CRITERIA FOR IDENTIFYING NEOFORMED LACUSTRINE CLAYS ON MARS.

T. F. Bristow[1*], R. E. Milliken[1] and J. P. Grotzinger[2], [1]JPL/Caltech, 4800 Oak Grove Drive, Pasadena, CA 91109. *tbristow@caltech.edu, [2]Caltech, Division of Geological and Planetary Sciences, 1200 East California Blvd, Pasadena, CA 91125.

Introduction: Mg/Fe smectites are widely reported from the Martian surface [1]. They are found interbedded with sulfate deposits in stratified sediments that fill craters and other depressions [2], and have been detected in deltas and other distributary deposits interpreted as supplying basins with water and sediment [2-5]. However, the origin and locus of formation these clays remains an open question.

On Earth, Mg-smectites such as saponite, stevensite and other Mg and Fe-rich authigenic clays are common constituents of modern and ancient lake sediments deposited under alkaline/saline conditions [6]. They form via transformation of detrital precursors washed into the basin, or by direct precipitation from pore fluid or solution. The clay assemblage that forms, as well as the types of accompanying authigenic minerals reflect local chemical conditions and the availability of reactive detrital clays in sediments. Therefore the identification of neoformed clays in lacustrine deposits on Mars could yield information about the physio-chemical conditions within lakes and the hydrological history of basins.

Neoformed clays on Mars: The identification of neoformed clays in putative Martian lacustrine strata is made difficult because the surface is largely basaltic. Saponites and nontronites are typical weathering and hydrothermal alteration products of basalts [6], and so there are probably ample external sources of clays that could be reworked by wind or water and deposited in basins. Even with detailed crystallographic, textural and chemical information the mineralogy alone is probably inadequate to prove that a particular clay formed in a lake. The types of clays found in terrestrial lake deposits may also differ from clays that might form in lakes on Mars. For instance, carbonate minerals and species in solution play an important role in the chemical evolution of lake waters on Earth and the precipitation reactions of some clays [7]. But carbonates seem to be a minor phase in Martian sediments and are not detected in most clay-bearing strata [8]. We propose that a better strategy for identifying clays forming in lacustrine settings on Mars is to look at the spatial and temporal distribution of clays and other authigenic mineral phases via the stratigraphic record. Looking for diagnostic stratigraphic patterns in the distribution of clays in Martian sediments provides a more robust means of distinguishing neoformed clays than mineralogy alone because these patterns are a determined by physical processes that ultimately control sedimentation and the hydrology of lacustrine basins.

Tests: The following criteria may help identify neoformed clay minerals in Martian lake deposits. More detailed information on these criteria will be presented based on terrestrial examples of modern and ancient lacustrines systems.

1) Recognizing differences in clay mineralogy of hydrologically closed vs. open basins. Neoformation of clays mainly occurs during periods of hydrological closure when clays become an important terminal ionic sink. At other times when a basin has an outlet the clay mineralogy is dominantly detrital and reflects mineral inputs from the catchment [9]. Identification and comparison of the Martian deposits formed in open and closed systems (for which there may be independent geomorphic or sedimentological evidence [10]) may demonstrate clay neoformation.

2) Concentric zonation of clays and other authigenic minerals. When a basin contains neoformed clays they often display concentric distribution that will also be expressed in other authigenic minerals such as zeolites, silica, phosphates and evaporites [11].

3) Stratigraphic changes in mineral assemblages. The hydrological balance in closed basins is particularly sensitive to external forcing, such as orbitally induced insolation changes. Concentric mineralogical facies are a temporal snapshot and over time their distribution and composition will continuely evolve with lake level. If clay neoformation is occurring then these changes should show up in the stratigraphic record, perhaps in a cyclical fashion, if there is a regular forcing mechanism [12].

References: [1] Mustard, J. F. et al. (2008) *Nature, 454,* 305-309. [2] Milliken, R. E. et al. (2010) GRL, in press. [3] Ehlmann, B. L. et al. (2008) *Nature Geosci., 1,* 355-358. [4] Grant, J. et al. (2008) Geology, 36, 195-198. [5] Milliken, R. E. et al. (2010) Phil. Mag., in press. [6] Meunier, A. (2005) *Clays,* Berlin, Springer, 472 p. [7] Jones, B. F. and Galan, E. (1988) *R. Min., 19,* 631-667. [8] Ehlmann, B. L. et al., (2008) *Science, 322,* 1828-1832. [9] Menkin, K. M. (1997) *GSA Spec. Paper 317,* 25-37. [10] Fassett, C. I. and Head, J. W. (2008) *Icarus, 195,* 61-89. [11] Larsen, D. (2008) *Geosphere, 4*, 612-639. [12] Webster, D. M. and Jones, B. F. (1994) *SEPM Special Pub. 50,* 159-172.