CLAY MINERALS IN NAKHLITES AND ON MARS.

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Background: The search for life beyond Earth is the driving motivation for present and planned missions to Mars by both NASA and ESA. Water is a key ingredient and medium for life, yet the aqueous history of Mars is very poorly understood. To deepen our knowledge of Mars' history, and aid in the search for life, it is essential to investigate secondary minerals, such as phyllosilicates, which formed by the interaction of igneous rocks with aqueous solutions.

Secondary minerals contain chemical, structural and isotopic records of their formation and alteration histories – including proxies for key environmental conditions such as temperature. A major challenge in understanding these records will be the efficient integration of data returned by lander/orbiter missions with high-precision laboratory studies of martian meteorites and terrestrial analogues. The present study has a two-fold approach: 1) Investigation of the effects of mineral heterogeneity on reflectance spectra, and 2) Investigation of clay mineral assemblages in martian meteorites, specifically the Nakhlites.

Samples: Clay minerals are very fine grained and typically occur in terrestrial geological settings as mechanically complex mixtures of several mineral species; the same is true for the clay veins in Nahklites [Fig. 1 and ref. 1,2]. Such complexity poses several problems for investigating lithologies dominated by secondary minerals on Mars. For example, reflectance spectra returned by instruments onboard Mars-orbiting spacecraft (CRISM, OMEGA) are interpreted [e.g. 3,4] with reference to databases of spectra obtained from terrestrial minerals. These databases do not contain well-defined mixtures of minerals, but generally are of single mineral phases (plus unknown/unwanted impurities). This has the potential to cause misinterpretation of certain lithological units on Mars.

The fine-grained complexity of clay assemblages also proves problematic in the nakhlite meteorites – the best hosts of martian clay minerals until a sample return mission. Fig 1 shows a clay-rich vein in the nakhlite MIL 03346. Advances in analytical instruments (NanoSIMS, Tip-Enhanced Raman Spectroscopy) will allow a more detailed mineralogical, chemical and isotopic investigation of these mineral assemblages.

Analyses: XRD analyses of a set of clay minerals, mixtures of minerals, and solid-solution series, will be conducted to ensure that all samples used in future physical, chemical, and isotopic analyses are of known mineral proportions. The effects of differing mineral proportions on reflectance spectra will be presented at the conference. Preliminary XRD analyses demonstrate the reliability of this technique in fingerprinting mineral composition and impurities, such as in smectite group minerals (Fig.2) which have been identified both in nakhlites [1] and on the surface of Mars [3,6].

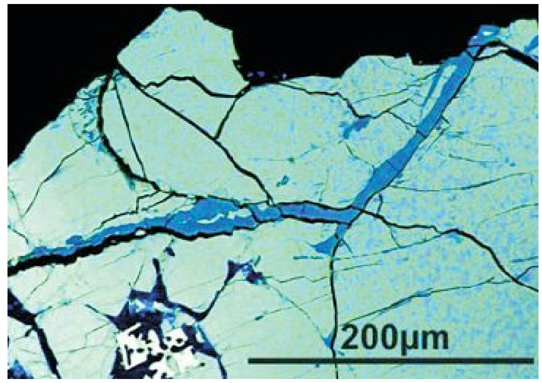

Figure 1 - False colour image of a clay vein in an olivine grain in the nakhlite MIL 03346 [5]. Recent advances in instrumentation will allow a better understanding of these fine-grained mineral assemblages.

Detailed petrological, chemical and isotopic analyses of the prepared terrestrial analogues – and of clay assemblages in the nakhlite meteorites – will also be undertaken. These results will help to improve our understanding of secondary mineral formation on Mars, which in turn will provide critical constraints on the timing and duration of Mars' putative 'warm and wet' early history.

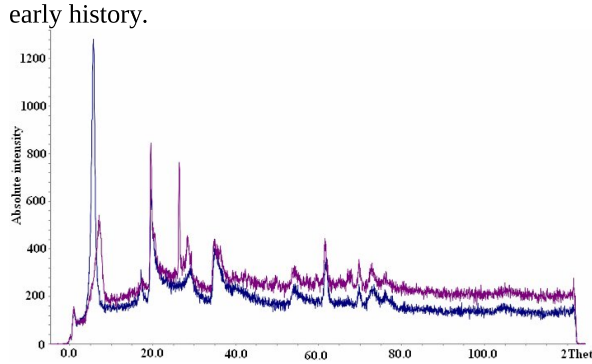

Figure 2 - XRD analyses are shown here to discriminate between two monmorillinite (smectite) samples. One sample (paler purple line) is richer in Na, and contains impurities of quartz (note the pronounced peak at 26 degrees)

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