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# Steep Terrain and the Evolution of Martian Surface Environments: Implications for Habitability (and its evaluation)

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To understand the evolution of a surface environment, you must either have *direct access* to earlier surfaces in the stratigraphic record or you must have indirect access to the former surfaces from knowledge of the processes that have affected the present surface. *That is circular reasoning.*

Photo by Kjell Ove Storvik

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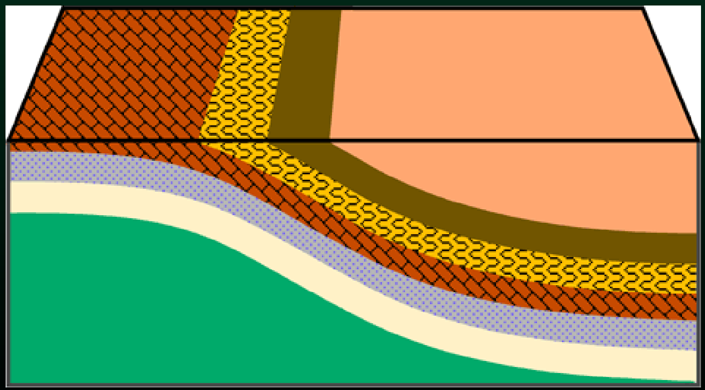
Exposed strata can provide access to more time than a flat surface, unless there are geologic processes at work that expose layers at an angle:



Mars looks pretty hostile relative to its past environment. Can we find a particularly catastrophic moment in Martian history that decreased its habitability potential?

There are four ways that we could potentially access the Martian subsurface:

1. We could drill beneath the present surface

1. We could access exposures of former surfaces at the *present surface.*

1. We might happen across volcanic ejecta. That gives an idea of what is happening beneath the surface, but is not informative regarding the past surface.

1. An impact event might excavate former surface material as ejecta. But you lose context.

# Exposed Steep Terrain Advantages

- One can access more layers of exposed former surfaces than are accessible via a modest length drill (potentially 100s of meters)
- The structural context remains in place
- One can measure some features of the present environment and compare values measured from the previous surfaces in real time

These features allow one to conduct a contemporary habitability assessment simultaneously to an examination of past surfaces. This takes the investigation out of the realm of a snapshot and enables characterization of a process--

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What things might we measure about the surface that tell us something about habitability?

| Physical | Chemical | Biological |
| --- | --- | --- |
| Altitude | Elemental abundance | Vegetation Survey |
| Latitude/longitude coordinates | Organic inventory | Biodiversity and spatial distribution (by PCR) |
| Solar radiation ($\lambda$ and intensity) | Stable isotopes of C and O | Functional diversity (by PCR) |
| Temperature of rock or soil and air | Abundance and state of water | ATP/LAL |
| Mechanical stability (slope, etc.) | Mineral content (and rock type) | |
| Electrical/magnetic environment | Total Nitrogen | |
| Wind speed, direction & variability | Volatile inventory (air) | |
| Humidity | Volatile Inventory (in rock & soil) | |
| General geomorphology | | |
| Geophysical environment (volcanism, seismicity, impact evidence, etc) | | |
| Sedimentary structures | | |

How are these measurements about the contemporary surface accomplished on former surfaces?

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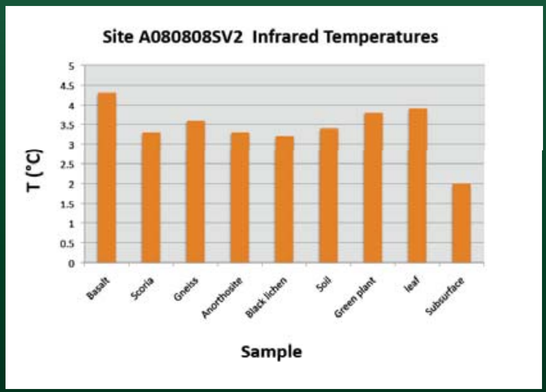
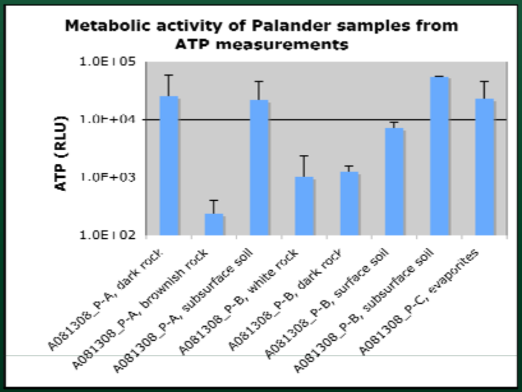
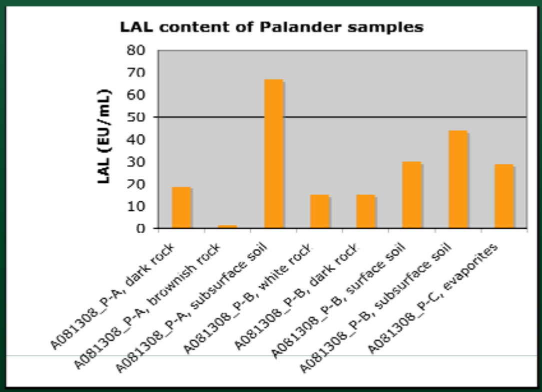
# In Situ vs "Returned" Samples

1. We could drill beneath the present surface
1. We could access exposures of former surfaces at the *present surface.*

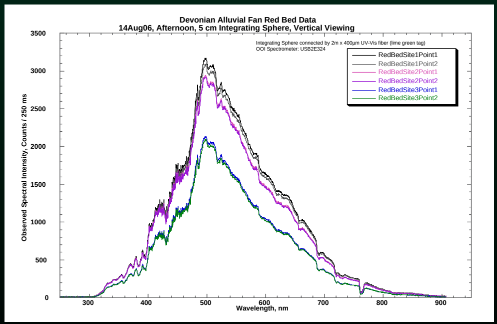



These must be done in place

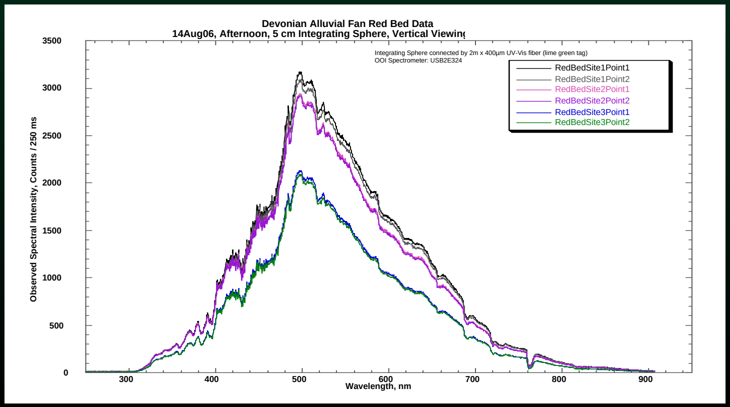
"In place" is relative. What measurements and relationships might be lost by hacking off a piece of the surface and looking at it later?



# Environmental Physics Measurements

Photo by Kjell Ove Storvik

- Ionizing radiation environment
- Mechanical environment (impacts, mass transport). This requires the big picture (literally), as well as smaller spatial scale clues.
- Electromagnetic environment
- Thermal history
- Solar environment



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# Time-resolved Measurements: Chemical composition and mineralogy

- Do chemical strata show cyclical trends or non-recurring gradients (or discontinuities)?
- Do changes in geochemistry cross mineralogical horizons? Are they diachronous or synchronous?
- Do they follow distinct textural characteristics such as grain size & shape, color horizons, etc?
- What relationship do spatially-resolved chemical measurements have to temporally resolved ones?

# "Desirements" Challenges

- How do you minimize surface disturbance?
- How do you maintain the same distance from the surface at each measurement point?
- How does the robot decide upon sampling intervals?
- Should the robot make its own digital elevation models?
- Should it rappel down to full extent and then climb up?
- How many sites along a cliff or crater wall should be representative of the larger structure? In other words could we have multiples units that provide time-synched and elevation-synched measurements?
- Can communications be networked between units and a meteorology package on a platform?

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# Summary

1. Steep terrain access enables near real-time comparison of both present and past surface environments.

2. Chemical, mineralogical and textural measurements are made in context.

3. We already have an idea of some of the technical challenges:
   - tether or not?
   - maintaining focal lengths for all measurements
   - Acquisition of samples: small cores, powders, how to store samples and how to hand them off later

4. A significant amount of thought needs to be given to operational design.