and aeolian transport on the Martian surface.

Conclusion and outlook: The first soil analyses from Gusev and Meridiani show similar compositions as found for Viking 1, 2, and Pathfinder landing sites, confirming an equatorially global homogenization of the soil by impact gardening and dust storms. However, local processes can change the ratio of heavy to light minerals. The higher K in Pathfinder soil might be related to the K-rich rocks in that area [5].

The first rock analyses in the Gusev crater will reveal the rock/soil relationship of this area. Combination of APXS measurements, brushing, and grinding by the RAT will provide insights into potential weathering products and allow the analyses of fresh clean rock material.

References: [1] Rieder R. et al. (2003), *J. Geophys. Res*., 108(E12), 8066, doi:10.1029/2003JE 002150. [2] Squyres S. W. et al. (2003), *J. Geophys. Res*., 108(E12), 8062, doi:10.1029/2003JE002121. [3] Clark B. C. et al., (1982), *J. Geophys. Res*., 87, B12, 10059. [4] Rieder R. et al. (1997), *Science*, 278, 1771. [5] Wänke H. et al., (2001), *Space Sci. Rev., 96*, 317. [6] Brückner J. et al. (2003), *J. Geophys. Res*., 108(E12), 8094, doi:10.1029/2003JE002060. [7] Wänke H. and G. Dreibus (1988), *Phil. Trans. R. Soc. Lond*. A 325, 545. [8] Grossman J. N. (1998), *Meteoritics & Planet. Sci.* **34**, A169. [9] Grossman J. N. (2000), *Meteoritics & Planet. Sci.* **35**, A199. [10] Grossman J. N. and J. Zipfel (2001), *Meteoritics & Planet. Sci.* **36**, A293. [11] Russell S. S. et al. (2002), *Meteoritics & Planet. Sci.* **37**, A157-. [12] Russell S. S. et al. (2003), , *Meteoritics & Planet. Sci.* **38** A189. [13] McLennan S. M. (2000), *Geophys. Res. Let*., 27, 1335.

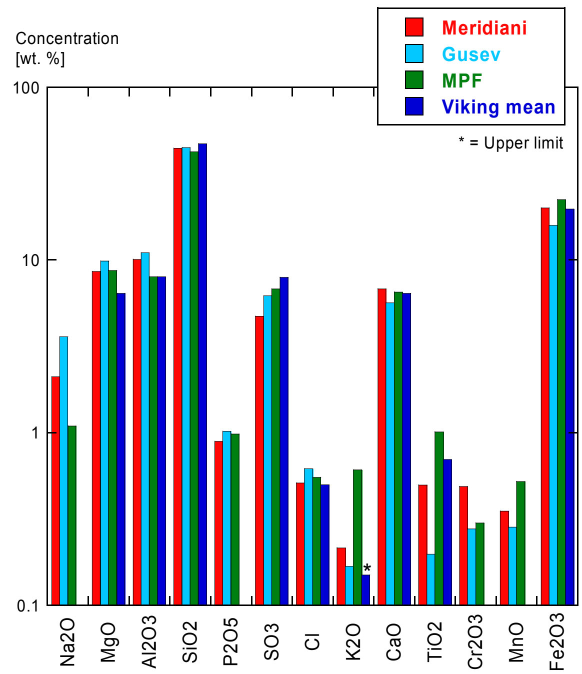

Fig. 2 Weight concentrations of oxides in Martian soils.

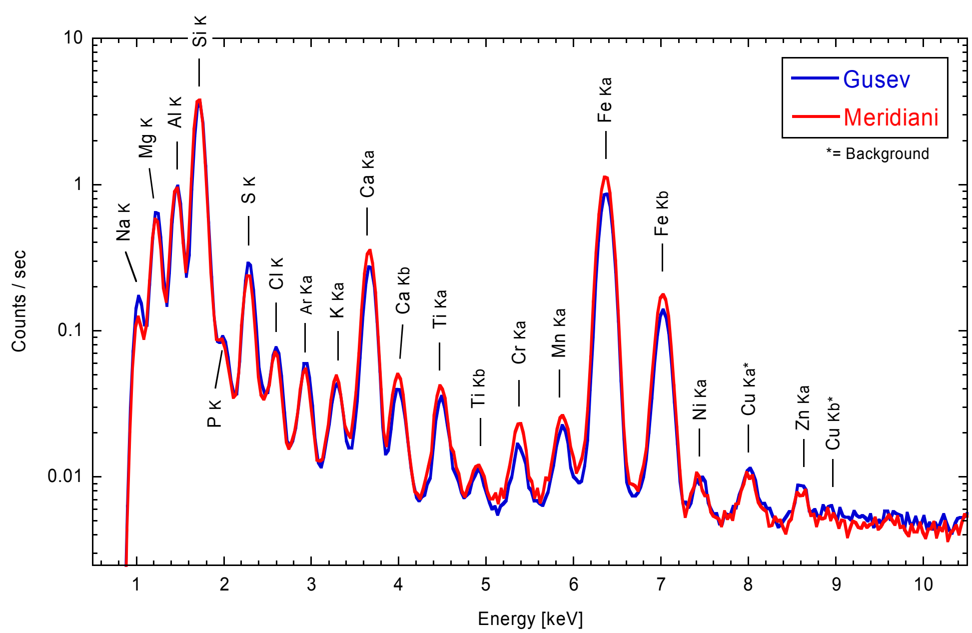

Fig. 1 APXS X-ray spectra of Martian soils measured at Gusev Crater (blue) and Meridiani Planum (red).