RESULTS AND IMPLICATIONS OF MINERALOGICAL MODELS FOR CHEMICAL SEDIMENTS AT MERIDIANI PLANUM. B. C. Clark¹, S.M. McLennan², R.V. Morris³, R. Gellert⁴, B. Jolliff⁵, A. Knoll⁶, T.K. Lowenstein⁷, D.W. Ming⁵, N.J. Tosca², P.R. Christensen⁸, B. Jolliff⁵, A. Yen⁹, J. Brückner⁴, W. Calvin¹⁰, W. Farrand¹¹, J. Zipfel⁴, S. Gorevan¹², S.W. Squyres¹³, and the Athena Science Team. ¹Lockheed Martin Space Systems, POB 179, MS S-8000, Denver, CO 80201, benton.c.clark@LMCO.com, ²State University of New York (SUNY), Stony Brook, NY, ³NASA Johnson Space Center, Houston, TX, ⁴Max Planck Institut für Chemie, Kosmochemie, Mainz, Germany, ⁵Washington University, St. Louis, MO, ⁶Harvard University, Cambridge MA, ⁷SUNY, Binghamton, NY, ⁸Arizona State University, Tempe, AZ, ⁹JPL, California Institute of Tech., Pasadena, CA, ¹⁰University of Nevada, Reno, NV, ¹¹Space Science Institute, Boulder, CO, ¹²Honeybee Robotics, New York, NY, ¹³Cornell University, Ithaca, NY.

Introduction: The Mars Exploration Rover (MER) “Opportunity” has explored chemically-enriched sedimentary outcrops at Meridiani Planum, Mars. In its first year, three different crater sites – Eagle, Fram and Endurance – have been explored.

Nineteen high-interest outcrop rocks were investigated by first grinding a hole to reach the interior (using the Rock Abrasion Tool, RAT), and then conducting APXS (alpha particle x-ray spectrometry) analysis, MB (Mössbauer) analysis, and close up imaging (MI, microscopic imager). Sixteen elements and four Fe-bearing minerals were assayed to good accuracy in each sample, producing 380 compositional data points. The Miniature Thermal Emission Spectrometer (Mini-TES) obtained spectra on outcrop materials which provide direct indication of several mineral classes.

Preliminary reports on Eagle crater and three RAT samples have been published [1-4]. Chemical trends and a derived mineralogical model for all RAT’d outcrop samples to date has been developed [5].

Variability of Elements. The data span a range of concentration variations, with rank order of elements in Fig. 2, from the least variable (first 5 elements, at ±12%) to SO₃ (at ±23%) to the hyper-variable Br. This variability enables trend analysis.

All samples from units E through F have significantly enhanced Cl concentrations compared to units higher in the sequence. This dichotomy produces a bimodal distribution for this element, Fig. 3.

Mineralogical Model. The salt minerals implicated include Mg-sulfates (with various hydration states possible, from kieserite to epsomite), Ca-sulfates (variously hydrated), and chlorides of Mg (bischofite) and possibly Na (halite). Aluminosilicates are abundant as well as some form of or enrichment in silica, and an apparent pyroxene (“Px”) remnant depleted in Ca and Mg. Mini-TES observations have demonstrated that crystaline silica minerals, such as quartz and chert, and carbonate phases are not present in these outcrops at abundances >~5%. Iron minerals, as reported by MB, include the “Px”, hematite, F3D3 (an unknown Fe³⁺ oxide or sulfate), and jarosite (Jar). Correlating APXS and MB trends implies an oxide or a low-S sulfate for

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Fig. 1. Ratio of element concentrations in indicated samples to Meridiani average dark soil.

Fig. 2. Ratio plots of minimum-to-mean and maximum-to-mean for element ranges in outcrop samples.
and hematite-rich spherules (presumably concretions), also require significant aqueous activity [8]. Serving as a sink for $\text{H}_2\text{O}$, we calculate the outcrop could contain up to 18% $\text{H}_2\text{O}$ just in hydration of salts alone. Depression of freezing points, especially by chlorides, Fig. 4, to below martian temperature excursions could cause mobilization of $\text{MgCl}_2$ and other Cl species (including perchlorates) while sulfate remains relatively immobile. Gravity-driven or porosity-aided seepage of phreatic $\text{H}_2\text{O}$ could possibly explain opposite directional concentrations of sulfates and chlorides. The enhanced solubilities and depression of freezing point for some bromides ($-42.7$ °C for $\text{MgBr}_2$) could explain the hypermobility of Br evidenced at the Meridiani site, Gusev crater [10] and in Viking Chryse duricrust sample [11].

Fig. 4. Freezing point depression for chlorides, nitrates, and sulfates of candidate cations, including acid (H) eutectics.

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