INVESTIGATING HYDROTHERMALLY ALTERED BASALTS IN LONG VALLEY, CALIFORNIA: POTENTIAL ANALOG FOR ALTERED BASALTS ON MARS. P. D. Casbeer[1], and R. V. Patterson[1,2], [1]Jacobs, NASA Johnson Space Center, Houston, Texas, (patrick.d.casbeer@nasa.gov), [2]University of Houston.

Introduction: The Long Valley Caldera in California is a well-studied geological site, but its potential as a Mars analog is relatively unexplored. The caldera shows evidence of hydrothermal activity and alteration of basalt units [1], but prior research has not focused on this. Understanding alteration trends and geochemical signatures in basalt could prove useful in our understanding of Martian geology. Research on Mars has shown alteration trends [2, 3, 4], but the exact mechanisms behind these, such as the influence of water, heat, and other environmental factors, remain enigmatic.

We identified a single basalt flow in Long Valley Caldera, California, that uniquely houses both fumarolic and hydrothermal alteration regimes [5]. By sampling throughout the basalt unit (Fig. 1), we aim to characterize the connections between types, degrees, and durations alteration mechanisms, along with the resultant mineral phases and textures, to better understand rover and orbital data of Mars basalts.

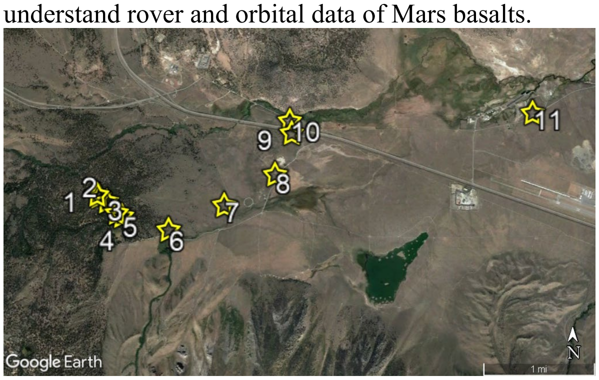

Figure 1. The Long Valley Caldera field site with sampling sites marked by yellow stars with numbers.

Background: Hydrothermal alteration of basalt has been extensively studied over the years [2, 6, 7, 8, 9, 10, 11], providing insights from different geothermal settings. Alteration by sulfuric-acid vapor and hydrothermal leaching of basalt has produced Al-, Fe-, Mg-, and Ca-sulfates, along with amorphous silica in a laboratory setting [6]. Similar minerals have been observed through basalt alteration at steam vents in Kilauea, Hawaii. [7, 8] Crystalline silica phases such as tridymite and cristobalite have been formed through basalt alteration by fumarolic gas at the Arsenatnaya active fumarole of the Tolbachik volcano [9]. Basalt alteration via fumaroles at Hverir in Iceland's Namafjall geothermal area has produced amorphous silica without considerable sulfur-bearing phases in many samples, presenting a potential analog for silica-rich soils in the Columbia Hills on Mars [10]. Additionally, studying hydrothermally altered basalts could be relevant for comparative planetary geology (i.e., using Long Valley as an environmental Mars analog site), as high-K basalts like those at Long Valley and their alteration products are known to exist on Mars at Gale Crater [2, 11].

A geochemically focused comparative planetology field campaign has not been conducted on the hydrothermally altered basalts in Long Valley. Studies have conducted extensive research on the geology and geothermal properties of Long Valley, including the basalts, but the primary focus centered on the mineralogy of pristine basalt lithologies, the Bishop Tuff and its alteration products, and other rhyolitic sources rather than hydrothermally altered basalts. [12, 13]

Methods: Sampling sites were selected along the basalt flow (Fig. 1) but were limited to those within regions covered by a permit. Eleven hand samples were photographed, recorded, and collected for analysis at NASA Johnson Space Center (Fig. 2).

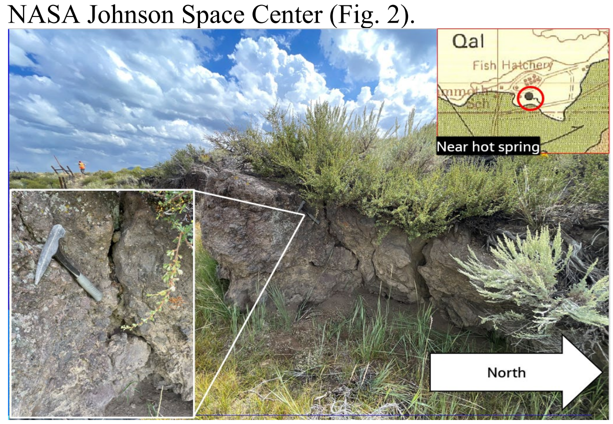

Figure 2. Unaltered basalt outcrop where sample #11 was collected.

A Panalytical X'Pert Pro MPD Diffractometer, using Co-Kα radiation at 45 kV and 40 mA, was employed to characterize the mineralogy of the powdered samples. The analysis ranged from 2 to 80° at a 0.0167° step size. The Rietveld method, with a 20 wt. % corundum internal standard, was used for quantitative crystalline phase estimation (Fig. 3).

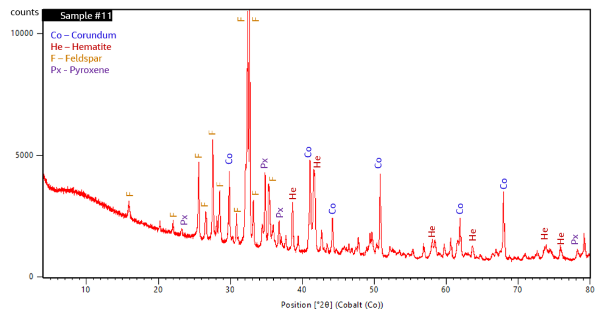

Figure 3 . X-ray diffraction pattern of Sample #11 with mineral peaks labeled. An internal standard of 20 wt. % corundum was used.

Results: There was insufficient evidence to support hydrothermal or fumarolic alteration of the collected samples at Long Valley Caldera. Limited variation exists in mineral phases across different sampling locations along the basalt flow. X-ray diffraction (XRD) analysis identified a typical basaltic mineral assemblage [14], with minimal evidence of hydrothermal alteration. Notably, 4 sites exhibited salts, which could indicate hydrothermal alteration [15]. However, salts were not present across all sampled locations.

Discussion: Martian basalt alteration can be characterized by Fe-rich smectite, saponite, palagonite, and in general Fe and Mg enrichment and CaO depletion in alteration products at the Pathfinder, Viking, Spirit, and Opportunity landing sites. [16] SiO_2 and K_2O enrichment has also been observed at the Curiosity landing site. [2] Preliminary XRD data of Long Valley samples, however, show a limited spatial and chemical range in minerals present within the studied basalt flow.

The minimal evidence of hydrothermal alteration observed is in opposition with expectations, indicating a need for more comprehensive research. Future work will focus on examining the textural detail via thin section analyses. Further sampling and analysis would be necessary to establish this geologic unit within Long Valley Caldera as a viable hydrothermally altered basalt Mars analog.

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Table 1. Rietveld analysis data for basalt samples from outcrops in SW moat of Long Valley Caldera. Minerology is in weight percent. These results show a typical olivine basalt minerology with little evidence for alteration.

Sample #	Quartz Wt. %	Mica Wt. %	Feldspar Wt. %	Pyroxene Wt. %	Olivine Wt. %	Fe oxides Wt. %	Salts Wt. %
1	0.0	1.7	74.5	15.7	8.1	0.0	0.0
2	0.0	1.1	77.1	14.5	1.8	2.8	2.7
3	0.0	0.0	72.5	17.2	2.2	4.0	4.2
4	0.0	0.0	69.5	17.8	8.4	4.3	0.0
5	0.0	0.0	79.0	17.0	1.1	2.9	0.0
6	0.0	0.0	74.4	18.0	3.3	4.3	0.0
7	1.3	0.0	72.8	17.6	3.9	4.4	0.0
8	0.0	2.4	81.8	11.1	2.6	1.0	1.0
9	0.0	0.0	79.2	15.5	5.3	0.0	0.0
10	0.0	1.9	76.0	12.9	7.0	0.0	2.1
11	2.0	0.0	68.4	21.2	3.7	4.7	0.0