CLAY MINERALS ON MARS: UPDATED CRYSTAL-CHEMISTRY FROM INFRARED REMOTE SENSING AND COMPARISON TO METEORITE DATA

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Introduction: Thousands of clay mineral-bearing deposits have been detected on Mars using near infared remote sensing [1-2]. Many clay deposits have been exhumed from the subsurface [3]. Here we compare the updated geochemical perspective on global clay detections to known compositions of meteorites - which represent proxy protoliths - and to clays within Martian meteorites, which provide a detailed view of clay mineralogy.

The remote sensing perspective: Based on IR remote sensing, the largest fraction of clay mineral-bearing deposits on Mars correspond to Fe/Mg-rich smectites [2-3]. Recent work placing strong crystal-chemical constraints on these smectitic clays, show that most (≥70%) of the detections correspond to clays with high FeO/MgO ratios [4]. These ancient (Noachian) clays are mostly dioctahedral Fe-rich clays with some Mg-substitution, but might also include complex di-trioctahedral mixed-layer clays [e.g. 5].

Comparison to Martian Meteorite compositions: The protoliths of the remotely sensed clays on Mars are not known, but Martian meteorite compositions [e.g. 6] represent a reasonable proxy for Martian materials altered to produce the clay deposits. For example, shergottites, which are relatively Fe-rich among the groups of Martian meteorites, have FeO/MgO ratios ranging from ~0.8-6 [7]. By contrast, most smectitic deposits detected remotely on Mars have FeO/MgO ratios of ~10-30 [5]. Therefore, clay formation on ancient Mars likely involved significant segregation of Fe from Mg. While the shergottites represent post-Noachian volcanic compositions, the global average FeO content measured by GRS (~18.4%, recast from Fe to FeO) is nearly identical to the average FeO content of shergottites (~18.7) [6] and therefore, we consider them a reasonable proxy protolith.

Clay minerals detected within Martian meteorites include a range of 7-, 10-, and 14-Å phases, most of which occur in the nakhlites (which have bulk FeO/MgO ratios of ~1-2) [e.g. 7-10]. The clays are genrally more Fe-rich than the meteorites in which they occur, and have FeO/MgO ratios of ~5-6 [5].

Conclusions: “Fe/Mg-rich” clay minerals detected by remote sensing are in fact quite Fe-rich. Most of them have much higher FeO/MgO ratios than all of the known Martian meteorites and they have higher FeO/MgO ratios than clays identified in Martian meteorites. Therefore, it is likely that clays detected by remote sensing, most of which seemingly represent Noachian deposits, formed in conditions that allowed for segregation of Fe from Mg. This likely implies higher water/rich ratios and relatively oxidizing conditions, compared to the conditions under which Amazonian clay minerals formed in Martian meteorites.

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