EVIDENCE FOR HALITE AT MERIDIANI PLANUM. A. S. Yen,[1] J. Grotzinger,[2] R. Gellert,[3] B. C. Clark,[4] S. M. McLennan,[5] R. V. Morris,[6] C. Schröder,[7] G. Klingelhöfer,[7] K. E. Herkenhoff,[8] J. R. Johnson[8] and the Athena Science Team. [1](Albert.Yen@jpl.nasa.gov) Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA , [2]California Institute of Technology, Pasadena, CA, [3]University of Guelph, Ontario, Canada, [4]Lockheed Martin Space Systems, Denver, CO, [5]State University of New York, Stony Brook, NY, [6]NASA Johnson Space Center, Houston, TX, [7]Johannes Gutenberg University, Mainz, Germany, [8]US Geological Survey, Flagstaff, AZ.

Introduction: The outcrop rocks investigated by the Mars Exploration Rover (MER) Opportunity at Meridiani Planum consist of altered basaltic fines emplaced through aeolian and aqueous processes. Diagenesis through episodes of groundwater influx is likely responsible for lithification of the sediments, formation and subsequent dissolution of embedded crystals, and development of hematitic spherules with occasional cemented overgrowths [1].

The action of liquid water in the development of these rocks prompts the search for pure evaporative salts such as chlorides. Extensive deposits of this nature have not yet been discovered and may be a result of erosion and removal from stratigraphic layers above those sampled by Opportunity, or burial beneath accessible depths [2]. Nonetheless, the presence of small amounts of halite (NaCl) associated with coatings and rinds is indicated by the available data.

Chemical Evidence: Pancam images provided the first indications of distinct rinds on outcrop surfaces while Opportunity was still within Eagle crater, but detailed analyses of such a target did not begin until "Fruit Basket" on sol 556 (Fig. 1). Figure 2 plots the molar abundances of Na and Cl in various targets calculated from elemental measurements obtained by the Alpha Particle X-ray Spectrometer (APXS).

The cyan line is a fit through outcrop targets brushed and abraded by the Rock Abrasion Tool (RAT), not including the black or blue points. The minimal slope of this line is an indication that Na and Cl are decoupled for typical outcrop deposits.

The black dashed line is drawn between the data points for "Strawberry" and the brushed surface of "Lemon Rind" (Fig. 1). The slope corresponds to a Na:Cl molar ratio of approximately 1:1.3. Given the precision of the APXS, this observed increase in both Na and Cl in the rind relative to the rock interior is entirely consistent with the addition of a few percent halite.

The blue dashed line is drawn between the only other data points that exhibit a pronounced increase in both Na and Cl from a RATted interior to the brushed surface. This target is from the rock "Escher" (Fig. 3), so named because of the polygonal fracturing suggestive of desiccation-related volume decreases. These data are also consistent with a few percent halite in a coating <1 mm thick on the surface of the rock Escher.

Morphology: MI data from "Lemon Rind" (Fig. 4) show a variety of cross-cutting hairline fractures suggestive of synsedimentary deformation. These cracks are filled with sediment or cements. Some have random curviplanar geometry, while others show distinct intersections of approximately 120 degrees. These cracks taper away from their intersection point. In addition, "Lemon Rind" has topographic mm-scale depressions with angles of close to 90 degrees, resulting in preservation of partial squares and rectangles. Collectively, these textures are interpreted to represent possible halite pseudomorphs, expressed by cross sections through corners, as well as edges and faces. Possible "hopper" geometries are also present, which suggest the crystals would have grown interstitially.

Mössbauer Mineralogy: Analyses by the Mössbauer (MB) spectrometer indicate that "Lemon Rind" is comparable to nearby outcrop rocks in iron mineralogy, with perhaps minor variations in the subspectral components. MB analyses of the brushed and RATted targets within "Escher" are essentially identical. Thus, the processes that increased Na and Cl on these surfaces did significantly affect the iron mineralogy.

Discussion: Available evidence is suggestive of minor halite concentrations in rinds and certain rock coatings. The mechanism for deposition is unclear, but may involve the action of transient liquid water films in the near subsurface [3]. This possibility is supported by the observation that rinds are generally found in areas that appear to have been recently exhumed.

There is at least one possible issue with this inference of halite: The Na-Cl trend from the brushed to the RATted analyses of "Lemon Rind" does not progress in the direction of "Strawberry," but rather moves towards higher Cl. This could be an indication of an interior Cl enhancement independent of Na, or a reflection of the APXS measurement precision.

Additional rind analyses are required to fully assess the hypothesis that halite is present in rock rinds and coatings at Meridiani.

Summary: Minor quantities (up to several percent) of halite are indicated by analyses of rinds and certain rock coatings at Meridiani Planum. Larger scale salt deposits which may have been associated with aqueous reworking of sediments in the outcrop remain undetected.

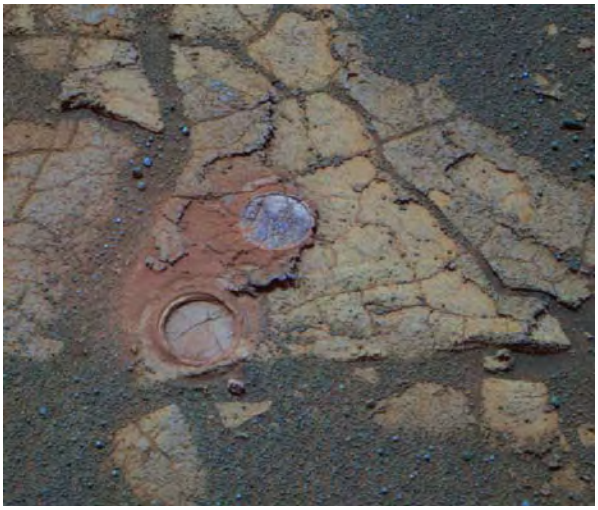

Figure 1: False color Pancam image (sol 560) of the "Fruit Basket" region showing a patchy, dark rind. At the center of the image is a ~1.5 mm deep (45 mm diameter) grind into "Lemon Rind." The other abraded spot is ~2.5 mm grind into "Strawberry," a representative sample of outcrop material without a visible rind.

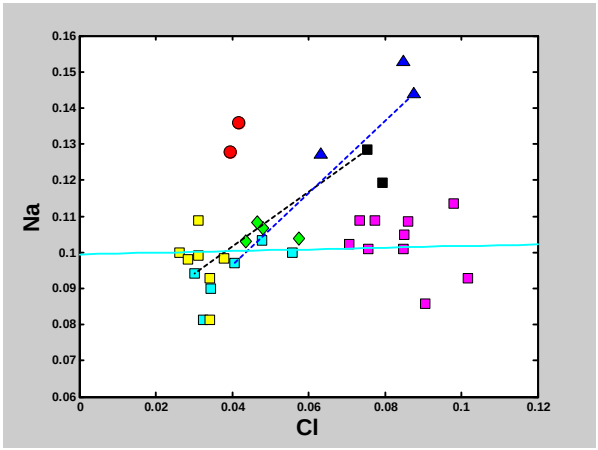

Figure 2: Scaled molar abundances of Na and Cl. RATted outcrop: Lower Endurance crater (magenta), Eagle crater and upper Endurance crater (yellow), and other RATted targets (cyan). Brushed outcrop (green), surface dust (red), "Lemon Rind" (black), and "Escher" (blue) are also plotted. See text for discussion of lines.

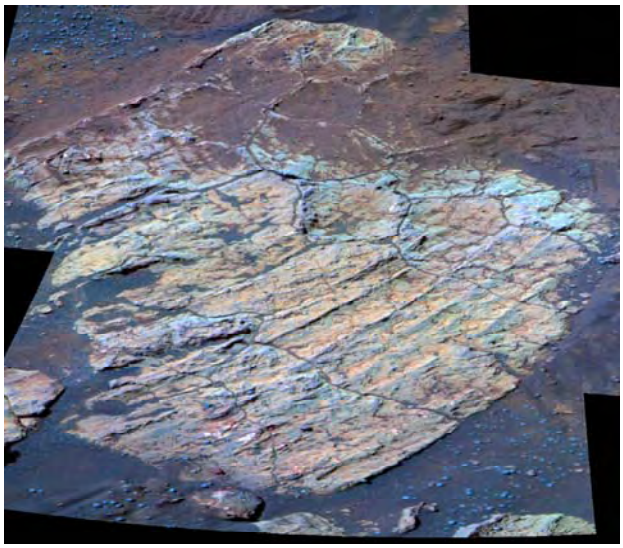

Figure 3: False color Pancam image (sol 208) of the "Escher" rock exhibiting a fracture pattern suggestive of volumetric changes. This target has significant and correlated enhancements of Na and Cl at the immediate surface.

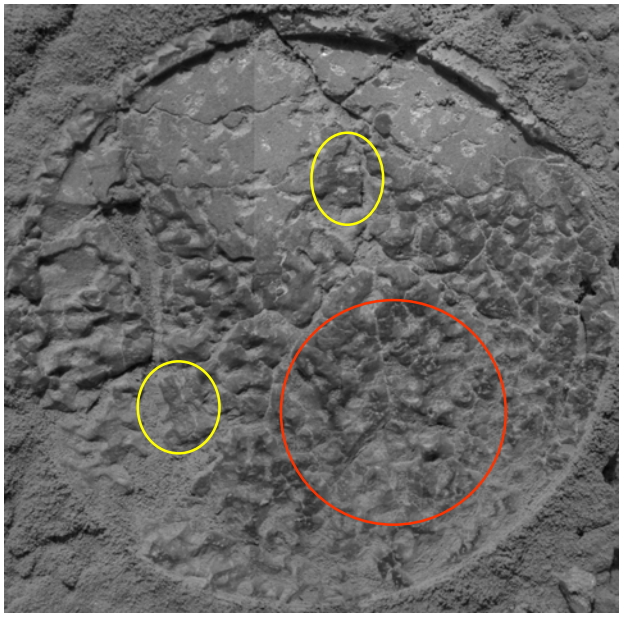

Figure 4: Microscopic Imager mosaic of "Lemon Rind" acquired on sol 560 after RATting. Region of ~120 degree intersections (red circle) and 90 degree angles (yellow circles) are depicted. The abraded region is ~45 mm in diameter.

References: [1] McLennan, S. M. et al. (2005) *EPSL*, *240*, 95-121. [2] Clark, B. C. et al. (2005) *EPSL*, *240*, 73-94. [3] Yen, A. S. et al. (2005) *Nature*, *436*, 49-54.