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Panel 1:

Four decades ago, planetary geologists began to hypothesize that lava tube caves in the lower gravity of Mars and the Moon might attain diameters of as much as 500 meters (e.g., Greeley, 1971 a,b). This idea has persisted, but, currently, our Martian and terrestrial data do not support it. Progress in understanding the origin and development of lava tube caves (e.g., Hon et al, 2004)has shown that several types of lava tube caves form in different ways. Since 1971, knowledge of an unsupported basalt roof 200 m wide on Furna do Enxofre (an incipient pit crater in the Azores) has become widespread but the widest terrestrial example of any type of lava tube cave is only 44 m wide.

In 1971, Greeley identified the role of roof plates in the formation of the commonest type of lava tube cave formerly present on Mars (Greeley, 1971 a,b). Within the limitations of Google Mars, we conducted a Mars-wide search for such roof plates. We identified and studied more than 100 such collapsed lava tube caves in lavas of Olympus Mons, Ascraeus Mons, the western flank of Alba Mons, and adjacent plains. In this inventory we differentiated collapsed lava tube caves from lava channels and stream gullies, and from sinuous and other rilles. This poster summarizes this representative sample of collapsed Martian lava tube caves. We did not find features which would permit differentiation of examples which collapsed immediately after withdrawal of buoyant molten lava from those which persisted for a time as caves. Also we identified no roof plates in any Martian rille.

Panel 2:

The type of lava tube cave emphasized by Greeley requires a pre-existing lava channel transporting considerable quantities of molten lava. On both Earth and Mars, some lava channels are produced by roof failure of lava tube caves. Characteristically, these are too choked by breakdown to permit profuse gravity-driven transport of molten lava. In addition to collapsed sections of their roof, remnants of intratubal deposition and erosion features differentiate such channels from others which never have been roofed. The overflow channel of Kauhako Crater on Hawaii's Kalaupapa Peninsula is an easily observed example of a lava channel which never has been roofed; it is near the outbound flight path of many commercial flights from Honolulu to the mainland (Halliday, 2001; Halliday et al, 2009). Initially it was interpreted as a sinuous rille, or as a collapsed lava tube cave (e.g., Coombs and Hawke, 1989) despite the width of its upper portion (105 meters). Shallow overflow levees alongside its upper section document its actual nature.

Many such lava channels on Mars are segmented by lava fingers, tongues, or sheet flows. Prior to high definition orbital photography, the resulting gaps in these lava channels commonly were interpreted as intact segments of lava tube caves. Now, lava surface patterns can be observed crossing the courses of such channels. On the other hand, gaps in Martian channels which have been roofed appear to be signatures of intact lengths of the original roof. We observed no features indicative of existence or size of any caves which may be intact beneath such intact segments of roof, however.

Panel 3:

For this study, we found Google Mars to be a limited but useful rapid scanning tool. Problems in its use included blurring of wide strips of the Martian surface, inability to measure accurately distances less than about 20 meters, a system of coordinates which differs substantially from that used by NASA, and consistent over-reading by its measuring tool by about 3% in comparison to NASA figures.

Our study process included detailed scanning, in diminishing intensity, of (1) previously identified Martian volcanic edifices, (2) plains with previously identified volcanic features, (3) rilles, I4) plains areas without previously identified volcanic features, and (5) miscellaneous highland areas. Using the criterion of characteristic intra-channel roof plates, we identified more than 100 collapsed lava tube caves, mostly in volcanics of the Tharsis Rise, especially its northern and western strato-volcanos. We found that collapsed lava tube caves on Mars had patterns generally similar to those of present-day analogues on Earth, i.e., unitary, branched or braided (Halliday, 1963), but their channels tend to be wider and much longer, and they taper down slope more uniformly. We also conducted a similar reconnaissance of the surface of the Moon, but found no characteristic roof plates.

In such features high on the northwest slope of Olympus Mons we identified overhanging roof plates. These are associated with "black spots" and with short lengths of shallow, apparently incomplete collapse of the lava tube within the channel. Such features may permit entry into residual cavernous segments of the original lava tube. For direct investigation, a new generation of svelte, rip-resistant space suits will be needed, but interim investigation by self-propelled robots with one or more variable intensity headlamps may be possible in the comparatively near future.

To Greeley's seminal identification of roof plates as signatures of collapsed lava tube caves, we add the concept of rectilinear compartments within the boundaries of their signature channels, formed by non-uniform collapse of accumulations of roof plates. Such compartments are seen commonly in this part of Mars, and occasionally on Earth (e.g., in Lava Beds National Monument, California, USA). We found none within rilles.

Panel 4:

On Earth, comparatively few large lava tube caves have formed by the roof plate mechanism. Perhaps the best known are in the southwestern rift zone of Mauna Loa volcano, Hawaii. In contrast, the well-known open lava channel in New Mexico's El Malpais National Monument contains several partially roofed lava trenches formed by roof collapse of cavernous segments such as Big Skylight Cave. No roofing by roof plates has been identified in this system. On Mars comparatively few lava tube caves formed by this mechanism but a notable example can be observed south of Alba Mons. Near the midpoint of a lengthy, slightly sinuous channel generally leading west, this feature makes a sharp turn to the south, followed by three linear collapse trenches 105 to 145 m wide. It then turns west and displays several small skylights en route toward a largely covered north-south rille. Here, the narrow lava finger containing the tube seemingly is aligned toward a funnel pit in the rille but curves north, then west following the raised lip of this pit. It then crosses the rille on a wide regolith bridge between funnel pits and continues generally west as before. Residual cavernous spaces may be present at several points within this unusual feature.

Elsewhere on Mars, numerous funnel and other rounded pits locally mark the course of other buried rilles, grabens and some extensional faults. Some are spaced so closely that they resemble the rectilinear compartments of collapsed lava tube caves. They are differentiated by their rounded parameters .

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