Venus: Characterizing Thermal Tectonic Regimes. M. B. Weller[1*] and M. S. Duncan[1], [1]Department of Earth Science, Rice University, Houston, TX 77005, USA (matt.b.weller@rice.edu).

Target:

Local geochemistry and heat flow measurements from 3 target areas: (1) NE slope of Beta Regio near 31.01° N, 291.64° E; (2) SE Ishtar Terra near 61° N, 15° E; and (3) Lavinia Planitia, 50° S, 350° E.

Science Goal(s):

1. Surface geochemistry II.B.1; III.A.2; major and minor element abundances (Si, Fe, Mg, K, Na, Al, Ca, Ti), trace elements abundances (e.g. Th, U), volatiles (C, H, S); major mineral identification.

2. Surface heat flow measurements II.A.3 II.B.1; in the 3 target locations.

Discussion:

The current and past tectonic states of Venus are hotly debated. It is currently unclear if Venus operates within a stagnant- to highly sluggish-lid [e.g., 1,2] or within an episodic regime [e.g., 3-5]. This uncertainty is extended to if the planet may have operated within a mobile-lid regime in its past, and whether an extreme surface temperature change may have preceded a switch in tectonic regimes [6-9]. A large amplitude increase in the surface temperature over geologic time scales leads to an increase in temperature within the interior of the planet, as is shown by scaling theory and numerical models [e.g, 6-9]. All things being held equal, this leads us to the conclusion that high surface temperatures should translate into a higher internal temperature for all tectonic regimes. Higher internal temperatures may lead to higher degrees of mantle melting, changing the composition of erupted material. This effect may be detectable in the surface composition and mineralogy using Alpha Particle X-Ray Spectrometer (APXS) type instrument. Additionally, heat flow measurements can help to constrain the thermal evolution of the lithosphere in these regions.

The net result of increasing surface temperatures is to increase the mantle geotherm, potentially intersecting the mantle solidus. Under this view, there should be an evolution in the geochemistry of melts produced, reflecting a change in the mantle potential temperature. For Venus, this may be a mantle potential temperature that increases in time. For this reason, we target 3 landing locations that encompass a diversity of potential formations environments and times.

1. The NE slope of Beta Regio was chosen for two reasons. First, it overlaps with the Soviet Venera 9 mission, and can be used to 'ground truth' some of those results (K, U, Th). Secondly, Beta Regio likely was formed under a thinner lithosphere and may reflect an older time period of mobile-lid tectonics [6].
2. The site in Fortuna Tessera was chosen due to its location in the 'highland' plateaus and due to its relative age. The plateaus and the tessera are likely products of an early stage of convective evolution in Venus [e.g., 10], similar to that of Beta Regio. Due to this similarity in formation ages/convective regimes, results can be compared between the two sites.
3. The last site is Lavinia Planitia, an example of younger lowland plains. This region is covered in highly deformed effusive volcanics that likely formed under the current convective state of Venus. Lavinia Planitia, a likely deformation belt on Venus [11], may provide a contrast to the two older environments.

We propose these sites for collecting mineralogical and heat flow data. An APXS type instrument measures chemical element abundances in sample rocks, from which mineral compositions and abundances can be calculated. The technique is well-characterized (at least for Mars), has wide range of unambiguous element identification, and has been used successfully on many missions to Mars. Calibration under venusian conditions will be performed prior to surface measurements, with relevant geologic samples to be determined. An onboard calibration target (e.g. basalt as for MSL [12]), will be used to check the calibration, and potentially be used to determine weathering rates of basalt on the surface of Venus depending on the lifetime of the instrument. The instrument would be placed on an arm that could be extended to multiple sides of the lander and be placed in direct contact with the ground for a period of approximately three hours to complete a full analysis. This instrument could be coupled with a brush or RAT to characterize and/or remove potential weathering rinds, and a microscopic imager that would visually characterize the analysis site (grain size, color, etc.).

Due to the placement requirements of this instrument on the surface, an addition of a flux plate [e.g., 13] to take high precision heat flow measurements (±5 mW/m^2) would be a valuable addition. Heat flow can be used to help constrain both convective styles and lithosphere thicknesses. Predictions for the heat flow of Venus range from a few to 60 mW/m^2 [e.g., 4, 14]. All things being equal, lower heat flows (< 20 mW/m^2) are indicative of a long standing stagnant-lid (on the order of a few 100 My). Higher heat flows are indicative of a more active lid state (i.e., closer to an overturn, or to a Mobile-lid state). Heat flow measurements can be used to infer the current, and recent tectonic regime, and used in concert with a geochemical instrument may allow for an estimation of the mantle potential temperature at the time which the lavas formed [e.g. 15].

The requirements for these measurements would be a set of 3 landers on the surface, perhaps deployed via atmospheric balloon package. Once on the ground, the lander would need to operate for a period of time extending between 5 and 24 hours. Longer time frames are for multiple analyses by the APXS system. As contact must be made and maintained with ground, very rocky or uneven terrain (at scales larger than the lander) would best be avoided. The flux plate would need to be in operation before and after the APXS would come online as there exists the possibility that the APXS could induce false readings in the heat flux measurements. APXS technology could be modified from the current curiosity mission for the venusian environment [e.g., 16].

References:

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