

ROCK SUITES OF ENDEAVOUR CRATER, MARS: COMPARING PERSEVERANCE VALLEY TO THE FLOOR OF SPIRIT OF ST. LOUIS CRATER. M. C. Bouchard¹ and B. L. Jolliff¹, ¹Dept. of Earth & Planetary Sciences, Washington University, St. Louis, MO 63130 (mcbouchard@wustl.edu).

Introduction: The Mars Exploration Rover Opportunity is currently exploring the rim of the 22 km diameter, Noachian-aged Endeavour crater [1-4]. An objective of the current extended mission is investigating the origin of Perseverance Valley, an ancient feature that cuts through Endeavour's Western crater rim. Hypotheses for the valley's formation include: 1) wind abrasion, 2) ice wedging, 3) flowing water from a catchment basin, 4) mass wasting along a radial fracture, or some combination of these mechanisms [1-2]. Microscopic Imager (MI) and Panoramic Camera (Pancam) imagery support the interpretation that wind abrasion has played an important role in recent modification of the valley, but the valley's origin remains in question [1-2]. This abstract explores comparisons between the composition of rocks within Perseverance Valley (PV) and other rock suites observed along the rim of Endeavour crater in search of possible constraints on the origin of PV.

Data & Methods: The bulk chemical compositions of rock targets are measured by the Alpha Particle X-ray Spectrometer (APXS) [5], whereas the MI and Pancam provide imagery for contextual and textural comparison [6-8]. Individual rock and rock-suite compositions are compared using a hierarchical cluster analysis and an error-weighted χ^2 similarity index [9]. Rock compositional relationships are explored further with a multi-component mixing model. Owing to loose surface material APXS analyses were done without surface treatment by the Rock Abrasion Tool. Clustering and similarity index (SI) values can be affected by the presence of dust and soil on unbrushed targets, so compositions were also compared on a normalized SO_3 - and Cl-free basis.

Similar Rock Suites: Hierarchical Cluster and SI analyses indicate that the targets on the floor of Perseverance Valley are most similar to the rock targets analyzed within Spirit of St. Louis crater, especially on a SO_3 - and Cl-free basis. Spirit of St. Louis crater is a 25-35 m ovoid feature at the entrance of Marathon Valley [10].

Perseverance Valley Rock Targets: As of the end of 2017 (sol 4956), seven targets have been analyzed with the APXS in Perseverance Valley. The targets were analyzed within 50 m of each other in the upper third of Perseverance Valley (Fig. 1). The integration field of view (iFOV) of targets Zacatecas (sol 4787), Albuquerque (4854), Durango (4916), and Carrizal (4943) are filled by loose bedrock material, soil grains, and rock cobbles (Fig. 2). The Parral (4794) and Mesilla (4895)

iFOV are filled with a single cobble, while the Bernalillo (4861) and Bernalillo Offset (4865) targets are dominated by a single cobble (Fig. 2).

Spirit of St. Louis Crater Rock Targets: Four rock targets were analyzed with the APXS in the interior of the Spirit of St. Louis (SOSL) feature (Fig. 1). The Donald A. Hall (4023) and Harold M. Bixby (4013) iFOV are filled by wind-etched bedrock, while the iFOV of the Lambert Field target (4003) is filled by a fine-grained rock from an outcrop. The fourth target analyzed within SOSL was the Lindberg mound target, Roosevelt Field (4009). Roosevelt Field is a member of the "blue rocks" and is dissimilar to the other rocks within SOSL and analyzed so far in PV [10].

Summary of Results: The PV rocks are interpreted as members of the Endeavour crater impact breccia, the Shoemaker formation. This interpretation is supported by cluster and SI analysis. When SO_3 and Cl are included in the analysis most Perseverance Valley targets (Zacatecas, Albuquerque, Bernalillo, and Durango) are within the compositional range that defines the Shoemaker formation, with the exception of SO_3 , which is higher in the SOSL rocks than in typical Shoemaker materials by a factor of two. When SO_3 and Cl are removed and compositions renormalized to 100, the SOSL and PV targets have 1-2 wt% higher SiO_2 than typical

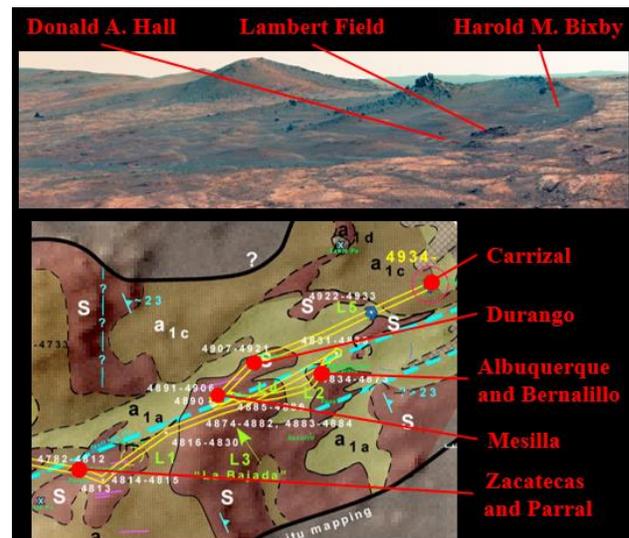


Figure 1: Top: Pancam mosaic of SOSL feature showing the location of three APXS rock targets in red (PIA19394, NASA/JPL-Caltech/Cornell/ASU). Bottom: Perseverance Valley with the yellow Opportunity rover traverse and provisional geologic units mapped by Larry Crumpler overlain on a HiRISE base image. Blue dashed lines represent potential radial fractures in PV, and the locations of APXS targets are annotated in red.

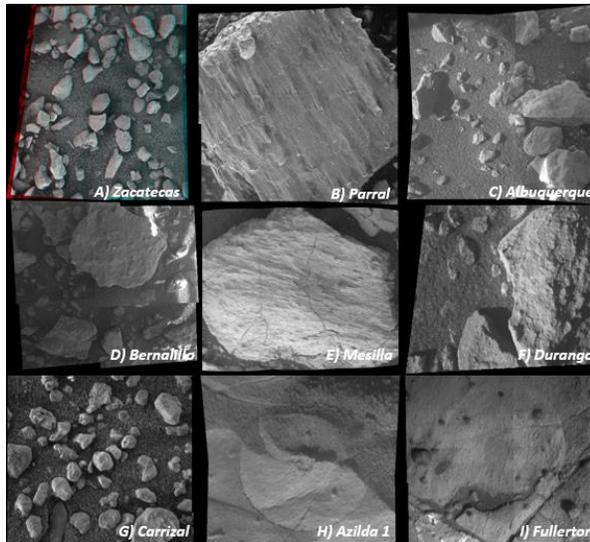


Figure 2: MI images of the PV targets (A-G), and the Matijevec targets Azilda (H) and Fullerton (I). The brushed circle visible on Azilda (H) is ~4.5 cm in diameter [11].

Shoemaker compositions, extended by the effect SO_3 has on the normalization (Fig. 3).

The Parral and Mesilla cobbles have distinct compositions compared to the rest of PV. On a SO_3 - and Cl-free basis Parral is highly similar to the Matijevec formation targets Fullerton and Azilda [12]. The Matijevec rocks are a pre-impact mudstone with weather resistant concretions [13]. Parral does not contain the “newberry” concretions but does contain resistant angular clasts. Parral and Mesilla may represent an allochthonous population of cobbles that have been deposited in PV (Fig. 2).

On an SO_3 - and Cl-free basis the Perseverance Valley targets (excluding Parral) are highly similar to the rocks analyzed within the SOSL feature (Donald A. Hall, Harold M. Bixby, Lambert Field). Differences in composition between the two rock suites can be further reconciled by considering the end-member components within the APXS iFOV. An average of PV target compositions can be modeled as a mixture of three components: average martian soil, cobbles of Parral composition, and bedrock similar to the SOSL feature floor. This interpretation is supported by good fits using a three-component mixing model.

Relationship between Perseverance Valley and the Spirit of St. Louis feature: SOSL is located at the mouth of Marathon Valley, North of PV. Both locations have Shoemaker-like bedrock covered with soil and pebbles. The SOSL feature is surrounded by a quasi-circular zone of “red” material, determined to be enriched in silica and oxidized. This “red zone” is an alteration zone that may have once been a conduit for aqueous fluid flow [14]. In PV we see “red” lineations oriented

subparallel to the down-valley direction [15], but have yet to visit or do in-situ analysis on one of these zones.

One of the hypotheses for the origin of the valley is that weakening along Endeavour crater radial fractures might have made PV a favorable location for downslope mass wasting, or erosion by ice, or flowing/seeping water, however supplied. The fact that we see evidence of alteration along such fractures and the similarity of compositions of PV materials to those within the and SOSL feature is intriguing and perhaps points to a similar post-Endeavour crater processing or sourcing of materials, yet to be discovered by ongoing exploration of the valley and its bedrock by the Opportunity rover.

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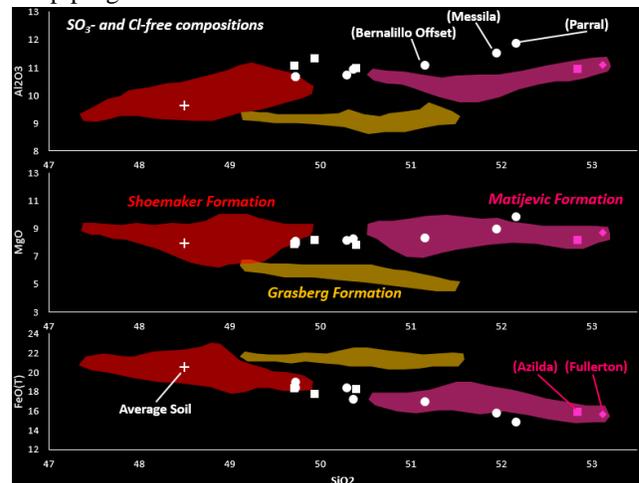


Figure 3: Composition plots comparing SO_3 - and Cl-free SOSL rock compositions (white squares) and PV compositions (white circles). Colored fields represent Endeavour rock formations (Shoemaker: red, Grasberg: orange, and Matijevec: magenta). The PV compositional variance is bounded by the SOSL targets (white squares), Average Soil (white + symbol), and the Parral and Mesilla cobbles.