

**COMPOSITIONAL VARIATIONS WITH DEPTH IN ICELANDIC CORES: APPLICATIONS TO INTEGRATED MARS REMOTE SENSING DATA SETS.** U.N. Horodyskyj, M.B. Wyatt, Brown University, Department of Geological Sciences, Providence, RI 02912

**Introduction:** The Martian crust is globally dominated by primary igneous minerals found in basalt (plagioclase, pyroxene and olivine) with limited degrees of surface alteration at high-latitudes [e.g. 1-4]. On local scales, a diversity of secondary hydrated mineral-phases (phyllosilicate, sulfate, opal, and carbonate) has been identified [e.g. 5-6]. Ice and transient water appear to have a regional influence on the production of secondary phases, whereas the effects hydrothermal alteration and prolonged high water/rock ratios are discovered in unique and locally diverse geological settings. The depth of alteration in the Martian crust is, however, poorly constrained. This is important for understanding both the timing and duration of aqueous-related processes on Mars.

For example, GRS measured chemistry in Acidalia Planitia reveals a basaltic crust (based on measured Si abundances) with little evidence of aqueous fractionation of elements [7-8]. The relatively constant K/Th ratio across Mars is not consistent with subaqueous or deep (centimeters to meters) subaerial aqueous weathering as K would fractionate from Th in both scenarios. However, TES and OMEGA observations of Acidalia Planitia are most consistent with basalt and alteration coatings of amorphous Si-Al-Fe rich mineral-phases [9].

To better constrain the regional effects and depth of alteration at high-latitudes on Mars, we are examining compositional variations with depth in Icelandic basaltic cores. Our goal is to develop a consistent geologic model with integrated GRS chemical and TES and OMEGA mineralogical data sets. In this study, we report initial near-infrared spectral properties and XRF measured chemistry of Icelandic basaltic cores and investigate the extent of aqueous alteration at high-latitudes on Mars.

**Iceland:** A young volcanic island in the North Atlantic, Iceland has an abundance of basaltic rocks which have been subjected to a variety of physical and chemical weathering conditions. The interior, specifically, in the rain shadow of the Vatnajökull icecap, includes basaltic deserts and terrain covered in extensive lava flows and tephra falls from the Krafla volcanic system and Askja caldera. Areas north and south of the icecap have been subjected to occasional jokulhaup activity, resulting in flood plain deposits, later subject to aeolian redistribution of materials. Basaltic materials in Iceland's interior appeal to a possible early model of the Martian environment and thus serve as a good terrestrial analog for our sampling depth questions.

**Field Approach:** A total number of X core samples were collected across Iceland's interior region using a specially modified lever and coring device. Core samples are 60 cm deep, which is analogous to GRS sampling depths. Surface rocks and soils were also collected for each sampling location. In the field, cores were initially classified according to common visual characteristics, based primarily on color and texture (ie – light, “rockier” tephra cores vs. dark, “fine” basaltic sandy cores). For this study, two largely basaltic cores were down-selected for chemical and spectral analyses. The samples include representatives of river plain/sand deposits from Jokulsa, north of the icecap, and Skaftafell, south of the icecap (post-glacial).

**Chemical Analyses:** The Jokulsa and Skaftafell cores were initially scanned with a hand-held XRF gun to obtain Fe, Ca, and K measurements every 2 cm, with two 60-sec count intervals. Ground-truth points (with measurements made at UMass-Amherst via standard XRF methods) were then selected for particularly homogeneous sections within the cores (typically on the 2 cm scale) to assess the accuracy of the hand-held XRF scanner data.

Figure 1 shows an image of the Jokulsa basaltic core with hand-held XRF scans of Fe, Ca, and K. Apart from the obvious tuff layer at ~ 45 cm, resulting in a decrease in Ca, there are no significant variations across Fe, Ca, and K for the Jokulsa core. Ground-truth XRF data from 10-12 and 32-34 cm (red boxes on image) are consistent with the hand-held XRF data providing confidence in the relative homogeneity of the basaltic core. The average bulk SiO<sub>2</sub> content for the Jokulsa core is 50.15 wt. %.

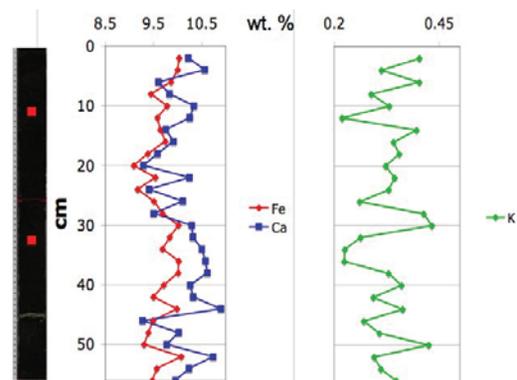


Figure 1. Fe, Ca, and K measurements, down-core, for Jokulsa. Increases in K correlate with decreases in Fe and Ca and vice versa.

The Skaftafell core in Figure 2 shows differing Fe and Ca in the upper 5 cm, a result of recent flood

deposits capping the core, and at 40 cm due to a layer of light fine-grained material. Ground-truth XRF data from 20-22 and 26-28 cm (red boxes on image), are consistent with the hand-held XRF data providing confidence in the vertical distribution of elements. The average bulk SiO<sub>2</sub> content for the Skaftafell core is 50.41 wt. %.

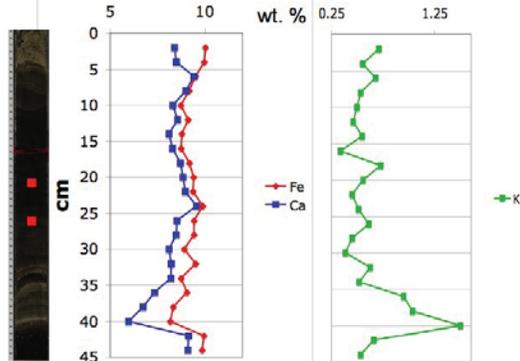


Figure 2. Fe, Ca, and K measurements, down-core, for Skaftafell.

**Future Chemistry Work.** Both the Jokulsa and Skaftafell cores will be further analyzed with a high-resolution XRF scanner at the University of Minnesota for detailed bulk chemistry (including SiO<sub>2</sub>). XRF measurements of Th abundances will also be completed to calculate K/Th ratios for comparison with GRS data.

**Near-Infrared Spectral Analysis:** The two basaltic cores were measured down-sample, every centimeter, using an ASD FieldSpec for a preliminary assessment of mineralogical changes with depth and to cross-correlate with chemistry data.

The Jokulsa core (Figure 3) does not show significant spectral variations with depth, similar to the chemistry results, with the exception of the tuff layer at 52 cm. The basaltic sediments show a characteristic mafic absorption near  $\sim 1 \mu\text{m}$  while the tuff layer has a relatively featureless spectrum with a blue slope (decreasing reflectance with wavelength). A representative, locally derived basaltic rock from Jokulsa is spectrally similar to basaltic sediments at depth, suggesting a relatively fresh natural surface.

The Skaftafell core (Figure 4) shows more spectral variation than the Jokulsa core with a characteristic mafic absorption near  $\sim 1 \mu\text{m}$  and absorption near  $\sim 1.4 \mu\text{m}$ , possibly from the overtone of the OH stretch. A representative, locally derived basaltic rock from Skaftafell, however, has a relatively featureless spectrum with a blue spectral slope (decreasing reflectance with wavelength). This spectral signature may be explained by secondary coatings masking out mafic mineralogical signatures.

**Future Spectral Work.** Spectral measurements of samples with depth will be made with the Brown University RELAB and Arizona State University Thermal Emission Spectrometer Laboratory facili-

ties. This data will be used for quantitative modeling of mineral compositions and abundances and for comparison with the OMEGA and TES data sets.

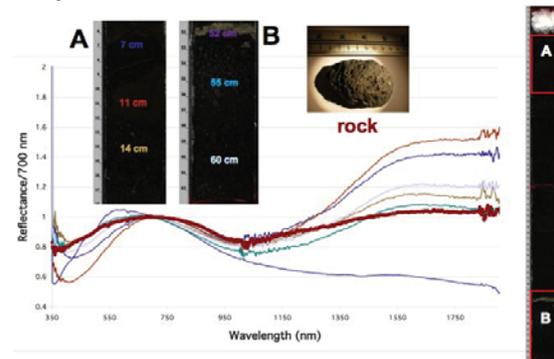


Figure 3. Spectral data, pinned at 700 nm, from the Jokulsa core. A and B correspond to upper and lower parts of core, from where spectral data is displayed. Rock, shown in dark red, demonstrates similarity to down-core spectra.

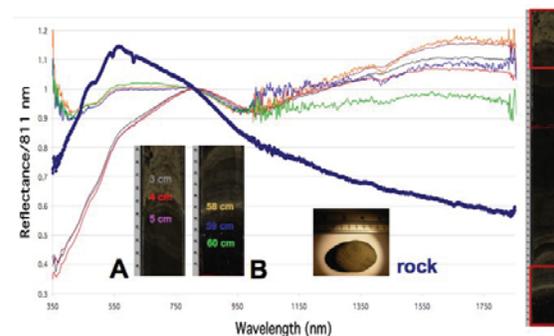


Figure 4. Spectral data, pinned 811 nm, from the Skaftafell core. A and B correspond to upper and lower parts of the core, from where spectral data is displayed. Rock, shown in dark blue, displays negative blue slope and is clearly different from spectra collected down-core.

**Future Integrated Analyses:** Preliminary chemical and spectral results indicate basaltic core samples and surface rocks show both primary and secondary compositions. A major goal of ongoing work is to create a compositional cross-section of combined spectral, mineralogical, and chemical properties of Icelandic core samples for comparison to OMEGA, TES, and GRS data sets. This work will help to constrain the effects and depth of alteration at high-latitudes on Mars

**References:** [1] Bandfield et al. (2000), *Science*, 287, 1626. [2] Wyatt et al. (2004) *Geology*, 32, 644-648. [3] Mustard et al. (2005) *Science*, 307, 1594-1597. [4] Rogers and Christensen (2007), *JGR*, 112, E01003. [5] Bibring et al. (2006), *Science*, 312, 400. [6] Ehlman et al. (2008), *Science*, 322, 1828. [7] Karunatillake et al., (2006), *JGR*, 111. [8] Taylor et al. (2006), *JGR*, 111. [9] Michalski et al. (2006) *JGR*, 111, E03004.