Occurrence and Absence Of Lava Tube Caves With Some Other Volcanic Cavities; a Consideration of Human Habitation Sites on Mars. W.R. Halliday (1,2), G. Favre (1,3), A. Stefansson (4), P. Whitfield (5) and N. Banks (6).

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In 1839, American missionaries in the Kingdom of Hawaii showed professor-to-be James Dana some locally celebrated pit craters on the east rift zone of Kilauea Volcano (1). Dana recognized them as remnants of circular pools of molten lava with subsequent withdrawal of their lava column. Other pit craters were found around the world, perhaps most notably on the rift zones of Hawaii's Hualalai Volcano where they are so isolated that few have been investigated. Dana's theory was further confirmed in 2004, when a field excursion of the 11th International Symposium on Vulcanospeleology visited Furna do Enxofre, on the remote Atlantic island of Graciosa. Participants found it a circular incipient pit crater whose comparatively thin lid of solidified basalt had not yet collapsed.

In the decades since 1849, few suggested any correlation between terrestrial pit craters and lava tube caves except at two well-known pit craters in Hawaii's Kau Desert. Here, observers on the surface believed that they could see the orifice of a large lava tube at the bottom of one or both of the pits (2,3). Philip Whitfield and David Jones of the Vancouver Island (Canada) Cave Exploration Group and Norman Banks of the US Geological Survey's Hawaiian Volcano Observatory (HVO) explored the western example on 20 December 1979 while Dallas Jackson, Craig Crissinger and Paul Greenland of HVO provided surface support. Whitfield initially reported their findings in considerable detail (2), specifically including the fact that no lava tube cave opens anywhere within it. The very few lava tubes seen in its walls were of subhuman size. Banks photo documented innumerable lava lake edges, further confirming Dana's theory. The more challenging eastern pit crater and a nearby cone crater were similarly investigated on 25 November 1981 by Gerald Favre and fellow members of the Swiss Speleological Society, with Norman Banks providing surface support. Whitfield and Favre reported these and other nearby subterranean observations at the Third International Symposium of Vulcanospeleology in 1982 (3,4). Favre provided an illustrated hard-copy report for the Proceedings volume of this symposium (5), including measured longitudinal sections of the eastern pit crater and the nearby cone crater. When published, the eastern pit crater was seen to be much like the western example, plus a small alcove at its base. Its walls contain three rudimentary lava tubes much like those in the western pit crater, but it does not connect to any lava tube feeding system, and as Favre remarked (5), it does not "open out into a vast underground system". Despite published statements to the contrary, no terrestrial pit crater has been documented as a skylight of any terrestrial lava tube cave, and, in our opinion, the observational record fails to justify contrary speculations about similar-looking features on Mars.

Favre's team also investigated "Wood Valley Pit Crater" (WVPC), a complex volcanic structure now recognized as a dilational fault cave in the tectonically active interface zone of Mauna Loa and Kilauea volcanoes. With a prominent planar wall, aerial photos of its collapse pit entrance look much like orbital views of "Jeanne", on Arsia Mons. It is less than 1 km west of Hawaii's Great Crack, an extensional fault/graben system with several cavernous expansions (6). At the time of Favre's 1981 study, terrestrial fault caves were generally believed to be too small, too rare and too jagged to warrant more than cursory attention. A few examples were recognized in basalt or in limestone in the western USA; narrow crevice caves at Devil's Hole, Nevada and in and near the Wupatki pseudokarst of northern Arizona, and in basalt in eastern Oregon and south central Idaho. In central Europe, such caves still are commonly viewed as being of importance especially in landslide studies (7). In Iceland, a small cave of this type (Grjotagja) is a tourist attractions because of its pleasantly warm volcanic water. More recently, Silfra and a few other Icelandic cold water cave dive sites have revealed larger fault caves submerged in fresh water. With increasing identification of dilational faults on Mars, such caves likely will take on further importance in planetary studies. Except perhaps for small surface tubes, few such caves coincidentally intersect cavernous lava tubes, however, and few if any are potentially useful to astronauts. Among the terrestrial fault caves, only WVPC is floored with a fresh-looking pahoehoe flow. However, Favre's recent videography projected at the 2011 First International

Planetary Caves Workshop demonstrated that WVPC would be a notably unfriendly site for astronauts because of multiple constrictions and sharp projections, and caves explored to date in the Great Crack (6) are even more daunting.

In contrast to pit craters (which have little or no overflow of their lava lakes), certain terrestrial open vertical volcanic conduits (8) contain evacuated magma chambers at comparatively shallow depths (e.g., Terceira's Algar do Carvao, Kilauea volcano's Mauna Ulu and Hualalai volcano's Puhi a Pele). No OVVC is a skylight of a lava tube cave or fault cave. Yet, in our opinion such OVVCs may be more suitable for astronaut habitation and/or study sites than are pit craters or dilational fault caves. Nearly 100 "pit crater-like" features are now known on Mars. Some are of the same order of magnitude and have the same general shape as pit craters, and it will not be surprising to find that some are pit craters and others are OVVCs with and without drained magma chambers. Orbital photographs of an apparently un-named "pit crater-like" feature on Mars show a sloping side wall resembling that of Algar do Montoso on the Atlantic island of Sao Jorge (9), an especially large OVVC with a side chamber. "Walk-in" caves of other types (10), such as littoral caves of the Martian analogue of Utah's Plio-Pleistocene Lake Bonneville (11), also seem likely to be astronaut-friendly sites. Not all OVVCs contain open magma chambers, however. Newly famous Thrihnukagigur near Reykjavik in western Iceland, for example, is locally considered to be a bottle-shaped subcrater chasm with overhanging walls rather than a magma chamber. Its volume is about 150,000 cu meters, 80 to 150 meters below the surface. This chamber has two side conduits and a downward side passage which reaches a depth of about 175 meters, but its side conduits are not lava tubes as that term is commonly used, and it contains no lateral magma chambers.

In summary, the Seven Sisters of Arsia Mons are highly unlikely to contain lava tube caves, and probably are not suitable for human habitation. Upon further research, however, some similar-appearing open vertical volcanic conduits and some "walk-in" Martian caves of other types may be found to contain areas suitable for human habitats.

References:

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