

ANALYSIS OF IRON-CONTAINING WEATHERING PRODUCTS IN SERPENTINE SOILS AND THEIR IMPLICATIONS FOR MARS T. A. Bamisile¹, E. M. Hausrath¹, O. D. Tschauner¹, Z. R. Harrold¹, C. Adcock¹, C. M. Phillips-Lander¹, S. Gainey¹ and R. Gabriel¹. ¹ *Department of Geoscience, University of Nevada, Las Vegas, Nevada, 89154* bamisile@unlv.nevada.edu

Introduction: Abundant X-ray amorphous material has been detected at Gale Crater by X-ray diffraction (XRD) using CheMin. Approximately 27% - 40% X-ray amorphous material [1,2] has been found intermixed with primary basaltic minerals at the Rocknest aeolian bedform. In XRD patterns, it was best fit by either basaltic glass or allophane (a hydrous aluminosilicate with a molar Si: Al ratio of typically 1:2 or 1:1), although it is believed based on chemical data to contain Fe [1,3]. The X-ray amorphous material is also volatile-rich based on Sample Analysis at Mars (SAM), which suggests that the amorphous material may contain secondary phases [1,2].

Similarly, John Klein and Cumberland (mudstone samples from Yellowknife Bay in Gale Crater), contain basaltic minerals, calcium sulfates, iron oxide or hydroxides, iron sulfides, trioctahedral smectites, and about 30% X-ray amorphous materials [4] that may be similar to Fe-containing allophane [5]. Confidence Hills, Mojave 2, Telegraph Peak and Buckskin (samples from the Murray formation in Gale Crater) contain 27 to 54% amorphous materials [6], and recent samples measured by CheMin, Marimba, Quela, and Sebina contain approximately 50% amorphous materials with variable Fe concentrations [7]. Amorphous or nanocrystalline materials, including materials believed to be allophane and ferrihydrite, have also been previously detected on Mars from orbit [8,9].

To better understand the identity and conditions necessary for the formation of Fe-rich X-ray amorphous weathering products, like those potentially present on Mars, we are investigating weathering products formed in Fe-rich and Al-poor terrestrial serpentinite soils from the Trinity Ultramafic Body of the Klamath Mountains, California. These soils have been recently deglaciated [10] and were formed under a cool, Mediterranean-type climate. The short timeframe of weathering in these recently deglaciated environments is relevant to potentially limited water-rock interactions occurring on Mars.

Methods: We collected serpentinite-derived soils from the Trinity Ultramafic Body at 1) a poorly drained area at the foot of Eunice Bluff (N41°20'11.3" 122°35'24.3"W, 2062 m elevation), and 2) at the foot of a hillslope of serpentinite rock near Deadfall Lake (N41°18'52.1" 122°30'05.3"W, 2199 m elevation), and collected a serpentinite-rich till near Kangaroo Lake as part of our previous work [11]. Serpentinite-derived soils were collected by digging a soil pit to the point of

refusal [12], and samples were collected from each soil horizon using a spatula that had been previously cleaned with 70% ethanol. Samples were placed in sterile Whirlpak® bags and stored in a cooler until returned to the laboratory. Samples were stored at 4°C in the laboratory before analysis.

Isolation of clay-sized materials: The clay sized-fraction was isolated from the soils via flocculation and centrifugation following methods modified from Iyoda et al. [13]. Briefly, 10 g of soil was weighed into a 250mL LDPE bottle, and 25 – 50 mL of 18.2 MΩ deionized water was added to each sample. The resultant slurry was sonicated at 40kHz for 30 mins, and the suspended fraction was pipetted into a 25mL centrifuge tube. Sodium chloride was added to the suspension to make up a 1M NaCl concentration, and then the mixture was shaken in a shaker bath at 45 rpm for 30 mins to promote the formation of flocs.

Samples were then centrifuged at 11,000rpm for 5 mins to form a pellet of the clay-sized fraction. The supernatant was decanted, and the pellet was washed 2-3 times to remove the NaCl by adding 18.2 MΩ deionized water, agitating and centrifuging the sample, and then decanting the supernatant.

Following centrifugation, the samples separated into visually distinct layers, and during the first or second washing, the topmost layer of samples became resuspended in the supernatant. This fraction was collected separately by decanting into a 25mL centrifuge tube and centrifuging for 5 or 10 mins. All collected materials were frozen for at least 24 h and then freeze-dried prior to characterization.

Material Characterization: Freeze-dried materials were examined by X-ray diffraction (XRD) to determine if broad diffraction patterns consistent with amorphous or poorly crystalline materials were present. XRD analyses were performed at NASA Johnson Space Center and the XRF/XRD Laboratory at UNLV. Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS) were used to examine the morphology and chemistry of the materials, respectively at the Electron Microanalysis and Imaging Laboratory (EMIL) at UNLV. Synchrotron micro X-ray fluorescence (μXRF) was used to obtain chemical maps of the isolated fraction on the scale of individual grains. μXRF was performed at the Lawrence Berkeley National Laboratory, beamline 13-IDE.

Results: Elemental maps of the materials suspended in supernatant from Kangaroo Lake analyzed by μ XRF indicate that the samples contain Fe, Ni, and Cr (Fig. 1). SEM images of material suspended in the supernatant had a platy morphology (Fig. 2). In contrast, the bulk clay-sized fraction had a more sub-angular grain morphology.

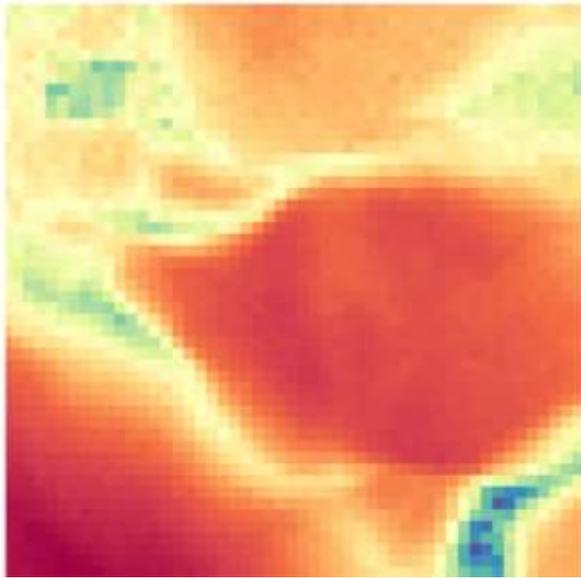


Figure 1. A μ XRF map of Fe (red) and Ni (blue) in a grain suspended in the supernatant measured at Lawrence Berkeley National Laboratory; beamline 13-IDE. (Spot size: 2 μ m)

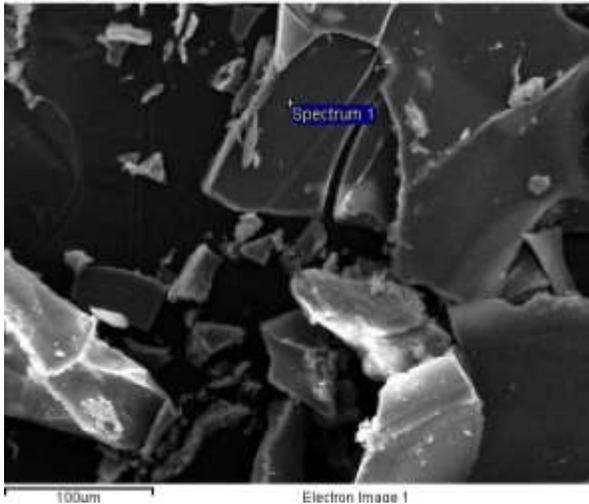


Figure 2. SEM image of the platy morphology of particles that remained suspended in solution

XRD analyses of materials in the bulk clay-sized fraction from all sites indicate the presence of primarily serpentine minerals, and that therefore minimal weathering has occurred. However, XRD analyses of the fraction suspended in the supernatant suggest the pres-

ence of poorly crystalline/amorphous materials (Fig. 3).

Discussion and Conclusions: This work suggests that Fe-containing poorly or nanocrystalline materials are being formed as weathering products in terrestrial serpentine soils. These weathering products, which appear similar to previous laboratory syntheses of Fe- and Mg-containing smectites [14], have the potential to shed light on possible Fe-containing amorphous/poorly crystalline materials on Mars.

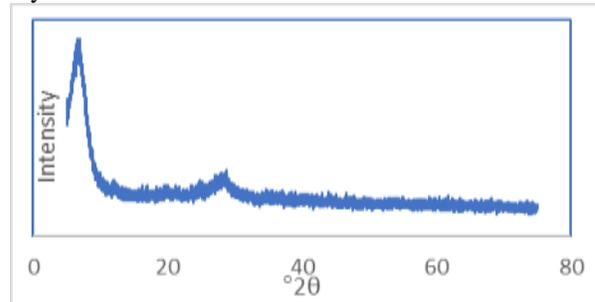


Figure 3. XRD pattern of a sample collected from the suspended fraction.

Future investigations will examine materials from the Trinity Ultramafic Body as well as serpentinites weathered under arid conditions in Nevada [15] to better understand the effect of different climatic conditions on the formation of secondary weathering products. We will use transmission electron microscopy for single grain scale examination, sequential extractions, and glycolation to differentiate smectitic clay minerals present. These analyses will help expand our understanding of Fe-rich poorly crystalline materials on Mars.

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