**ON THE GEOCHEMISTRY OF SOILS AT GUSEV CRATER AND MERIDIANI PLANUM, MARS: SIMILARITIES AND DIFFERENCES.** J. Brückner[1], I. Fleischer[2], R. Gellert[3], G. Klingelhöfer[2], Athena Science Team, [1]Biogeochemistry, Max-Planck-Institut f. Chemie, Mainz, Germany, j.brueckner@mpic.de [2]Institut f. Anorganische u. Analytische Chemie, Mainz, Germany, [3]Dept. of Physics, University of Guelph, Guelph, On, CA.

**Introduction:** The NASA Mars Exploration Rovers (MER) Spirit and Opportunity landed on Mars in 2004, Spirit at site A (Gusev Crater) and Opportunity at site B (Meridiani Planum), 180 degrees apart. They have now been working for more than 6 and 7 terrestrial years, respectively. Numerous soils were investigated by the two rovers along their 7 and 25 kilometers long traverses, respectively. In-situ measurements were made on undisturbed soils (SU) and soils disturbed by rover wheels (SD) using the Alpha Particle X-ray Spectrometer (APXS) to determine their chemical composition [1] and the Mössbauer Spectrometer (MB) to provide data on their iron mineralogy [2]. The Microscopic Imager (MI) provided information on the texture of the soils. These and images by the Panoramic Camera and data from the Mini-TES are reported elsewhere.

The martian soils are surficial deposits that are formed by a variety of geological processes, such as impacts, weathering, volcanic activities, aeolian and subsurface processes [3, 4].

**Data:** The Mg/Si versus Al/Si ratios of most of the soil samples fall in a relatively small field except for a few samples (Fig. 1) indicating similar chemical compositions of the soils at both landing sites. The B soils have somewhat lower ratios than the A soils (see blue oval). Some SD soils deviate very much from the "parent cluster", which are those soils that were modified by special aqueous processes in the subsurface [1] and, hence, show strong enrichments of one or more of the elements Mg, Si, P, S, or Cl (not shown here). In general, site B soils have higher Fe concentrations compared to site A ones.

The compositions of the SU and SD soils are mainly a product of weathering of rocks, formation of grains, and subsequent transportation of dust. Saltation of sand is an effective means for raising dust into the atmosphere under wind speeds, which would otherwise be too low for grain transport [5]. Thus, large areas can be the source of saltating sand, which gradually averages the soil composition of a whole region. Interestingly enough, regional averaging of site A and B produces similar soil compositions in spite the fact that they are located on opposite sides of the martian globe.

APXS and Mössbauer data revealed the occurrence of iron-rich spherules, also called blueberries [1, 6]. Iron/Mn concentration ratios act as planetary fingerprints as long as Fe is dominantly $Fe^{2+}$. In Fig. 2, Fe/Mn ratios are compared with hematite contents

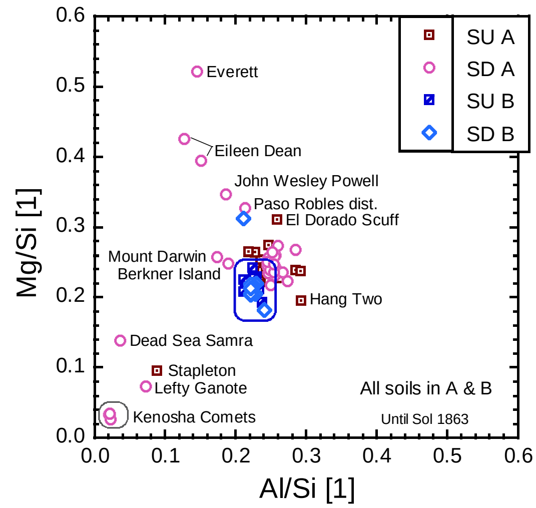


Figure 1: Concentration ratios of all soil samples (up to sol 1863) of two types (SU, SD) in the two sites A and B. The SU B samples include hematite-bearing material.

determined at different Meridiani locations, such as outcrops, soils, and rocks. The mean of shergottites and normal Gusev soils may indicate the global variation of Fe/Mn ratios varying between 40 and 50. Samples with many spherules in the field of view of APXS and MB have high Fe/Mn ratios (enrichment of Fe, only) and high hematite contents. However, in Meridiani outcrop samples the Fe/Mn ratios are comparable to the global mean value, while their hematite contents are elevated (though no spherules in the field of view). This points to the fact that formation of the hematite in the outcrops did not involve differential movement of Fe and Mn ions, except for formation of spherules.

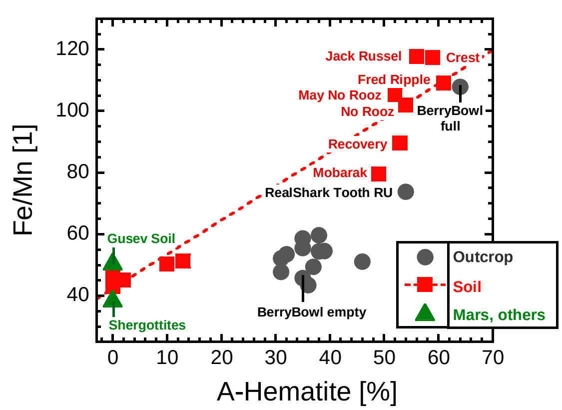


Figure 2: Fe/Mn ratios vs. A-Hematite (percentage of total Fe in the mineral hematite) from different Meridiani samples (outcrops, soils), mean of shergottites, and mean of normal Gusev soils.

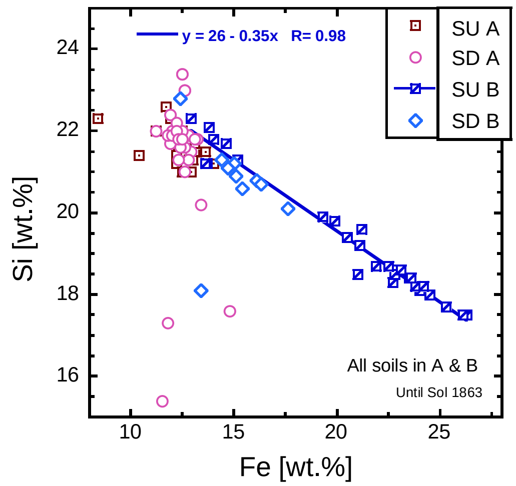


Figure 3: Concentrations of Si and Fe (in weight percent) for all soil samples. The trend line of the SU B soils can be interpreted as a dilution of Si by Fe.

The difference in Fe contents for site A and B is due to the occurrence of mm-sized hematitic spherules, which by virtue of their size and high density cannot be transported long distances by martian winds. These spherules were formed by an isochemical process inside the vast sediments and subsequently weathered out of their host material [R04]. Hence, the heavy spherules are responsible for the local enrichment of Fe. The Meridiani sedimentary rocks with up to 10 wt.% S are the substrate below the soils over many kilometers, yet the soils of Meridiani show the average S content of Gusev soils (and other martian soils).

The occurrence of elevated Fe contents in the site B soils results in an excellent trend line of Fe and Si

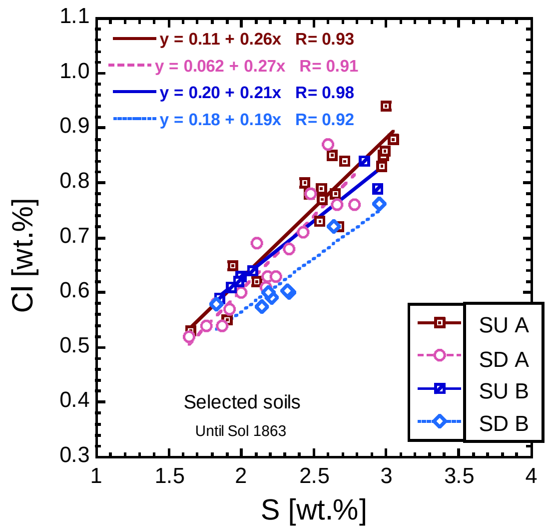


Figure 4: Chlorine vs. sulfur for selected soil samples of two types. The trend lines of the SU and SD soils in site A are very similar (same slopes). Both site B lines have similar slopes, but different intercepts.

contents indicating the dilution of Si by Fe (Fig. 3) and other related major elements, such as Mg, Al, and Ca (not shown). This clearly reveals the effect of hematite spherule contributions to the soils.

Other types of contributions to the soils can be seen by the occurrence of sulfur and chlorine. These two very volatile elements originally stem from volcanic exhalations [1]. Today, they exhibit similar trends at both MER sites (Fig. 4). For SU and SD soils at both landing sites, all four correlation parameters R are very good (R> 0.9) with slopes and intercepts of the SU and SD trend lines that are rather similar at each site, respectively. The two sites have comparable Cl-S trend lines in spite the large distance between them. This observation points to a mechanism that provides S and Cl in similar ratios to these two sites and by inference to most other places on Mars, too. One possible mechanism is that that S and Cl may reside on phases that are very fine, easily air-borne, and thus distributed globally via large dust storms. By comparing the nanophase ferric iron oxide (npOx) component of the Mössbauer spectra [7], a weak correlation (R~0.6) between npOx and S and Cl can be observed (not shown), hence, npOx could be a carrier of S and Cl to some extent. In this way, S and Cl are globally distributed by periodic large dust storms, which only can transport very fine material (grain size in the lower micrometer regime) over global distances [3, 1, 8]. The outcome of these weather events can be best seen at the rather constant ratio of Cl and S at both MER sites.

**Conclusions:** There is general similarity in the composition of the soils at Gusev crater and Meridiani Planum. This reveals that the surrounding regions seem to have very comparable compositions. Excluding Cl and S, the soils have a basaltic or mafic composition [9, 3], probably representing the general crustal composition of Mars [1, 8]. A strong distinction is caused by the occurrence of hematitic spherules at Meridiani, only. A striking similarity is seen for chlorine and sulfur ratios that seem to have a global distribution caused by large dust storms at the surface of Mars.

**References:** [1] Brückner J. et al. (2008) In: The Martian Surface (Ed. J. Bell), Cambridge University Press, p. 58. [2] Morris R. V. et al. (2008) In: The Martian Surface, Cambridge Univ. Press, p. 339. [3] Yen A. S. et al. (2006) JGR, 111, E12S11. [4] McLennan S. M. (2010) Fall Meeting AGU, Abstr. P51F-01. [5] Greeley R. (2002) Planet. Space Sci., 50, 151-155. [6] Morris R. V. et al. (2004) Science, 305, pp. 833 - 836. [7] Morris R. V. et al. (2006) JGR, 111, E02S13. [8] McSween H. Y. et al. (2010) JGR, 115, E00F12. [9] Rieder R., et al. (2004) Science, 306, 1746.