Clay minerals on Mars: linking meteorite and remote sensing data

J. R. MICHALSKI

Natural History Museum, London, UK

Some Martian meteorites (especially the Nakhlites), contain up to several percent clay minerals, which formed in the Martian subsurface. The clays are compositionally similar to the bulk rock compositions in which they occur, suggesting that little chemical fractionation occurred during their formation and that aqueous activity responsible for their formation was limited in volume/duration [1-2]. Given that Mars has been cold and hyperarid for 3 Gy, it is not surprising the Nakhlites, which formed at ~1.3 Ga [1], contain only limited alteration. NWA7034, a potential regolith breccia, also contains clay minerals [3] that might be vastly different but have yet to be discussed in detail.

While meteorite analyses provide the most robust evaluation of Martian mineralogy, including clay composition, they lack geologic context, are mostly younger than most altered surfaces on Mars, and are a biased sample group because they consist of competent rocks that have survived ejection events (i.e. biased toward rocks that are not very altered). Remote sensing observations provide less detail, but still can be used to strongly constrain the crystal-chemistry of Martian clays, and have the advantage of providing a more balanced global view.

Importantly, many of the remotely observed clay mineral deposits on Mars occur within materials that have been exhumed from the subsurface by impact and erosion (at ~3.5-3.8 Ga) [4]. They provide a geological, if not temporal, link to the alteration observed in Martian meteorites. The exhumed clays include serpentine, FeMg-smectite, and chlorite-group minerals [4], analogous to 7-Å, 10- Å and 14-Å clays observed in Martian meteorites [2]. Detailed treatment of orbital spectral data reveals trends in the crystal-chemistry of the clays, especially of the >1000 detections of smectitic clays observed so far [5]. Most of the smectitic clays are quite Fe-rich (FeO/MgO = 10-30) compared to clays detected in Nakhlites (FeO/MgO ratios of ~1-2) or compared to shergottites, which might be representative of typical Martian crust (FeO/MgO ≅ 0.5-4). This suggests that ancient aqueous processes potentially resulted in significant segregation of Fe from Mg [6].

References: [1] Gooding, J.L. et al., MAPS, 26 (2), 135-143, 1991. [2] Changela, H.G. and J. C. Bridges, MAPS, 45, 1847–1867, 2010. [3] Agee , C.B., 8th Mars, #1173, 2014. [4] Ehlmann, B. L. et al., Nature, 479, 53-60. [5] Carter, J. et al., JGR, 118, 831–858, 2013. [6] Michalski, J. R. et al., EPSL, 427, 215-225, 2015.