MARS SCIENCE LABORATORY: FIRST 100 SOLS OF GEOLOGIC AND GEOCHEMICAL EXLORATION FROM BRADBURY LANDING TO GLENELG.

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Introduction:

The Mars Science Laboratory rover, *Curiosity,* touched down on the surface of Mars on August 5, 2012. It was built to conduct an investigation of modern and ancient habitable environments [1]. *Curiosity* has a lifetime of at least one Mars year (~23 months), and drive capability of at least 20 km. The MSL science payload was specifically assembled to assess habitability and includes a gas chromatograph-mass spectrometer and gas analyzer that will search for organic carbon in rocks, regolith fines, and the atmosphere (SAM); an x-ray diffractometer that will determine mineralogical diversity (CheMin); focusable cameras that can image landscapes and rock/regolith textures in natural color (Mastcam, MAHLI); an alpha-particle x-ray spectrometer for *in situ* determination of rock and soil chemistry (APXS); a laser-induced breakdown spectrometer to remotely sense the chemical composition of rocks and minerals (ChemCam); an active neutron spectrometer designed to search for water in rocks/regolith (DAN); a weather station to measure modern-day environmental variables (REMS); and a sensor designed for continuous monitoring of background solar and cosmic radiation (RAD) [1].

Vasavada et al. [2] present a summary of the mission results related to environmental studies.

Measurements: As of Sol 100 *Curiosity* has obtained 11 APXS measurements; ~425 ChemCam analyses using ~14,000 laser shots; ~171 DAN measurements using ~480,000 neutron pulses; ~11,000 Mastcam, MAHLI and MARDI images; ~14,000 RAD observations, several CheMin analyes; four SAM solid sample evolved gas GCMS measurements, and eight SAM TLS/QMS measurements of both atmosphere and evolved gases. REMS has obtained over 2,500,000 seconds of data. At the Rocknest soil locality over 2,500 motions were conducted to process samples and deliver scooped soil samples to CheMin and SAM. The science payload and sample processing systems are performing as designed and planned for surface observations.

Mapping: The landing ellipse was mapped with emphasis on defining relationships between the distal end of the Peace Vallis alluvial fan and the base of Mt. Sharp [3-6]. Four major geologic/geomorphic units were recognized: smooth hummocky plains (including Bradburg Landing Site), heavily cratered plains/surfaces, light-toned fractured surfaces, and bright-toned "rugged" terrain. "Glenelg" was defined as the area where the former three of these terrains intersect ~500 m due east of Bradbury Landing Site. *Curiosity* drove mostly across the smooth hummocky plains, but after passing "Point Lake" then entered a transition zone that gives way to the light toned fractured surface. The boundary closely corresponds to the transition from lower into higher thermal inertia terrain [1].

Between Bradbury Landing and the contact with the light-toned fractured surface the elevation drops by ~20 meters. A number of in-place outcrops were encountered along this descending traverse and, assuming that bedding dips are horizontal, then it allows a simple stratigraphy of seven units to be constructed [7]. This stratigraphy suggests a dominace of basaltic volcanic units lower in the section that give way to cross-stratified and conglomeratic sedimentary rocks higher in the section.

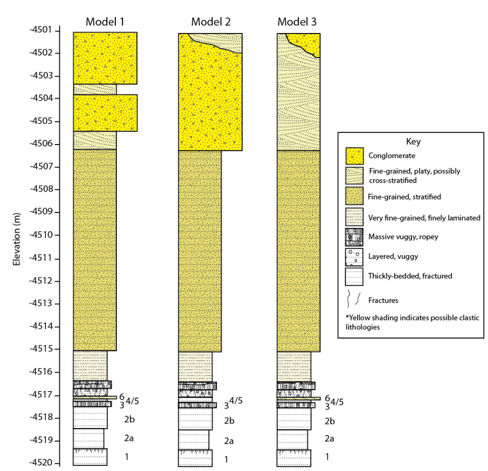

Figure 1. Options for stratigraphy of Bradbury Landing to Glenelg. In all cases it is likely that basaltic volcanic rocks underlie sedimentary rocks of probably fluvial origin. From [7].

Conglomerates: At Bradbury Landing Site the decent stage engines created enough thrust during impingement on the surface to excavate and expose bedrock. Here, and at several other localities distributed over ~600 meters en route to Glenelg, *Curiosity* observed conglomeratic bedrock [8]. This included the Goulburn, Link, and Hottah exposures. This conglomerate at Link and Hottah contains rounded pebbles ranging in size from 5-40 mm, forming beds at least 5 cm thick with locally well-developed planar stratification; this, plus grain-supported and imbricated clast fabrics suggest transport in aqueous flows with depths of 0.1-0.8 m, and velocities of 14-63 cm/sec [8]. These conglomerates and associated uncemented gravels were likely derived from the Gale crater rim and transported down the Peace Vallis channel network [6]. ChemCam data suggest the presence of feldspar and basaltic composition rock fragments as pebbles, consistent with derivation from the crater rim [9].

Jake Matijevic and other rocks: On Sols 43 and 44 *Curiosity* studied an isolated (float), pyramidal-shaped rock, "Jake Matijevic", of likely volcanic origin. APXS revealed an evolved, alkaline composition similar to nepheline-normative muegerites, and suggestive of high pressure partial melting of the mantle, or partial melting of older metasomatized crust/mantle rocks [10]. Complementary ChemCam data indicates laser tunneling into pyroxene and plagioclase minerals providing independent assessment of the rock's likely coarser grain size. Other rocks studied with APXS ("Bathurst Inlet", "Et-Then", "Rocknest-3"; Sols 54, 91, and 102, respectively) and ChemCam show basanitic composition, with high K_2O, low SiO_2, and high FeO [11].

Rocknest soil: Between Sols 56 and 110 Curiosity hunkered down next to the "Rocknest" eolian deposit. A linear, sharp-crested wind shadow was selected for scooping and eventual delivery to CheMin and SAM [12].

Rocknest was first analyzed by Mastcam, ChemCam, APXS, and MAHLI and eventually considered safe enough for introduction into the Sample Acquisition/Sample Processing and Handling system (SA/SPaH); i.e. its material properties were judged to not have potential for clogging the system through dehydration reactions, electrostatic effects, etc. REMS wind sensor data were collected to evaluate the best time in the sol for sample drop off, to minimize the chance for wind to blow the sieved sample away from the sample inlet tubes. Two scooped samples were sieved to obtain the fraction less than 150 microns, and these were used for cleaning and then discarded. A third sample was scooped and a portion was delivered to the Observation Tray where it was examined for its physical appearance and the APXS was used to obtain its composition, isolated from all other soil components, relative to the well-characterized background of the titanium tray itself [13]. The APXS composition of this sample plus a scuffed and compacted soil sample created by the rover tread ("Portage") is consistent with average Mars soils encountered by previous missions (SO_3 + Cl ~6 wt.%) [14]; this was taken as evidence that the soil would pass easily into the sample inlet tubes. A second portion of scoop 3 was passed into CheMin and analyzed, revealing the presence of forsterite, pigeonite, augite, plagioclase, and several trace minerals including quartz, anhydrite, magnetite, hematite and illmenite [15]. The fourth and fifth scoops of Rocknest revealed similar materials [16].

SAM analysis of the fifth (and final) scoop, based on four different portions, yielded four different Evolved Gas Analysis (EGA) experiments depending on the temperature at which evolved gases were sent to the TLS versus the hydrocarbon trap and GC [17]. Heating of the sample to 825 °C EGA yielded a rich set of gases with variable overlap including H_2O, CO_2, O_2, and SO_2. These suggest the likely presence of perchlorates, sulfates and/or sulfides, and carbonates in the soil. Detection of simple Cl-bearing organic compounds (such as CH_3Cl) by the QMS does not demonstrate the presence of organics in the Rocknest soil until terrestrial contaminent souces can be ruled out. A D/H measured by TLS of ~5x terrestrial values indicates significant enrichment, suggestive of early H escape.

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