ZEOLITES - FATE OF MARTIAN WATER? P. J. Jakes and D. Rajmon, Charles University, Faculty of Science, Institute of geochemistry, mineralogy and mineral resources, Albertov 6, 128 43 Prague 2, Czech Republic; E-mail: jakes@mail.natur.cuni.cz, rajmon@mail.natur.cuni.cz

Terrestrial volcanism and consequent low temperature alteration are used as an analogy for the model of partial loss of water from the hydrosphere and atmosphere of Mars. Infall of pyroclastic products associated with basaltic volcanism causes the formation of zeolite type minerals and loss of water into zeolite structure.

During the development of microscope with the reflectance spectroscopic capabilities for Martian surface, we have found that suggested minerals and their compositions and reflectance spectra of the Martian surface (pyroxenes, clay minerals, feldspar) do not match the actually measured values (Banin et al., 1992; Clark, 1993). We have therefore examined the other „possible“ mineral groups that could have been formed at surface of the Mars and that could have been responsible for the volatile interaction of the atmosphere and the crust. Zeolites appear to be suitable candidates.

The presence of the water at Mars surface in past seems to be firmly established (Clifford, 1993; Carr, 1995). Major arguments are in the morphological features of the Martian surface as well as in the isotopic composition of volatile phase, derived from SNC meteorites. The cause of absence of water at recent surface and in the recent atmosphere is less well established. It is generally accepted that freezing of surface and atmospheric waters forming the permafrost layer is responsible for the loss.

The isotopic evidence (e.g. Jakosky and Jones, 1997) suggests the intensive interaction of Martian crust (rocks) and volatiles (water). The processes are viewed in terms of hydrothermal activity. Though the knowledge of the Martian volatile system is incomplete, this activity could be a cause of the loss.

We argue that water-rock interaction forming zeolites could explain the absence of water at surface, and that the large part of the water is bound in zeolite structures, and that zeolites form substantial part of Martian surface.

In the terrestrial conditions the zeolites are very common minerals. They form as products of a hydrothermal alteration of different types of volcanic rocks that are formed through infall of pyroclastic material into water reservoirs. Zeolites may also crystallize as authigenic sedimentary minerals in a deep sea or in lakes, or as a products of diagenesis or low pressure and low temperature metamorphism. Almost all zeolites can be produced by hydrothermal alteration of basic lavas and tuffs (Gottardi and Galli, 1985). The terrestrial examples suggest that infall of basaltic ash into warm lakes produces zeolites.

A natural zeolite is a framework alumino-silicate whose structure contains channels filled with water and exchangeable cations. Ion exchange is possible at low temperature (100°C at the most) and water is lost at about 250°C and reversibly re-adsorbed at room temperature. These features may have played an important role at Martian surface. The general formula for natural zeolites is

$$(Li, Na, K)_a(Mg, Ca, Sr, Ba)_d[Al_{(a+2d)}Si_{n-(a+2d)}O_{2n}]\ .\ mH_2O$$

where the part in square brackets represents the framework atoms and the part outside the square brackets represents the extraframework atoms, cations plus water molecules. This formula allows an enormous mineralogical variability within the zeolite family and also within a single zeolitic species (Gottardi and Galli, 1985).

Stratigraphical studies of Martian surface suggest that marine environment may have periodically existed on Mars. The total volume of volcanic material produced through Martian history was estimated to be 6.88×10^7 km^3 (Greeley and Schneid, 1991). This is rather conservative value comparing to other authors and the estimates of total volume of magmatic products are comparable to the size of the crust. The amount of volatiles exsolved from magmas during Martian history, would be about 100 times smaller than the volume of magmatic products. Clifford, 1993 estimates that the northern hemisphere ocean was 10^2-10^3 m deep and the amount of water was 6.5×10^7 km^3 (ref. in Clifford, 1993).

The amount of volcanic products that post dates the existence of ocean is very difficult to estimate. The calculations show however, that the amount of water that could be bound in zeolites represent 13-24 wt.% of their mass. If we suppose a total alteration of basaltic volcanics (6.88×10^7 km^3) to zeolites about 10 % of all available water on the surface could be stored in the mineral structure.

The consequences of loss of liquid water from the surface of Mars is prime cause of climatic change, freezing of Martian surface. The advantage of having zeolites in the surface layer of Mars as compared to clay minerals (e.g., smectites) is in the fact that zeolites contain other „basaltic“ cations e.g., Ca, Na, K as well as Mg. A possible advantage for human colonization is the fact, that water stored in zeolites is easily recoverable.

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