MARTIAN DUST AS AN END-MEMBER OF SEMI-COSMIC WEATHERING

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Introduction. On the Earth now there are no conditions for weathering processes typical for the Mars. That is why minerals analogous to Martian weathering products are not formed in natural conditions of the Earth.

On the Earth, the main active weathering agents over millions years are atmospheric factors. And terrestrial water is so far the main "reactant" of chemical weathering of natural and artificial rocks. It is quite possible that through millions years the Earth surface will be covered by products of both the rock destruction and the weathering of rocks and artificial materials.

Millions years of environmental activity have also covered the Martian surface with products of rock weathering taking place for a long period and now without liquid water, at hard ultraviolet irradiation and low atmospheric pressure [1]. The main and long-term factor of Martian weathering is not chemical, i.e. water, but physical – cosmic radiation, particles, meteorites etc. End-products of the Martian weathering are on the Martian surface or have been carried away in the space.

Hypothesis. The Martian dust can be considered as a product of semi-space weathering of the planet surface. For example, the Moon surface is known to be exposed to hard space weathering because of absence of atmosphere. The Martian surface is protected by certain atmosphere and exposed to lesser space weathering called the semi-space one. The space weathering includes dehydration, oxygen removal from compounds or reduction and fully occurs in a surface layer of objects being in the open circumsolar space. A chemical oxygen-metal bond is broken off due to space wind resulting in formation of new minerals such as Hapkeite – Fe_2Si [2].

Subtraction of oxygen from a terrestrial mineral called fayalite ($2FeO*SiO_2$) results in a new stoichiometry corresponding to the oxygen-free lunar Hapkeite. As for the Mars, its superficial mineral layer is exposed to a “weaker” variant of space weathering. This feature can explain the absence of simple terrestrial analogues and difficulties with their simulation in laboratory condition.

Initial data. We used IR spectra of rocks, dust, and the Mars surface received by devices fixed on satellites and rovers as initial data. They were compared with IR spectra of terrestrial natural and artificial rocks, sedimentary deposits, clinker minerals, and refractors.

Preconditions. As is known, transition IR spectra of silica have features which make it possible to distinguish crystal and amorphous silica forms such as silicagel, zeolite, kizelgure. On the other hand, Martian hematite has been identified due to following spectral signs: the absence of absorption typical for Si–O–Si bounds and the presence of two absorption peaks typical for iron oxide (III) [3].

It is well known that absorption peaks in the range of 800 – 900 sm^{-1} are characteristic for bounds of X–O–Fe, X–O–Al types, for example, Fe–O–Al, Ca–O–Al, Mg–O–Fe. Absorption peaks corresponding to these bounds are observed in the IR spectra of terrestrial spinels, clinker minerals, refractory.

Discussions. The sharp double peak between 780 – 800 sm^{-1}, which is typical for IR spectra of crystal silica is practically absent in the IR spectra of Martian surface and dust [4]. It indicates on prevalence of amorphous forms of silica in planet surface materials. In all spectra designated or derived as Martian dust spectra one can see a peak of characteristic absorption in the range of 840 – 850 sm^{-1} and no peaks typical for absorption of Si–O–Si bounds [5,6].

IR spectra of Martian dust includes absorption peaks typical for–O–Al–O–Fe– or O–Fe–O–Ca(Mg)–O bounds corresponding to compounds similar to amorphous spinels (aluminum or ferrite spinels). For example, in terrestrial conditions green $FeAl_2O_4$ – Hercynite is formed in a thin interface layer of refractory in the process of steel melting. An analysis of IR spectra of rocks and their RAT-fines indicates that composition of a top layer of rocks is close to that of dust. The deeper layer of rocks contains silica compounds and can be considered as residue of Martian weathering.

To summarize the above, under the influence of hard semi-cosmic weathering in surface layers of Martian minerals there is a “deoxygenation” process, i.e. partial removal of oxygen from chemical bounds and, respectively, changes in the chemical composition of compounds. This process of semi-cosmic weathering is not identical to Lunar space weathering but results in formation of Martian dust as an end-member of this weathering.

Conclusions. The Martian dust is not silica but a compound close to terrestrial amorphous spinel’s minerals such as Hercynite, spinel ferrites. There are no sands similar to terrestrial ones on the Martian surface. Martian silica is amorphous modification of silica similar to silicagel.

The semi-cosmic (with hard UV participation) weathering prevails on Mars. It affects the mineral surface by both ways: reduction (in the top layer) and oxidation (in the deeper layer). The spectra under consideration are an additional evidence of the thermal shock hypothesis.

References: [1] Bandfield *et al.* (2000) *Science*, *287*, 1626-1630, [2] M. Anand (2003)*LPSC XXXIV*, #1818, [3] Christensen *et al*. (2001) *JGR-Planets*, *106*(E10), 23823-23871, [4] Bandfield *et al.* (2003) *Science*, *301*, 1084-1087,[5] Christensen *et al*. (2004b) *Science*, *306*, 1733-1739, [6] Hamilton and Christensen (2005) *Geology*, *33*,