INTEGRATED RESULTS FROM ANALYSIS OF THE ROCKNEST AEOLIAN DEPOSIT BY THE CURIOSITY ROVER. L.A. Leshin[1,] J.P. Grotzinger[2], D.F. Blake[3], K.S. Edgett[4], R. Gellert[5], P.R. Mahaffy[6], M.C. Malin[4], R.C. Wiens[7], A.H. Treiman[8], D.W. Ming[9], J. Eigenbrode[6] and the MSL Science Team. [1]Renssalaer Polytechnic Institute, Troy, NY, 12180, Leshin@rpi.edu, [2]California Institute of Technology, Pasadena, CA, [3]NASA ARC, Moffett Field, CA, [4]Malin Space Science Systems, San Diego, CA, [5]Univeristy of Guelph, Guelph, ON, Canada, [6]NASA GSFC, Greenbelt, MD, [7]Los Alamos National Lab, Los Alamos, NM [8]Lunar & Planetary Institute, Houston, TX, [9]NASA JSC, Houston, TX.

Introduction: The Mars Science Laboratory Curiosity rover spent 45 sols (from sol 56-101) at an area called Rocknest (Fig. 1), characterizing local geology and ingesting its aeolian fines into the analytical instruments CheMin and SAM for mineralogical and chemical analysis. Many abstracts at this meeting present the contextual information and detailed data on these first solid samples analyzed in detail by Curiosity at Rocknest. Here, we present an integrated view of the results from Rocknest – the general agreement from discussions among the entire MSL Science Team.

Observational Methods: Remote observations of the Rocknest site were performed with with MastCam and ChemCam, contact science was performed with APXS and MAHLI, and scooped samples were analyzed by CheMin and SAM. The engineering goal for this first solid sample was to 'clean' terrestrial contamination (especially organics) from the sample processing and handling system, essentially using martian fines as 'scrubbing powder.' Three processing and discard cycles were required prior to delivery of the first sample to SAM.

The Rocknest deposit is the dune-like deposit in Fig. 1. It is an aeolian sand shadow in the lee of the Rocknest cobbles on the left side of Fig. 1. This deposit was confirmed to be "rock free," and therefore safe for scooping, by scuffing with the rover wheel. Scoops 1, 3, 4 and 5 (Fig. 2) were processed through the sample handling system, yielding sieved samples with grain sizes <150 μm. Scoop 2 was discarded soon after scooping because a bright object was discovered in the scoop trench. The identification of this object is still unknown, though team consensus (which came after dumping the sample) considered it to be a bright sand grain. After sieving, aliquots from scoops 3, 4 and 5 were delivered to CheMin for individual analysis. Four aliquots from Scoop 5 were delivered to four different sample cups in SAM for analysis.

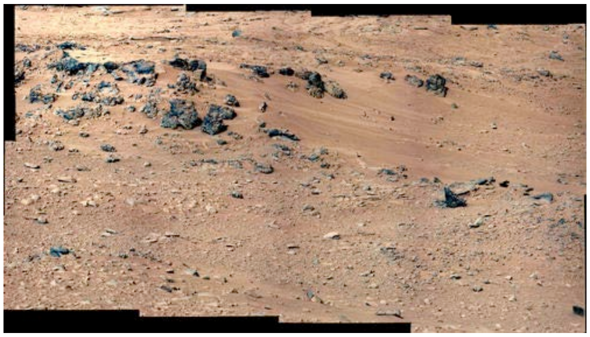

Figure 1*. The Rocknest aeolian deposit. Mosaic of images taken by the Mastcam right-eye on sol 52, four sols before the rover arrived at Rocknest. The Rocknest patch is ~1.5m x 5m.*

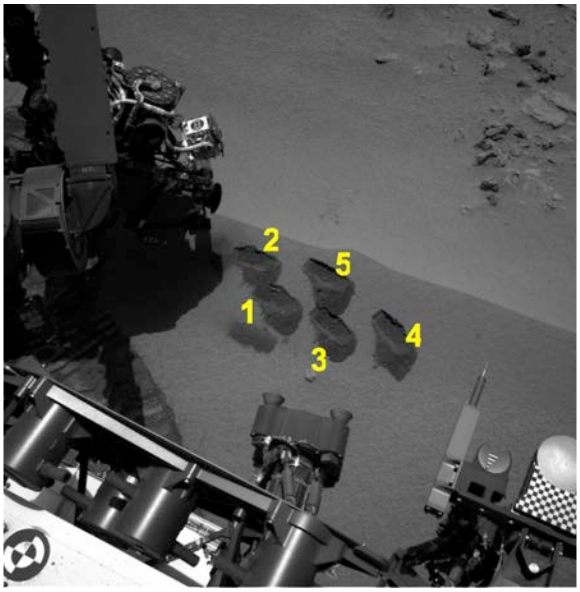

Figure 2*. Five scoops marks in the Rocknest aeolian bedform. This image is from Curiosity's left navigation camera, taken on sol 93 just after the 5th and final scoop was taken at Rocknest.*

Rocknest Results: A summary of the observations at Rocknest that are agreed upon by the MSL Team, with the most relevant instrument to the observation given in parentheses, are as follows:

Size/shape/color: Most material in the scoop trenches is fine to very fine sand or smaller with a range of shapes and colors (MAHLI) (Fig. 3); color/brightness variations are observed in bands (possible layers or horizons) scoop trenches (Fig. 4); reflectance spectra (MastCam, ChemCam) are consistent with previous analysis of fines on Mars, e.g. by MER and Phoenix.

Chemistry: Major and minor elements in the

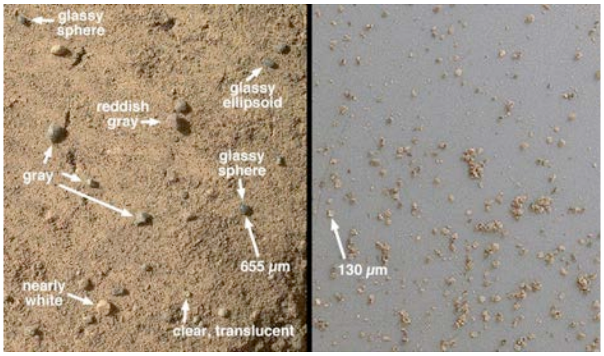

Figure 3. *Close-up views from MAHLI of sands in the Rocknest area. Left image is from sol 58 and is ~1.9 cm across. This area was flattened by the left front rover wheel and shows clear, translucent grains, gray and white sand, and glassy spheroids. The right image, from Sol 73, shows grains collected in the 3rd scoop, sieved to <150 µm and placed on the rover's observation tray. The image is about 6.5 mm across. Many of these fine sand grains are angular pieces of crystalline minerals.*

Figure 4. *A view of the 3rd (left) and 4th (right) trenches made by the scoop at Rocknest in October 2012 acquired by MAHLI on Sol 84. The upper surface of the drift is covered by coarse sand grains approximately 0.5-1.5 mm in size. These coarse grains are mantled with fine dust. Beneath the surface is finer sand, which is darker brown. The left end of each trough wall shows alternating light and dark bands, indicating that the sand inside the drift is not completely uniform.*

Rocknest sediment, measured at the nearby wheel scuff site named "Portage," and consistent with a small amount of analyzed Rocknest fines delivered to the Observation Tray, are consistent with previous analyses of martian fines elsewhere on Mars with minor exceptions (APXS).

Minerals/Compounds: The <150 µm fraction includes unaltered igneous minerals (olivine, 2 pyroxenes, feldspar, and Fe-Ti-Cr oxides plus other minor phases) and a significant fraction (~30%) of X-ray amorphous material. Anhydrite ($CaSO_4$) and hematite (Fe_2O_3) are the only non-igneous minerals detected, and are present in minor amounts ~1% (CheMin).

Cl and O release from heated samples observed by SAM suggest the presence of a perchlorate-like substance, although lack of detection by CheMin means that it must be poorly crystalline or < 1% by weight (SAM, CheMin)

Volatiles: The <150 µm fraction of the scooped material is relatively volatile rich with several wt. % water, and CO_2-and S-bearing phases (SAM) and H detected by ChemCam. CheMin detects $CaSO_4$ at ~ 1% (by mass).

Isotopes: H_2O has δD value consistent with D-enriched atmosphere values, ~+5000 ‰ (SAM TLS).

Organics: Hydrocarbons, many Cl-bearing, are evolved over a broad temperature range, including silylated products consistent with reaction with one of the derivitization agents carried to Mars in SAM (MTBSTFA).

Discussion: The Rocknest campaign represents a comprehensive analysis of martian aeolian fines. The results are broadly applicable to understanding the production and evolution of soil and dust on Mars because the APXS, MAHLI, MastCam and ChemCam results suggest this material is very similar to that analyzed by previous missions such as MER [e.g., 1,2,3].

Key observations in interpreting these data include the high abundance of igneous minerals in the crystalline component of the fines, suggesting that a large fraction of the material is derived from physical weathering of igneous rocks without significant alteration. However the mixture of these unaltered minerals with the X-ray amorphous materials is especially interesting. The relatively high temperature of release of the volatiles observed by SAM, combined with the lack of detection of water or CO2-bearing crystalline phases by CheMin, suggests that the X-ray amorphous material is the source of most of the volatiles (especially the water and CO_2, and possibly Cl) observed by SAM. Given that this material makes up on the order of 1/3 of the 150 µm fraction of the fines, this suggests a high abundance of water-bearing phases and carbonate- and perchlorate-bearing materials in the X-ray amorphous component. The D/H value of the water suggests the formation or exchange of the volatiles in this material with the atmosphere, consistent with formation of the amorphous component in association with modern atmospheric processes.

At this time, there is not definitive evidence that the organic compounds detected by SAM at Rocknest are of martian origin. Future analyses of rocks will continue the search for indigenous martian organics.

References: [1] Bell et al. (2004) Science **305**, 800 [2] Herkenhoff et al. (2004) Science **305**, 824. [3] Gellert et al., (2004) Science **305**, 829.