

THE SIGNIFICANCE OF LAVA TUBES AND CHANNELS IN COMPARATIVE PLANETOLOGY. R. Greeley, Univ. Santa Clara, NASA-Ames Research Center, 245-5, Moffett Field, CA. 94035.

The existence of lava tubes and channels on the lunar surface was a contested subject prior to the "J" mission Apollo landings. Now, however, the majority of lunar investigators accept this origin for most lunar sinuous rilles. The turning point in opinion occurred with the Apollo 15 landing at the Hadley Rille (a lava channel - collapsed lava tube) and the acquisition of low sun angle photographs of mare surfaces showing abundant lava flow textures and structures. Concurrent with the Apollo missions, geological field studies of terrestrial lava tubes and channels provided the quantitative and qualitative data to aid in the interpretation of the structures observed and photographed on the mare surface. These same studies were beneficial in analyzing suspected martian volcanic features imaged by Mariner 9 and enabled the rapid identification of lava tubes and channels on Mars. The next stage in the analysis of planetary lava flows is to extend the studies beyond simple recognition of lava tubes and channels toward an understanding of the implications that these features have in terms of eruptive histories, styles of volcanism, and relations to the stratigraphic record.

Lava tubes form exclusively in basaltic lavas, primarily of fluid varieties; their formation is a complex phenomenon dependent on the chemical and physical properties of the lava, the rate of eruption, and the pre-flow topography. The distinction between lava tubes and lava channels is somewhat arbitrary - a lava channel involves restricted flow without a surface crust or roof, a lava tube involves restricted flow beneath a roof. A single flow structure may be part channel and part tube; many lava tubes collapse as soon as the liquid lava drains. Both features are efficient conduits for feeding lava flow fronts, and heat loss is very low within lava tubes (a drop of only 10-20°C was measured in Hawaii for flow within a tube over a distance of 10 km (1)), thus enhancing their role in extending basalt flows over long distances.

Knowledge of the parameters governing the formation and morphology of lava tubes and channels ultimately will allow better interpretations of analogous extraterrestrial structures. While that knowledge is far from complete, observations of actively forming lava tubes and channels (2,3,4), studies of cooled tubes (5,6,7), and theoretical considerations of lava tube activity (8,9) permit sufficient information to be drawn together to make some generalizations about channel and lava tube geology and the resulting implications for planetary surface studies:

1. Presence of lava tubes - indicative of basaltic lavas; rate of eruption was probably intermediate to high (comparable to Hawaiian rates); extremely high rates (Columbia River style) do not appear to produce lava tubes; eruptions were probably sporadic, but of long duration.

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2. Vent area - Mapped distributions of sets of lava tubes provide a good indication of source, or vent areas within basaltic plains, such as in the lunar maria. However, because tubes and channels can develop within flows away from the vent, the upper end of a single tube or channel is not definitive evidence of the source area unless there is an obvious vent, such as a crater.

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3. Transport mechanism and stratigraphic relations - Because of their heat retention properties and their mode of forming distributary systems, lava tubes and channels are effective conduits for transporting lava from the vent to the flow front in certain types of basaltic eruptions; therefore, mapping their distribution and orientations provide insight for geologic mapping of flows and flow units. The final position, however, of the lava tube or channel can be any place within the flow, even along the lateral margin of the flow.

(1)

(2)

(3)

(4)

The planimetric form of tubes and channels ranges from single units of rather straight course-lines, to single meandrous structures, to complex anastomosing networks of tubes and channels. The form is dependent, at least in part, on the preflow gradient (more gentle slopes result in more meandrous and/or branching forms), volume of eruptive surges (high volume surge causes lava to rupture tube roofs, or to over flow existing channels, which results in braided flow systems; these are common near the vent area), and preflow tubes and channels, which are frequently used by subsequent eruptions.

(5)

(6)

(7)

(8)

(9)

4. Erosion within lava tubes and channels - Erosion of pre-flow rocks by lava within tubes through melting and "plucking" has been noted within lava tubes (7), and inferred from observations of active flows (4). Hulme (8) and Carr (9) believe that erosion by lava plays a significant role in the formation of large, uniform lunar sinuous rilles.

(10)

5. Surface features related to lava tubes - A variety of distinctive basaltic surface features are often directly associated with lava tubes, including collapse craters, tumuli, perched lava ponds, lava lakes, and others. Many of these features are identified on planetary surfaces.

Although not genetically related, the course of lava tubes and channels is often influenced or partly controlled by faults, rift zones, and fissures.

Preliminary analyses of the distribution of probable lava tubes, channels, and related surface features in lunar maria suggest that different styles of volcanism operated during the emplacement of lunar basalts (10). Similar studies of some martian channels show that "plains-forming" volcanism

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occurred in some regions of Mars, similar to the younger basalt eruptions on the Moon. The apparent absence of lava tubes and channels on Mercury, however, might indicate that either the smooth mercurian plains were emplaced by flood eruptions or are not of volcanic origin.

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