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Lewis and Clark Fund for Exploration and Field Research

Hyperspectral study of the Painted Desert, AZ to characterize clay alteration environments and provide implications for astrobiology at Mawrth Vallis, Mars, a likely Mars Science Laboratory landing site

Project Report

With funding from the American Philosophical Society, I have completed a study of the mineralogy of rocks in the Painted Desert, Arizona (Fig. 1). A study of the mineralogy allows better characterisation of the formation environment(s) of the Mawrth Vallis region on Mars, which exhibits similar mineralogies to those present in the Painted Desert. Rocks on Mars are primarily igneous and those that are not likely evolved from igneous rocks, such as basalt. The sediment in the Painted Desert weathered from volcanic arcs to the south and evolved into primarily smectite-bearing rocks. The sediments at Mawrth Vallis are composed primarily of two types of smectite: nontronite and montmorillonite.

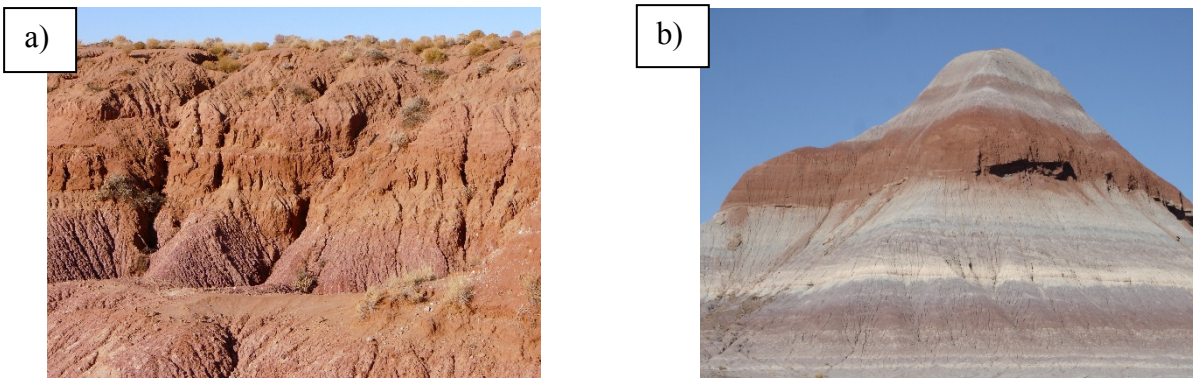


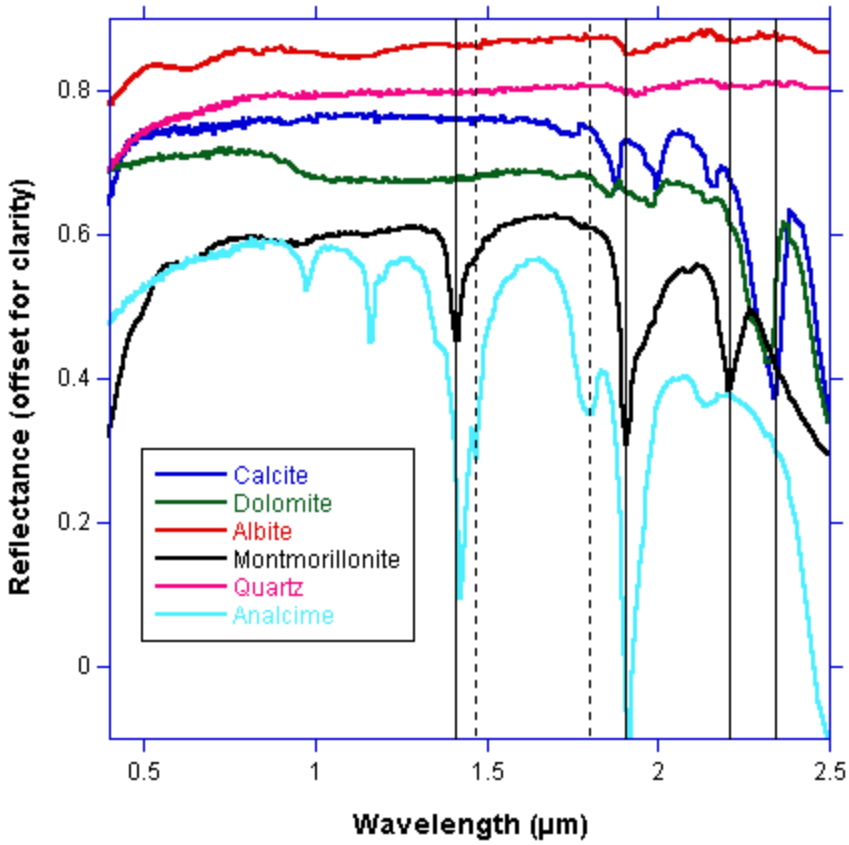
Fig. 1: Photographs of two sample sites in the Painted Desert, AZ. Different colours indicate different mineralogies. The transition from white/purple to red in (b) indicates the transition from anoxic to oxic conditions, similar to what may be present at Mawrth Vallis at the boundary between the nontronite and montmorillonite-bearing units.

I performed field studies at two locations in the Painted Desert, gathering spectra and samples for laboratory analyses. After returning these samples to the lab, I measured spectra of these hand samples and sent them off for further mineralogic characterisation via x-ray diffraction (XRD).

Spectral results indicate the presence of montmorillonite, kaolinite, calcite, and iron-bearing minerals. XRD results indicate the presence of quartz, calcite, montmorillonite, plagioclase, dolomite, analcime, and palygorskite. The differences between the two are a result of the different methods used but are nonetheless significant. Quartz and plagioclase, for example, are not detectable in the visible-near infrared and shortwave infrared wavelengths (Fig. 2) used by the spectrometers; therefore, they would never be detected even if present. Their presence in the Painted Desert samples strongly suggests that such components may be a part of the rock units at Mawrth Vallis along with the phyllosilicates, such as montmorillonite. Modelling of spectra from Mawrth Vallis include plagioclase in order to accurately recreate the observed spectra. The

presence of analcime and palygorskite, once known, can be detected in the field spectra; however, the absorptions are weak enough that they were not easily or immediately identified in spectra alone. It is unlikely there is calcite or dolomite at Mawrth Vallis; carbonates have only been identified in a handful of locations on Mars, despite the strong spectral absorptions in the 2.3-2.5 µm region.

Fig. 2: Laboratory spectra of some of the minerals identified in the Painted Desert samples. Note the flat, featureless quality of the quartz and plagioclase (albite) spectra which make them near-impossible to identify in these



wavelengths.

These mineral identifications are important because minerals such as analcime form under higher temperature conditions than montmorillonite. Therefore, if there is analcime at Mawrth Vallis then there may not just have been a redox gradient (as indicated by the transition between oxic and anoxic conditions) but there may also have been temperature variations over time, which could provide another source of energy for microorganisms.