

AN EARTH SEDIMENTARY DEPOSIT AS ANALOGUE TO MARTIAN: THE COMPARISON OF IR-SPECTRA

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Introduction. Sedimentary deposits of rock planets in our solar system can have similar chemical composition and spectral characteristics in case of similar conditions during their formation, accordingly, transformation and decomposition. It can be useful to analyze spectral peculiarities and similarities of end products of transformation and decomposition of Earth sedimentary deposits and Martian.

On the territory of modern Belarus (in the Mogilev region) on the bottom of an ancient sea a sedimentary deposit – trepel (similar to the deposit Tripoli), was formed during cretaceous period. This sedimentary deposit is studied with the practical purposes. And it was used to find spectral similarities and spectral features in comparison with IR-spectra of the Martian surface components. Different trepels vary in chemical composition. The trepel extracted in Belarus includes amorphous SiO_2 20 – 30 %. It includes zeolites 20 – 22 %, crystalline SiO_2 about 2 %, CaCO_3 from 18 to 25 %, clays (montmorillonite) up to 20 %, oxides and compounds of iron from 7 to 15 %. Also it includes oxides and compounds of magnesium, aluminum, titanium, chromium and other elements.

Methods. Taking into account that scientists have received infrared Martian spectra that have a global character [1] and spectra from the local view, for the comparative qualitative analysis, correspondingly, two directions has been chosen. A comparison of the spectra received by different instruments is based on the presence in the analyzed emission spectra of some transmission part of infrared radiation. The global emission spectra may include several components and one of them is a transmission component, because thermal waves pass through atmosphere and surface substances [2]. The free presented (by JPL and ASU sites) emission IR-spectra of dust and surface (TES MGS) and spectra of Martian rocks named EI-Capitan, Bounce rock, Mazatzal and Humphrey (Mini TES) were compared consistently with several transmission IR-spectra received in the laboratory using KBr pellets method. For the comparative analysis the transmission IR-spectra of initial and experimentally processed samples of Earth sedimentary deposit – trepel and spectra of the artificial materials (cements, brick, concrete) were selected and four groups from these spectra were formed (fig. 1-4) being guided by [4] and other works.

Spectra description and comparison. Two top spectra of the Martian surface and dust in the fig. 1 are copied from free Internet data. Both spectra were received from the orbital instrument – TES MGS (ASU data). Such global spectra average the emission characteristics of certain surface area. For comparative qualitative analysis below two spectra of Martian substances seven transmission spectra are placed. The spectrum 3 presents spectral data of the sample of the standard white silicate brick after it was exposed at temperature 1100°C. The spectrum 4 was received by using of an artificial rock hand made from clay with addition of carbonates of magnesium and calcium. This rock also was exposed at temperature 1100°C. The spectrum 5 shows the data of a new artificial rock made from high pressed powder of trepel. The spectra 6 and 7 were registered by using of two probes of gray cement: one of them after processing by hot water and the second without processing but by long time exposing in the air. The spectral curve 8 shows a spectral peculiarity of the silicon dioxide mixed with a hard hydroperoxide salt. The spectrum of this peroxide salt of sodium has the number 9. The analysis of the ranges 1100 - 1000 and 1000 - 800 cm^{-1} reveals many common compounds appearing during high temperature action (similar to calcinations at clinker production)

and hydration. On the Martian surface such macro processes could occur that could lead to high temperature clinkering of the sedimentary deposits, later processes of hydration and more hard actions by hydroperoxides could occur.

The top spectrum 1, the fig. 2, was by the Mini TES instrument obtained from the Martian rock named EI-Capitan. Number 2 is the spectrum of the calcinated (at 1100°C) stone made from powdered and humidified trepel. The spectrum 3 shows changes and differences caused by the four times humidifying during heating of the similar stone from trepel. The spectrum 4 was received by using the stone, that was hand made from clay and calcinated (950°C). The spectrum 5 belongs to white porcelain. The spectrum 6 is the spectrum of a product from the trepel (made in Russia) where amorphous SiO_2 makes more than 90 %. Spectra 7 and 8 shows changes which occur during the action of different temperatures (550°C and 1100°C accordingly) on the trepel stone that was made by using of water containing organic substances (proteins and carbohydrates). The spectrum 9 shows the spectral peculiarity in the range 1300 - 1100 cm^{-1} that characterize pure amorphous SiO_2 that is a deposit formed from armours of diatom's seaweeds. This deposit (of SiO_2) included water earlier before natural and following artificial drying.

The comparison of the EI-Capitan spectrum with spectra of trepel stones and materials shows that Martian rocks could be subjected to such actions that could lead to the processes of ceramization. Subsequently the repeating actions of salt water solutions were possible. At calcination of wet artificial stones, that were made from clay and trepel, at free access of air (into the laboratory muffle) a superficial top layer such as crust (1-2 mm thickness), colored differently from inside part, was appearing on the stones top surface. Such process can be explained by prevalence of oxidizing processes in leaky top layers.

Spectra, included in the fig. 3, show that Bounce rock (1 and 2), may consist from a mixture of hydrated silicate compounds like ettringite (FTIR-ATR spectrum 3 from IJVS), products of its decomposition (FTIR-ATR spectrum 4 from IJVS) and also calcium or magnesium silicates. The trepel stones, calcinated at 1100°C (the spectrum 5), contain calcium (and magnesium) aluminosilicates but much less than Bounce rock because of great quantity of SiO_2 . The synthesis of the magnesium aluminosilicate can be noted in the spectra 7 and 8 (between 840 - 790 cm^{-1}). They show changes that appear during heating at 550°C and 1100°C accordingly in artificial stones (that were made from clay with the addition of magnesium carbonate). The spectrum 6 shows a presence of calcium silicate (the smooth peak near 900 cm^{-1}) and the rest of hydrosilicates (the characteristic peak of OH-groups at the 1000 cm^{-1}) in the concrete made in the laboratory and processed at high temperature (increasing up to 1100°C).

The fig. 4 presents spectra of the ferrite Martian rocks named Mazatzal (1), Humphrey (2) and three pattern spectra of the transmission (di-calcium silicate 3, three-calcium aluminate 4, tetracalcium aluminoferrite 5). The differences between laboratory transmission spectra are placed below. The latter were calculated to determine the regions that were caused by the appearing of aluminates or silicates in the composition of calcinated stones. The spectra difference 6 is received by subtraction of the spectra of the trepel stone calcinated at 550°C from the spectrum of the trepel stone, calcinated at 1100°C. The difference 7 was received by subtracting from the spectra of the trepel stone (at 1100°C) from

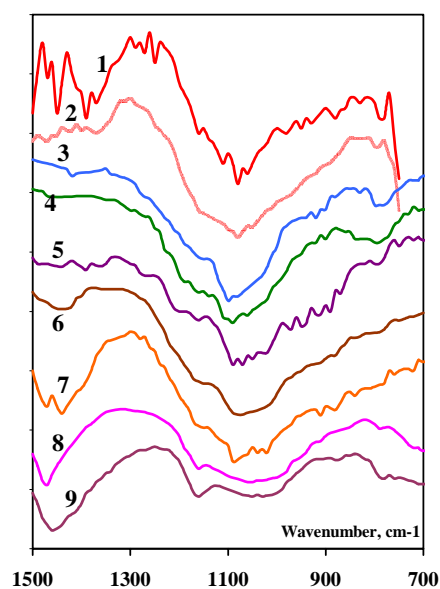


Fig. 1

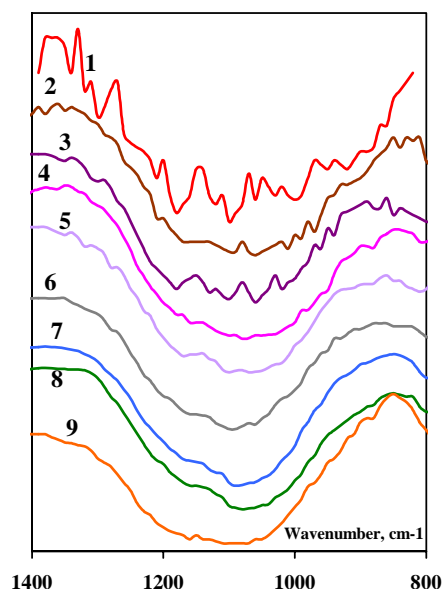


Fig. 2

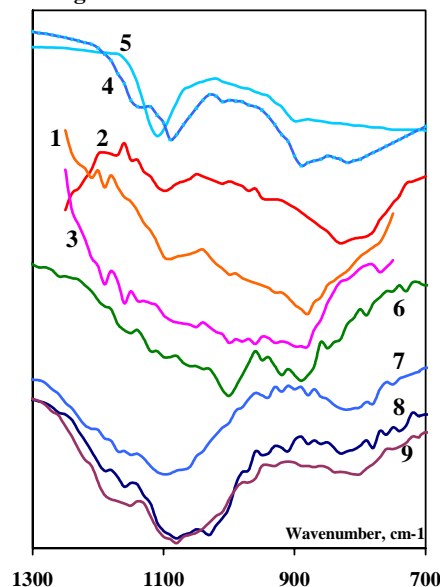


Fig. 3

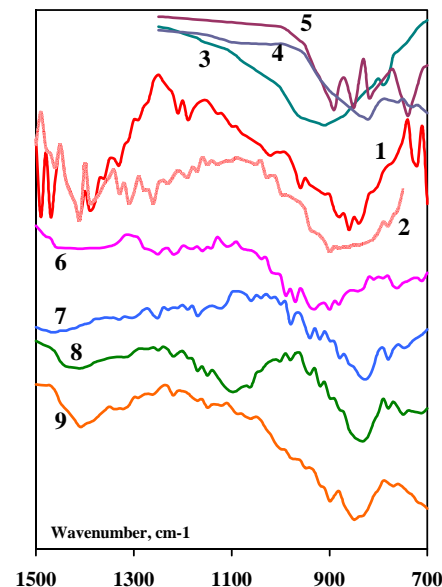


Fig. 4

the spectrum of the initial trepel powder. It shows the appearance of certain ferrite part in the spectrum of the trepel stone (rich by Fe-compounds). The spectra difference 8 is calculated from the spectrum of the calcinated trepel stone and the spectrum of the silicate base (the kieselgure). And the curve 9 is derived as the difference between the spectra of the silicate of iron (it was synthesized in a mixture using kieselgure) and the pure silicate base (of the same kieselgure). Comparing data it could be supposed that Martian rocks Mazatzal and Humphrey show not only the iron oxides and silicates [3] but the presence of aluminates as well, in particular the aluminate of iron ($830 - 850 \text{ cm}^{-1}$).

Conclusions. Chemically active compounds, appearing during artificial or natural high temperature processing of the sedimentary deposits in the rock form, cause the synthesis of silicates like to olivines, aluminates like to spinels and aluminosilicates that can be similar to components of clinker or ceramics phases. There can also appear compounds chemically stable that can be accumulated by circling processes, repeating actions of temperature and water. Compounds, again synthesized from sedimentary deposits, can be considered as artificial or natural secondary minerals. At high

temperatures from clay, morphous silica, carbonates as secondary minerals could be synthesized Mg-, Fe-, Ca-silicates and aluminates, spars, mullite, ettringite in case of water sulfates actions.

The part of Martian rocks are outcrops of the sedimentary deposits that could be subjected to action of high temperatures [5], water solutions and then to following prolonging weathering. Now they are being weathered too and decomposed and scattered in aluminates and silicates. On the rocks surfaces the aluminates are prevailing. In a loose the hydrated silicates pass, loosing water under hard UV-action and dispersing around as Martian dust.

Estimating end-products and spectra it can be supposed the main global thermal, most probable, explosive event occurred on Mars for a long time ago and in presence of oxygen and water.

References. [1] Bandfield J.L. et al. (2000) *Science*, 287, 1626-1630. [2] Harry Y. McSween Jr., Victoria E. Hamilton, and Bruce W. Hapke (2003) LPSC XXXIV #1233. [3] V. E. Hamilton and P. R. Christensen (2004) LPSC XXXV #2131. [4] Bell, J.F. et al. (2000) *JGR*, 105, 1721-1755, [5] D. L. Blaney LPSC XXIX #1655.

Acknowledgements. I thank to my adviser Prof. Bruce Hapke, my chief Prof. P.I. Markov and to the "opportunity" to work for Mars.