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SYNTHETIC MARS ANALOGUE MATERIALS

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For most planetary investigations only remotely sensed or robotic lander data are available. With the exception of meteorites, the Moon is the only celestial body, from which material was brought into terrestrial laboratories, up to now. For the correct identification of the extraterrestrial materials, comparisons with terrestrial analogue materials are absolutely necessary. From former Mars missions several well defined material properties of the Martian surface soil are known: bulk chemistry (*Viking, Mars Pathfinder*), vis/NIR reflectance spectra (*Mars Pathfinder, Phobos 2*, ground-based telescopes), grain size limits (*Mars Pathfinder*), specific surface (*Viking*), thermal emission spectra (TES on *Mars Global Surveyor*). Mössbauer spectroscopy – a part of *Beagle 2* (lander of ESA´s Mars Express mission) – will provide useful data on oxidation states in addition to existent vis/NIR reflectance spectra [1]. From reflectance studies at the *Pathfinder* landing site [2] it was found that almost all iron in the Martian dust or soil occurs in oxidation state III (Fe^{3+}/Fe^{2+} = 20–3), which is in contrast to oxidation states of Martian andesites (Fe^{3+}/Fe^{2+} = 3–0.7). Obviously, oxidation occured during soil formation. The mineralogy of the weathering products is hardly known. Studies of multispectral properties argue for hematite and nanophase goethite. Maghemite, akaganeite, schwertmannite, and nanophase lepidocrocite are also possible interpretations for Martian ferric weathering minerals [2]. Mg-sulphates, chlorides and clay minerals are additionally regarded as weathering phases [3, 4, 5].

The synthesis of analogue mixtures may give insight on formation processes of Martian surface materials. Provided that the condition of formation of the terrestrial analogue materials is known properly, this could lead to a better knowledge of the formation of these materials on other planets. In this context it is important that the co-genetic mineral-paragenesis is considered as an integrity.

Hence, the search for numerous planetary analogue sites on Earth is an important task in comparative planetology [6]. Further, appropriate analogue materials in planetary simulation experiments could reveal processes, which are not only important for the understanding of the planet of interest, but also for the solar system in general. To decide between natural and synthetic phase mixtures in analogue mineralogy, one has to take under consideration the aim of each experiment. The advantage of nature-sediments is the possibility of cheap delivery of large amounts of soil. The disadvantage is the uncertainty in characterising of natural soils (not useful e.g. in quantitative adsorption-experiments and other experiments with high or even unknown complexity) and the (recent) difference in soil-forming-processes between Earth and Mars. Synthetic mixtures may nicely complement natural materials. An advantage of synthetic materials is the possibility of fine-adjustment of their components and therefore the evaluation of their influence. The physico-chemical properties of the prepared material can fit as much as possible the observed data from space missions. The synthesis of analogue materials may be adjusted to the kind of experiments and the complexity of the desired information. To define and characterise analogue materials, several analytic techniques are necessary: chemical analysis (XRF), X-ray diffraction (XRD), diffuse reflectance vis-NIR-spectroscopy, FTIR-spectroscopy, Combustion Analysis, Mössbauer spectroscopy, grain size analysis, Scanning Electron Microscopy, nitrogen desorption and adsorption experiments (pore volume and specific surface area), etc.

We prepared synthetic mixtures of synthetic rock glass powder with - partly nanophased - ferric oxides, sulphates, chlorides and clay minerals. The synthetic rock glass matches the chemical composition of Martian fines diminished by anticipated weathering phases. Additionally, the oxidation state of iron was adjusted to different levels by means of glass synthesis under controlled oven atmospheres. Comparisons with data from the Martian surface and other analogue materials will be shown. Especially, vis/NIR Reflectance and Mössbauer Spectroscopy results are considered.

References

[1] KLINGELHÖFER, G. ET AL. (1996): Mineralogical analysis of Martian soil and rock by a miniaturized back-scattering Mössbauer spectrometer. - Planet. Space Sci., 44, 11, 1277-1288.

[2] MORRIS, R. V. ET AL. (2000): Mineralogy, composition, and alteration of Mars Pathfinder rocks and soils: Evidence from multispectral, elemental, and magnetic data on terrestrial analogue, SNC meteorite, and Pathfinder samples. - J. Geophys. Res., 105, 1757-1817.

[3] TOULMIN, P. ET AL. (1977): Geochemical and Mineralogical Interpretation of the Viking Inorganic Chemical Results. - J. Geophys. Res., 82, 4625-4634.

[4] McSWEEN JR., H. Y. & KEIL, K. (2000): Mixing relationships in the Martian regolith and the composition of globally homogeneous dust. - Geochim. Cosmochim. Acta, 64, 2155-2166.

[5] WYATT, M. & McSWEEN JR., H. Y. (2002): Spectral evidence for weathered basalt as an alternative to andesite in the northern lowlands of Mars. - Nature, 417, 263-266.

[6] KOLB, C. ET AL. (2001): Mineralogy of Mars Soil Analogue material. - IWF-137, 50 pp.