Life in the Atacama

ROVER FIELD TEST: Site C
**Introduction**

**Primary Objective** – Similar to Site B to locate, characterize, and identify biologic habitats through satellite and long-range roving (field-based and microscopic perspectives; e.g., geologic mapping, characterization, and analyses) (*smart reconnaissance; geology & biologic type often correlate in nature—driver of our approach!; Atacama?*).
Regional geologic and physiographic setting:

The regional slope of the ellipse and surrounding region is generally to the southwest, with elevations ranging from nearly 2000 m to the east to less than 1250m to the west. The regional slope is interrupted by clusters of promontories, local topographic basins, and drainages, some of which appear to controlled by major northeast- and northwest-trending tectonic structures), and materials of varying morphologic characteristics and albedo.
Satellite: Dissected terrain with varying albedo. The primary drainage is to the south-southwest. Hilly and etched unit appears differentially eroded exposing lighter materials.

Field-based: Light and dark materials: light materials comprised mostly of small, poorly sorted angular clasts (diameters < 1m), darker mostly fine-grained, angular rock materials (centimeters or less), and angular meter-sized dark blocks sourcing from topographic highs.

Microscopic: Diversity in lithology based on color (black, red, gray, white), shape (angular to rounded; some elongated), and size (generally centimeter or less). Fines (mm scale) are visible.
Interpretation/hypotheses: The white materials and dark meter-sized rocks are derived locally with possible aeolian deposition. The white materials appear to be an evaporite (resulting from standing body(s) of water and/or underground hydrogeologic activity), while the dark materials may be volcanics or evaporitic (marine or lacustrine) derived from local outcrops. In addition, fine-grained materials may also include aeolian deposits and/or volcanic airfall/pyroclastic materials. Interpretation based on spectral analysis indicates possible evaporitic materials (gypsum), alteration minerals (talc/clays), and/or hematite (difficult to ascertain whether dark materials are volcanics or sedimentary). Some of the white materials could include volcanic materials such as ash flow/ignimbrite materials. The geomorphic expression of the landscape indicates past aqueous activity (possible bodies of water, drainage—drainages and alluvial fans, and local of water, which may have been (is) conducive to life)
**Microscopic:** Plow activities appear to have partly removed the mantle of darker materials. In addition, centimeter-scale white clasts are visible in a matrix of white mm-scale materials.
Satellite: Visible are patches of light materials and dark material and scarps.

Field-based: Background: Sky appears mostly sunny, though hazy. In addition, the general location of the landing site is visible to the north-northeast. Foreground: Topographic low, which displays light albedo materials, is bounded by a scarp to the south near the present rover location. The scarp appears to extend along the margin of dark materials to the north-northwest near the margin of the hilly unit. Near the rover’s location, a greater rock abundance is visible when compared to the landing site.

Microscopic: Diversity in lithology based on color, shape (angular to rounded; some elongated), and size (generally centimeter or less). Fines (mm scale) appear less abundant then at the landing site.

Rationale: Traverse to the light albedo material located to the south-southeast.
LOCALE 29 - Sol 10

Rationale: Traverse to the light albedo material located to the north.

Satellite: Visible are patches of light materials and dark material and scarps.  
Field-based: Background: Sky appears mostly sunny, though hazy (similar to yesterday). Other promontories, which were visible yesterday on the horizon, are no longer visible. 
Foreground: Abundance of distinct rocks (relatively large ~ 15cm or greater) is considerably less than Locale 26. In addition, polygonal patterns are visible. When compared to the landing site, few if any larger dark rocks and white clasts are visible. In addition, polygonal patterned ground is thus far unique. 
Microscopic: Diversity in lithology based on color, shape (angular to rounded; some elongated), and size (generally centimeter or less). Greater percentage of white surface when compared to the non-plowed surfaces of the previous 2 localities.
**Interpretation:** The rover is now within the relatively small basin near the western margin. White materials are mantled by dark materials, which are comprised mostly of centimeter scale or less rocks. The rock materials record (not necessarily exclusive of one another): (1) sheetwash from heavy periods of precipitation, (2) local ponding to form evaporites (e.g., polygons), (3) formation of concretions and hard pans/duricrust from groundwater activity (e.g., gypsum), and (4) volcanic deposit. Dark mantle (detritus) transported during flood events from relatively local sources. Wind-related deflation is part of the resurfacing history. The scarp most likely is erosional in origin (though it could also mark a flow margin). The small topographic low could be from wind deflation and/or water erosion or from flows that thin at this particular site.
**LOCALE 30 - Sol 10**

**Rationale:** Stop along the way to the quartz-enriched (dark tone) region based on satellite observations. (Panoramic view)

**Satellite:** Visible are patches of light materials and dark material and scarps.

**Field-based: Background:** Elongated promontory(ies) north and northeast, hilly materials to west, southwest, and south and large southwest-trending valley. A road occurs along the margin of the elongated promontory to the north. **Foreground:** Mantle of dark materials is mostly visible, though a paucity of white patches can be observed. Abundance of distinct rocks (~15cm or greater) appears to be similar to Locale 26.

**Microscopic:** Diversity in lithology based on color, shape (angular to rounded), and size (centimeter or less). When compared to other locales (i.e. 26), there appears to more millimeter-sized, angular to subrounded particles in the image (obscuring the underlying white surface).
**Interpretation:** The rover is located in the satellite-based dark materials. Interpretation of rock materials is similar to that of Locale 26 \( \{2\} \) (e.g., flood deposition, alluvial fan emplacement, groundwater activity, wind deflation). Some of the detritus appears to be quartz based on the microscopic imager. Greater dark material abundance could be related topography (e.g., shielded from resurfacing processes). Some of the larger rocks appear to be granites from the spectra. This observation may help explain some of the hills with the hilly terrain (intrusive rocks cropping out through less competent materials). Spectral analysis using both TIR and VNIR indicates granites, gypsum (white patch near the rover), metamorphic materials, clays, and desert varnish.
**LOCALE 34 - Sol 11**

**Rationale:** Stop along the way to the quartz-enriched (dark tone) region based on satellite observations.

**Satellite:** Smooth plains-forming materials. Satellite-based spectral analysis indicates a prominent quartz signature.

**Field-based:**

- **Background:** Sky appears to be partly cloudy. The elongated promontory near the previous Locales are visible to the northeast. Parts of the meandering, southwest-trending primary drainage to the southwest, south, and southeast, distinct promontories and hills beyond the drainage, and northeast-trending range of promontories in the distant horizon to the northeast-east.
- **Foreground:** Dark materials appear to mantle light-colored material. Rock abundance (size ~ 15 cm or greater) appears to be less than previous Locales. In addition, a distinct cluster of rocks is visible near the rover to the north (beyond the road). Rocks appear mostly angular to subangular.

**Microscopic:** Diversity in lithology based on color, shape (subangular to subrounded; some elongated), and size (generally centimeter or less). Desert varnish is visible.
Following plow activities, linear grooves are visible indicating non-competent/”soft” near-surface materials. In addition, larger rocks are removed with a remaining soft/granular layer of materials. White rocks are exposed. When compared to other locales, particularly Locale 26, there appears to a granular/“sandy” matrix.
LOCALE 34 - 2nd strike - Sol 12

RGB_FI
C12_519
After plow

1 cm
**Interpretation:** The rover is located in the smooth-plains forming materials along the eastern margin of the primary south-southeast-trending primary drainage. The spectral signature of quartz from orbit, the diversity of lithologies (e.g., possible intrusive, volcanic, metamorphic, sedimentary/conglomerate, and quartz/chert), and the granular-like matrix (including loose/soft/sandy) may collectively indicate a paleofloodplain (older floodplain, which marks an ancient high water mark when compared to more recent fluvial activity in the primary drainage). Other processes that may have contributed to the surface expression includes alluvial-, groundwater- (e.g., white rocks exposed by plowing could be precipitates), and wind-related activities. Spectral analysis using both TIR and VNIR indicates granites, rhyolite, clays, and desert varnish. Intrusive bodies may be poking up through a less competent cover. Evaporites are believed to be related to groundwater and ponding of water. One question is how extensive is the white materials (lateral extent and depth?; layering at depth? - possibly indicated by differential erosion in the hilly unit near the landing site).
**Rationale:** Stop and sample in the main south-southeast-trending primary drainage, where light materials are visible using satellite imagery.

**Satellite:** Target site is located down gradient from outcrops of hilly materials, which are embayed by dissected materials. Hilly materials are also visible to the west and south of the target site. **Field-based:** Background: Sky appears to be mostly cloudy with thicker clouds to the southeast. Also visible are hilly materials to the west and south. Railroad tracks raise human contamination concerns. Scars are visible on the hillslope formed by the hilly materials to the south. **Foreground:** Mostly white “crusty” rock materials (fractured in places) with a paucity of medium size dark rocks (>15 cm). Overall, this Locale is distinct from the previous Locales. **Microscopic:** Mostly white, angular to subangular rocks. Rocks display dark spots (inclusion/rock fragment?, phenocrysts?, Dirt in vugs?). In addition, rock surfaces display vesicles/vugs. Millimeter-scale, angular to subrounded fines of varying color are visible among the larger white rocks.
**Interpretation:** Locale - Zoe is located in the primary south-southeast-trending primary drainage, which is highlighted by the white materials. This geologic terrain is distinct from the previous Locales. Resurfacing of Unit d2 appears to be younger than medium dark smooth plains-forming materials (Unit p2). As of yet, there is no spectra for rocks of this locality (both this Locale and the Locale at the end of Sol. 12). With this in mind, the white rocks may be volcanic or sedimentary with the darker fines of diverse lithology. A primary concern is man-made reworking/contamination at this Locale and Locale 38. White rocks are the primary constituents and locally derived.

**Regional:** Both orbital- and field-based perspectives (including reconnaissance geologic mapping) suggest that the region records magmatic, tectonic (basement structures), hydrologic/hydrogeologic (flooding, ponding to form bodies of water, and groundwater-related phenomena), and wind-related activity (e.g., deflation and transport of fines).
Field-based: Background: Mostly similar, but the clouds are fewer and Zoe moved closer to the hilly materials to the south. In addition, human contamination remains a concern. Foreground: Similar to previous Locale, but road cut is clearly visible in foreground (cut appears to be less than 2 meters). Microscopic: Post-plow activities show mostly millimeter-sized particles (much greater abundance of white). In addition, rock materials appear to be unconsolidated. Spectral analysis indicates that the white rocks are felsic volcanics (rhyolites?, ignimbrites?, etc.).
**Interpretation:** **Locale** - Zoe is located in the primary south-southeast-trending primary drainage, which is highlighted by the white materials. This geologic terrain is distinct from the previous Locales. Resurfacing of Unit d2 appears to be younger than medium dark smooth plains-forming materials (Unit p2). Spectral analysis indicates that the white rocks are felsic volcanics (rhyolites?, ignimbrites?, etc.). White rocks are the primary constituents and locally derived. **Regional:** Both orbital- and field-based perspectives (including reconnaissance geologic mapping) suggest that the region records magmatic, tectonic (basement structures), hydrologic/hydrogeologic (flooding, ponding to form bodies of water, and groundwater-related phenomena), and wind-related activity (e.g., deflation and transport of fines). The felsic volcanic rock signature is a significant line of evidence, and supports the interpretation of primary geologic processes of the region (e.g., magmatism and tectonism).
**Satellite:** Zoe is located on the eastern margin of the main south-southeast-trending primary drainage (geologic contact that separates Unit d2 from Unit p2). **Field-based:** More abundant darker “mantling” materials (observed below and near the rover) than previous location. Dark rocks appear to be angular to subrounded. The percentage of white rocks, which occur in the mantle of dark materials, is relatively small when compared to the dark rocks. Dark rock materials partly mantle a white surface, which displays polygons (cracks?, ridges?; hard to tell with the sun angle).

**Rationale:** One of the many planned Locales along a lengthy traverse (> 7km) on Sol. 13. In order to save both time and energy, the stops largely consist of imaging down near Zoe.
Rationale: Similar to previous Locale. **Satellite:** Zoe is located in Unit d2. **Field-based:** White surface is mantled by less abundant dark angular to subrounded rocks; white materials appear to be unconsolidated similar to Locale 38 {{7}}. Some of the dark rocks display white patches (some rectangular).
LOCALE 41 - Sol 13

spec_spi_pan
C13_551
LOCATE 25 - Sol 14

Back near landing site!
Results/Interpretation

The experiment resulted in the characterization of the geology along science traverses in and near the landing ellipse for Site C, including Zoe traversing through:

Interpretation/hypotheses:

(1) the white and dark rocks in and near the landing site are mostly derived in situ and/or locally. The white materials appear to be an evaporite (resulting from standing body(s) of water and/or hydrogeologic activity), while the dark materials may be igneous or evaporitic (marine or lacustrine) derived from local outcrops. In addition, fine-grained materials may also include aeolian deposits and/or volcanic airfall/pyroclastic materials. Based on spectral analysis, materials may be evaporitic (gypsum), alteration minerals (talc), and/or hematite. Some of the white materials could include volcanic materials such as ash flow/ignimbrite materials.

The geomorphic expression of the landscape indicates past aqueous activity (e.g., possible bodies of water, surface drainage, and groundwater movement, all of which may be conducive to life)

(2) smooth-plains forming materials along the eastern margin of the primary south-southeast-trending primary drainage with a spaceborne-spectral signature of quartz may mark a floodplain (e.g., a mantle overlying materials of (1),

(3) a primary drainage contains white rock materials and to a lesser extent black rock materials; spectral-based analysis indicates that there are felsic volcanics (rhyolites?, ignimbrites?, etc.), though a greater diversity of rock types may exist (e.g., evaporites, clays, igneous, etc.) derived from fluvial, lacustrine, and eolian activity,

(4) various lines of evidence (field-based and microscopic) collectively indicate that local igneous outcrops may be poking up through a less competent cover, and

(5) the region records magmatic, tectonic (basement structures), hydrologic/hydrogeologic (flooding, ponding to form bodies of water, and groundwater-related phenomena), and wind-related activity (e.g., deflation and transport of fines).