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Zeolite-rich spreusteins after alkaline rocks or smectites of unknown origin find the martian rover Spirit and OMEGA, HRSC instruments of Mars Express?

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An intensive hydrothermal alteration or surface weathering of feldspathoid rich alkaline rocks lead normally to formation of zeolite-rich rocks. A mixture of various zeolites with some admixture of iron oxides giving this mixture somewhat reddish color is known as “spreustein” or “rotten stone”. This process of spreusteinization is very widespread in known alkaline massifs of Earth. Alkaline rocks, syenites, albitites, granites were predicted before landings of “Pathfinder” and “Spirit” [1]. They were considered as the best candidates for the martian highland lithologies because the highlands (the southern hemisphere) standing much higher –on an average 6 km over lowlands (the northern hemisphere) must be significantly lighter than the lowlands. This is necessary to keep angular momenta of different level tectonic blocks (here two different level segments – hemispheres) in one rotating body more or less equal. Higher difference in blocks planetary radii – higher density difference of composing them lithologies. Thus, very dense lowland Fe-basalts must be opposed by very light rocks, lighter than the Earth’s andesites (an average composition of the Earth’s continents). That is why syenites were considered as the best candidates [1]. The martian gravity, more or less even over the whole surface, confirmed that this purely mechanical requirement of rotating body is fulfilled. Found andesites (directly) and dacites (remote sensing) showed that rocks of the lower density than basalts really exist. Now, Spirit found an outlier of layered highland rocks (Columbia Hills) enriched in Al, alkalies, P, S, Cl, Br, Ti [2]. This is already a direct evidence of existence of the alkaline family rocks. Rocks of “Algonquin” class fall on a petrological diagram directly into field of alkaline foidite and tephrite rocks. This forced Dr. Mc-

Sween to declare existence on Mars of “an alkaline igneous province”(Internet, 23 Aug. 2006). The layered rocks of Columbia Hills fall into several petrologic classes, some are Fe-rich, some Fe-poor, quantities of K, Na, P, S, Cl vary. All this is typical for layered syenite massifs. Often rocks are with cavities, rotted that is typical for weathering of feldspathoid rich rocks. The “Independence” class rocks have 3-5 wt.% Fe –the lowest up to now on Mars - and contain hydrated minerals of smectite group [3] (this could be as well a mixture of zeolites more suitable for weathered foidites !). The remote sensing (OMEGA, HRSC/Mex) discovers large bright outcrops mostly on the Noachian Plateaus at Mawrth Vallis consisting of thin layers different of lava flow deposits. They are phyllosilicates-rich and thick often more than 100 m.[4]. Their composition is similar to Fe-rich smectites (nontronite) and Al-rich smectites (montmorillonite). They could be as well enriched in mixtures of zeolites if primary rocks before hydrothermal alteration or weathering were like syenites. Zeolites, like montmorillonites. also are Fe-poor, Al-rich light silicates containing constitutional water. Their development is more logical for alkaline igneous provinces. So, zeolites or clays? Both can be present as the weathering products. We inclined to give preference to zeolites [5] not only because foidites are already reported but also because some foidites with sodalite (hackmanite) and nosean are enriched in sulfur that could give rise under hydrothermal leaching to sulfates so widespread on the martian surface [6]. **References: [1]** . Kochemasov G.G. (1995) Possibility of highly contrasting rock types at martian highland/lowland contact // Golombek M.P., Edgett K.S., Rice J.W.Jr. (eds) Mars Pathfinder Landing Site Workshop II: Characteristics of the Ares Vallis Region and Field Trips to the Channeled Scabland, Washington. LPI Tech. Rpt. 95-01. Pt. 1. Lunar and Planetary Inst., Houston, 1995. (63 p.), P. 18-19; **[2]** Gellert R., Brückner J., Clark B.C., Dreibus G. et al. (2006) Chemical diversity along the traverse of the rover Spirit at Gusev crater // LPSC-37, Houston, 2006, Abstract 2176, CD-ROM; **[3]** Dreibus G., Brückner J., Gellert R. et al. (2006) Chemical composition of rocks in the Columbia Hills at Gusev Crater, Mars // EUROPLANET-2006 Sci. Conf., Berlin, Germany, Sept. 22-26, 2006, Abstr. EPSC2006-A-00399; **[4]** Loizeau D., Mangold N., Poulet F. et al (2006) Geology of phyllosilicates rich outcrops in the Mawrth Vallis region, Mars, as seen by OMEGA and HRSC/Mars Express // Ibid, Abstr. EPSC2006-A-00168-1; **[5]** Kochemasov G.G.(2006) Zeolites as a possible sink for important amounts of constituent water in the martian crust (abs.), posted Feb. 2006 in a Workshop on Martian Water: Surface and Subsurface, NASA Ames Research Center, Moffett Field, California, Febr. 23-24, 2006 at

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