EXTENDED, HIGH-TEMPERATURE COOLING OF LAVA TUBE INTERIORS: ANALOG FOR VENUS.

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Introduction: Mauna Loa's North East Rift Zone (NERZ) has erupted a total of eight times commencing in 1843, and halting in 1984. The eruptions on the slopes of the NERZ disperses lava at a significant rate, and in combination with the steep topography it results in fast-paced, long traversed lava flows. From 1843 onward, Mauna Loa has erupted a total of thirty three times, with most eruptions occurring prior to 1950. The eruptions originated from Moku'āweoweo, a 3-km by 5-km collapsed caldera that is the summit of Mauna Loa. Half of which were detained within the summit, and the other half migrated towards the Southwest Rift Zone (SWRZ) and the Northeast Rift zone in the direction of Hilo (USGS, Lipman). The 1843 lava flow resides within the NERZ's 50-km exposed surface. The 1843 lava flow, which erupted from the upper slopes of the NERZ and a north-flank radial vent, is one of the oldest Mauna Loa lava flows to be distinguished by association from specific dated eruptions. Several centuries prior to 1843, there was reduced volcanic activity off the flanks of Mauna Loa (Lipman).

Terrestrial lava tubes: Sparkle Cave

On Earth, it is challenging to locate a region that can sustain Venus-like conditions. That is due to the natural environment of Earth, the surface temperature is much cooler. The demand for a site that could sustain basalts cooling at extended, high-temperatures was critical. The specified location that was targeted is Sparkle Cave, from the 1843 lava flow off the slopes of Mauna Loa. The interior of a recently formed lava tube could provide the adequate environment for slow cooling basalts in contact with extended, high-temperatures. Due to Earth's cooler temperatures, the time in which a lava flow is exposed/oxidized to elevated temperatures is massively reduced (2). A lava tube's inception originates when the surface of a moving lava flow begins to crust over, insulating that molten flow underneath. Over a period of time, the tube will begin to evacuate the lava that was once flowed beneath the surface. This process will result in superheated air and volcanic gas building up in the upmost part of the tube. (3) Although a tube can evacuate the lava from within, the tube can remain hot for weeks, to months, or even years after it has been drained. This is predominately due to the hot air within the tube can remain insulated.

Relevance to Venus: Unlike Earth, the surface of Venus is extremely harsh. The average temperature is (~464°C) and the atmospheric pressure is (90 bars). In comparison Earth has an atmospheric pressure of (1 bar). The basaltic rocks that we find on Earth if exposed to Venus-like conditions would undergo the weathering process in a distinguishable manner. Utilizing instruments that observe the surface of Venus (orbital spectroscopy) could tell a different story from what is observed on the surface, contrast to the bulk composition. Thus, the oxidation of basaltic exteriors (surface) at extreme temperatures could develop a veneer of hematite. This veneer of hematite has a lower emissivity than the original basalt. Due to the formation of this coating, it has the ability to mask the indication of olivine from orbital sensors.

Methods: The exterior powder was gathered utilizing a dental drill. The interior was gathered by utilizing a rock hammer, followed by putting the interior pieces inside what is called a "shatter box" to powder the sample. Both powders were then analyzed using X-ray Diffraction (XRD) using a Bruker D8 Focus (Mineral assemblage).

Results: The results demonstrate that a hematite-rich layer formed on the exterior and interior of analyzed samples. These samples were exposed to extended, high-temperatures as the lava tube cooled. Within this environment, olivine oxidized and form a thin veneer of hematite.

	Samples					
Mineral:	ML-13-06 Exterior	ML-13-06 Interior	ML-21-07b Exterior	ML-21-07b Interior	ML-21-06b Exterior	ML-21-06b Interior
Anorthite			X	X		
Diopside	X	X				X
Hematite		X	X	X	X	X
Forsterite		X	X			
Ilmenite						
Albite	X				X	X
Gypsym	X					
Quartz			X			
Augite				X	X	
Cristobalite						X

Mineral Chart of results from (3) different sets of samples

Discussion: We propose that the interiors of basaltic lava tubes, which provide an environment in which lava remains in a high-temperature surface environment for days, weeks, or months following solidification, could serve as a useful analog for weathering under Venus surface temperatures, with the formation of hematite surface coatings as an example. Future work could include Near-Infrared spectroscopic analysis of lava tube basalt surfaces, and a comparison between more quickly cooled lava surfaces (surface lava flows) and lava tubes from the same flows, to assess the effect that the length of time exposed to high temperatures after solidifying has on the surface mineralogy.

References: [1] Basilevsky A.T. et al. (2012) *Icarus 217*: 434-450. [2] Filiberto J. et al. (2020) *Science Advances 6*, eaax7445. [3] Forti P. (2005) *J Cave Karst Stud 67:* 3-13.