THE CHEMICAL COMPOSITION OF THE MARTIAN SURFACE. H. Wänke[1], J. Brückner[1], G. Dreibus[1], G. W. Lugmair[1], R. Rieder[1], and T. Economou[2], [1]Max-Planck-Institut für Chemie, P.O. Box 3060, D-55020 Mainz, Germany, e-mail: waenke@mpch-mainz.mpg.de [2]Enrico Fermi Institute, University of Chicago, Chicago, Il 60637, USA.

The Pathfinder mission yielded the first in situ analysis of the chemical composition of Martian rocks with the APX-spectrometer on the rover Sojourner. The preliminary data [1] indicated that the soil on Mars might be chemically homogeneous on a global scale as the Pathfinder soil is chemically almost identical to that at Viking 1 and 2 sites. The rocks embedded in the soil at the Pathfinder site turn out to be rather similar to each other but very different compared to the soil. In contrast to the mafic character of the SNC meteorites the Pathfinder rocks are felsic rocks, rich in SiO_2 and K and low in Mg. Hence, the consensus generally reached after the Viking soil analyses of a rather primitive and mafic composition of the Martian surface has to be put into new perspective.

More precise data were now obtained for minor elements. The recalculated data yield about 1 % K_2O for the rocks and 0.6 % for the soil samples. The determinations of the XRF-spectrometers on board of Viking 1 and 2 yielded only upper limits of 0.15 % K_2O [2]. We have no apparent explanation for this difference. Now we were able to also obtain reliable data on Mn and Cr which offer proof that the Pathfinder rocks exhibit the same elemental characteristics as known from the study of SNC meteorites.

As reported previously, the 5 rocks analyzed at the Pathfinder site (Barnacle Bill, Yogi, Wedge, Shark, and Half Dome) show sulfur concentrations between 0.3 and 1.6 %. This reflects the fact that all these rocks are partly covered by soil. Good linear regressions of the concentrations of each element versus sulfur were found and the composition of a ”sulfur-free rock” could be calculated. The extrapolation of the regression line of each element calculated for rock data points only, also matches the soil data points. Fitting rock and soil data points, the fit is best for Mg which might indicate that sulfur in the soil is in part present in form of $MgSO_4$ (Fig. 1).

Both sulfur and chlorine dominate in the soil. But now it became evident that even rocks with no adhering soil (sulfur-free rocks) show enhanced chlorine concentrations of about 0.25 % (Fig. 2). Such high chlorine concentrations are outside the range observed in most terrestrial igneous rocks. At a first glance this might be taken as evidence of a sedimentary origin. It may also be that the chlorine sits in veins due to infiltration of water from the early northern ocean [3 and 4]. Pathfinder rocks compositionally match terrestrial andesites. This seems now even be true for chlorine. The recently discovered magnetic features [5] on Mars point to crustal spreading. On Earth chlorine in andesites (up to 0.15 %) is directly related to the involvement of seawater in their genesis. Is there an analogous mechanism indicated for the SiO_2 rich Martian rocks?

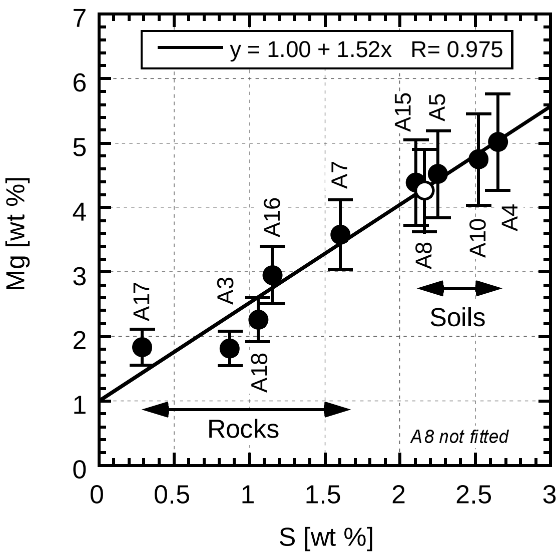

Fig. 1 Correlation of magnesium versus sulfur for Pathfinder rocks and soils.

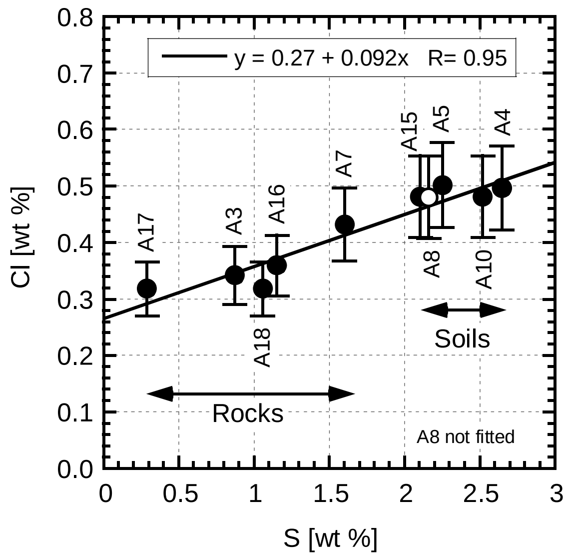

Fig. 2 Correlation of chlorine versus sulfur for Pathfinder rocks and soils.

Finally, we note that high chlorine concentrations in igneous rocks derived as partial melts from the Mars mantle might be expected due to two reasons. First, the chlorine abundance in the Martian mantle seems to exceed the terrestrial values by about a factor of 3 [6]. Second, on the Earth the main reservoirs of chlorine are the oceans which accumulated (over the age of the Earth) all the chlorine extracted from the mantle [7]. Contrary to other highly incompatible elements, chlorine is recycled back to the mantle to a small degree, only. Hence, in the absence of long lasting oceanic reservoirs on Mars most of the total chlorine might have remained in the mantle at the time of the extraction of the melt which formed the Pathfinder rocks, in the case they are igneous rocks.

As indicated above, the 5 rock samples are very similar in composition within our limits of uncertainty. The element Ca, for which the highest variations were found, may be an exception. For the K-Ca plot (Fig. 3) we corrected each rock for adhering soil by subtracting an amount of mean Pathfinder soil equivalent to the rocks's sulfur concentration. It is evident that calcium in these rocks is anticorrelated with potassium and, hence, might reflect a variation in the mineral content.

With the assumption that the soil data reflect the mean composition of the Martian surface, a mixing diagram with the mean composition of Pathfinder rocks as felsic end-member and the mean composition of all SNC meteorites as mafic end-member was derived (Fig. 4). Surprisingly good fits of the mixing lines were found for all elements considering this rather crude approach, which neglects other possible components as well as possible sample alterations. The mixing diagram indicates that the felsic component and the mafic component contribute about equally to the Martian soil. We suspect that this also reflects the abundance ratio of the two major provinces on the Martian surface. The southern highlands could be the home of the felsic, highly fractionated component while the mafic, more primitive component, is probably derived from the younger volcanic provinces like the Tharsis region.

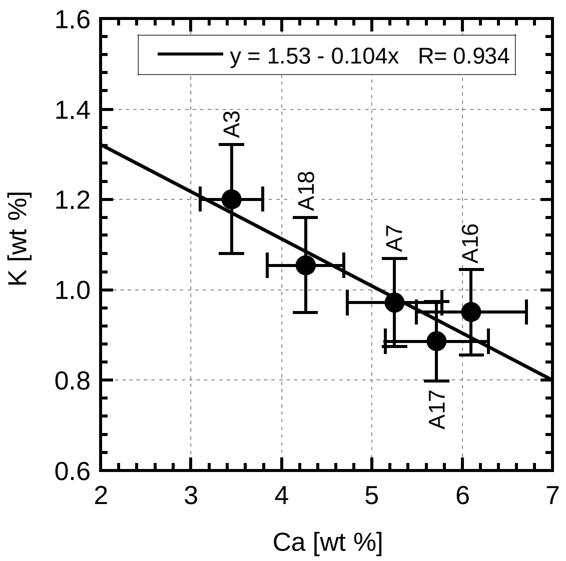

Fig. 3 Correlation of potassium versus calcium for Pathfinder rocks.

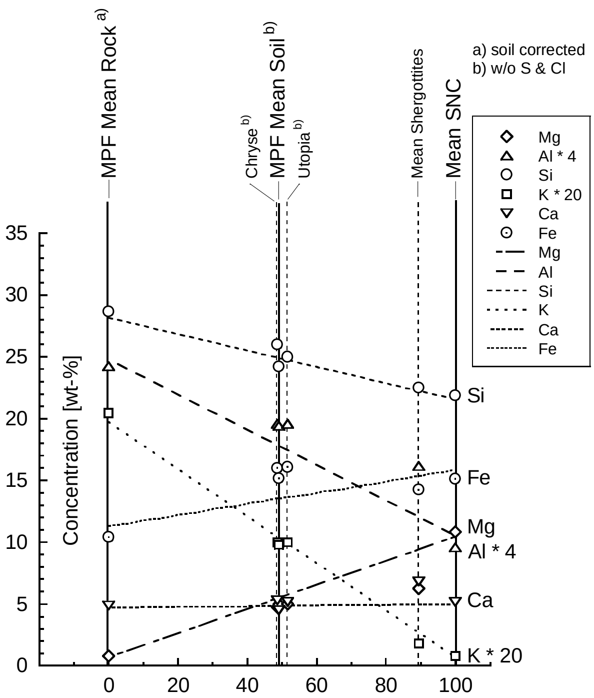

Fig. 4 Mixing diagram for Martian surface components.

To obtain data on chemical composition of larger areas, we have to wait for the results to be obtained by the gamma-ray spectrometer of the Mars Surveyor 2001 orbiter. The anticipated maps of chemical composition should reveal the rather huge differences of the potassium concentrations in the felsic and mafic areas even if the signal will be dominated by the soil component in each location.

References:

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