COMPARISON OF PHYLLOSILICATES OBSERVED ON THE SURFACE OF MARS WITH THOSE FOUND IN MARTIAN METEORITES.

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Introduction: Phyllosilicates are an important indicator of aqueous processes on Mars and have been observed on the martian surface as well as inside martian meteorites. Here we survey the types of phyllosilicates detected at the surface of Mars and inside martian rocks in order to gain a better understanding of aqueous alteration processes taking place at Mars. Comparing the phyllosilicates observed on the surface today with those found in meteorites [1] may provide clues toward understanding which phyllosilicates formed in surface environments and which formed through subsurface processes.

Martian Surface: Fe/Mg-phyllosilicates are present in numerous sites where the Noachian rocks are exposed [2]. These have been detected and characterized with the OMEGA [3] and CRISM [4] imaging spectrometers. Fe-rich smectite is the most abundant phyllosilicate on the surface of Mars [5], but a large variety of phyllosilicates and short-range-ordered (SRO) materials [6] have been observed. These include: nontronite, saponite, clinochlore, chamosite, serpentine, prehnite, talc, illite, beidelite, montmorillonite, kaolinite, halloysite, opal, hydrated silica, allophane, and imogolite. These are often observed together with iron oxides/hydroxides (FeOx), sulfates or carbonates. Phyllosilicates and SROs have also been detected on Mars by CheMin on MSL [7]. Analyses of these data from several locations indicate the presence of trioctahedral and dioctahedral smectites and SRO phases [8, 9].

Martian Meteorites: Fe-rich smectites have been detected together with FeOx and carbonates in several nakhlites, shergottites and chassignites [10, 11]. The orthopyroxenite ALH 84001 also contains small amounts of an Fe-bearing phyllosilicate as part of the aqeous alteration phase [12]. Unfortunately, the phyllosilicates present in meteorites tend to occur in extremely tiny aliquots on the scale of nm or smaller and are poorly crystalline, thus challenging researchers to identify and characterize them. The nakhlite meteorite group contains the largest quantity of phyllosilicates and for this reason they have been characterized in more detail. The most abundant phyllosilicates present in nakhlites include poorly crystalline trioctahedral Fe-bearing saponite and serpentine [13, 14].

Phyllosilicate Comparisons and Implications: Ehlmann et al. [15] suggested that some phyllosilicates, termed crustal clays, formed in subsurface locations on Mars. The clay minerals formed in these environments tend to be more Mg-rich and include mixtures of smectites plus chlorite, serpentine or talc, while surface clays tend to be more Fe-rich and are often primarily dioctahedral smectite [16]. Modeling of alteration pathways for formation of the observed phyllosilicates and associated phases in martian meteorites suggest evaporation from low temperature brines in contact with parent igneous rocks [17]. More recent modeling efforts on Fe-smectites in nakhlites indicate temperatures of 150-200 °C with pH~6-8 and a water/rock ratio ≤300 [18]. This is also consistent with the Mg/Fe-phyllosilicate mixtures collected at hydrothermal sites in the ocean on Earth [19, 20]. Thus, the alteration occurring in nakhlites could be associated with the phyllosilicates formed in subsurface environments on Mars.

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