QUANTITATIVE CHARACTERIZATION OF WEATHERED ROCK SURFACE TEXTURES AND EFFECTS ON VNIR SPECTROGONIOMETRY. L. E. Duflot*[1], M. D. Kraft[1], M. S. Rice[1], S. A. Curtis[1], K. E. Lapo[1] ,[1]Western Washington University, Bellingham, WA, USA *duflotl@wwu.edu

Introduction: Visible/near-infrared (VNIR) spectroscopy is commonly used to characterize near-surface composition and alteration processes on Mars [e.g., 1]. Compositional characterization of weathering rinds and coatings is key to the study of Martian surface processes and paleoclimate reconstruction. Alteration of rock surfaces is caused by aqueous weathering, formation of rock coatings, or physical weathering such as aeolian abrasion. Alteration processes can result in compositional changes to rock surface compositions that are reflected in their spectra as various absorption and reflectance features, or changes in slope [2-5]. However, alteration can also result in textural changes to rock surfaces, which is generally overlooked in spectroscopic studies of weathered surfaces.

We are investigating how rock alteration affects microscopic surface texture and, in turn, how surface texture affects photometric properties, as measured by VNIR spectrogoniometry [6-8]. Our earlier efforts used 3-dimensional visualization of scanning electron microscope (SEM) images to qualitatively assess the surface roughness of altered rock surfaces [9].

In this study, we quantify the microscopic roughness of altered rock surfaces, using the software MountainsSEM® from Digital Surf to determine sample topography from stereo-pair SEM images. We use these models to derive surface roughness for comparison to spectrogoniometric VNIR data. Further, we show that rocks altered in different ways have different roughness characteristics, which contribute to the rocks' photometric characteristics.

Method: The surface topography of three chemically and/or physically-altered natural basalt surfaces – an aqueous weathering rind, a rock coating and a ventifact (Table 1) – was measured using stereo pair SEM images. These were backscattered Electron (BSE) shadow images taken with a Tescan Vega 3 SEM. Samples were imaged under variable pressure (10-20 Pa), with a 10 keV beam at 25 mm working distance. Stereo pair images were processed with MountainsSEM® to derive surface topography. Then, a metrologic filter was applied to quantify the surface roughness based on the calculated 0.08-mm waviness of the target surfaces.

Table 1. Naturally weathered rock samples.

Sample	Description
Ferrar Ventifact	Wind-abraded Antarctic basalt, strongly forward scattering
CRB_Fs	Fracture or joint surface of basalt with rock coating, forward scattering
CRB_Bs	Basaltic weathering rind with disaggregated surface, backscattering

Results: BSE shadow images of the basalt surfaces qualitatively illustrate different surface roughness between samples, and the differences in roughness are quantified in the calculated models (Fig. 1). The surface texture can be influenced by rock type and composition, but the surface textures of the basalts examined here resulted from the type of alteration each experienced.

These samples offer distinguishable roughness and textures for relatively similar mineralogy. The physical abrasion of the Ferrar ventifact resulted in a very smooth surface. The Columbia River Basalts (CRBs) were from the same outcrop but were exposed to different styles of alteration. One is rough and disaggregated, while the other is smoother and coated.

Previous spectrogoniometric observations of the two CRB rocks showed that the rough surface was backscattering while the smoother, coated surface was forward scattering [6,9]. Goniometric spectra of the ventifact showed it to be strongly forward scattering.

Discussion: The samples' roughness profiles can be correlated to their scattering behavior by the root mean square (RMS) height of the surface and patterns on extracted roughness profiles (Fig. 2). CRB_Bs has the highest RMS height out of the samples, and its roughness profile is the least smooth. This observation correlates with the backscattering behavior of the sample. The RMS height for CRB_Fs is half that of the backscattering sample and is overall smoother, although still containing significant "bumps." Finally, the ventifact has a very low RMS value compared to the CRBs as well as a smooth roughness curve and is the most forward scattering sample. RMS height values were calculated from the full image roughness (Fig. 1) while profiles (Fig. 2) were extracted from single line transects to help visualize surface roughness.

Conclusions and Future Work: We used stereo-pair SEM images and the software MountainsSEM to create a model for roughness quantification of altered rock surfaces. We showed that surface roughness varies depending on the alteration style affecting rocks and correlates with their photometric characteristic. Rougher surfaces have higher RMS height and backscatter, while smoother surfaces have lower RMS value and forward scatter. In our ongoing investigation, we will characterize surface texture for a larger set of weathered rocks including andesites, dunites [7], and additional basalts. We will use those textures to better understand the effects of weathering on spectrogoniometric observations. With more data we will seek out relationships between roughness and scattering behavior, which can be used to assess VNIR spectra from weathered rocks on Earth and Mars.

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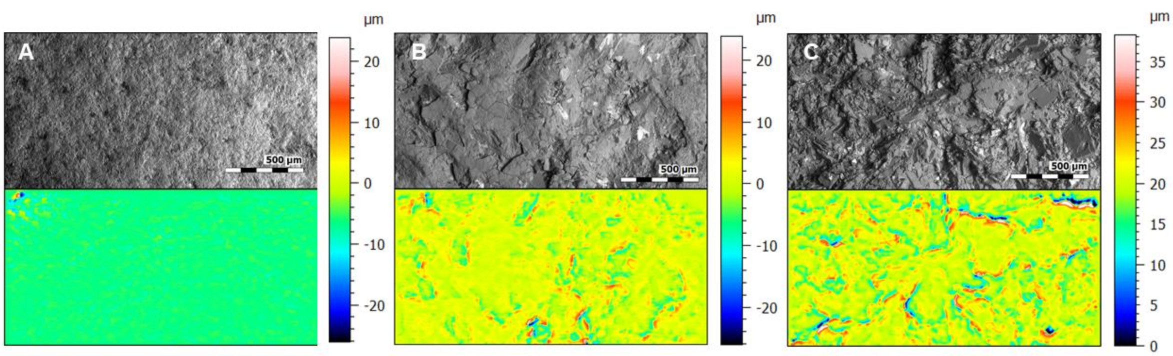

Figure 1. SEM image (top) and calculated surface roughness (bottom) of the same area for (A) Ferrar ventifact, (B) CRB_Fs, and (C) CRB_Bs.

Figure 2. Profiles of calculated roughness for each of the weathered basalt surfaces, and corresponding values of RMS height calculated from the full roughness image.