

## Cavities and Caves Throughout the Solar System: Prospects Revisited for Occurrence and Astrobiological Significance. P. J. Boston,<sup>1</sup> NASA Ames Research Center.

**Background:** Our earliest work suggesting that the Martian subsurface could be the last best place to look for life on Mars [1], has been followed up by 28 additional years of considering all aspects of the potential occurrence of cavities on other Solar System bodies [2], their potential for astrobiological significance [3], as repositories for other types of geological, volatile, and atmospheric indicators, and as potential human habitats on the moon and Mars [5]. It is time to revisit earlier deliberations and conclusions in light of large amounts of new data from Mars, the Moon, and many other Solar System bodies [e.g. 6, 7].

**Speleogenetic Matrix:** In 2004, I first published a systematic treatment of the potential mechanisms of cave formation in a wide variety of planetary/small body environment types [2]. It has been updated twice for presentations and is now nearing its third major update for presentation at this conference. Figure 1 shows the last version prior to the work currently ongoing but to be completed and shown at the present meeting.

**Online Bibliography:** To support the goals of producing a highly interdisciplinary picture of the likely occurrence of planetary/small body cavity occurrences, their utility for astrobiological studies, and easily accessible information for mission concept planners and engineers, I have compiled a comprehensive cross-indexed bibliography of relevant work between the speleological, planetary, and astrobiological communities. It will be unveiled at the present meeting.

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**References:** [1] Boston, P.J. (1992). *Icarus* 95:300-308. [2] Boston, P.J. (2004). *Encyclopedia Cave Karst Sci.* 355-358. [3] Boston, P.J., et al. (2001) *Astrobiol* 1(1):25-55. [4] Boston, P.J. (2015), *2nd International Planetary Caves Conference*, Abstract #9039 [5] Boston, P.J. (2000) *Mars greenhouses: Concepts & challenges: Proc 1999 Wkshp.* NASA Tech. Mem 2000-208577:9-17. [6] Cushing, GE, et al. (2007). *Geophys Res Lett* 34(17):117201. [7] Haruyama, J., et al. 2009. *Geophys Res Lett* 36:121206. [8] Titus, T. & Boston P.J. (2012) *EOS Trans.* 93(20):196.

Process-based Cave Classification

CAVE TYPE	Dominant Processes	Parent Materials	Earth Examples	Possible Extraterrestrial Variations
Solutional	Dissolving rock by solvent (With or without chemistry)	Soluble solids plus a solvent	Classic karst, gypsum, halite	Non-water solvents, different thermal regimes
Erosional	Mechanical abrasion via wind, water, grinding, crystal wedging, etc.	Any solid	Sea coast caves, Tafonation, Aeolian rock shelters, etc.	Non-Earth erosional processes, e.g. radiation spitting, frozen non-water volatile wedging
Tectonic	Fracturing due to internally or externally caused earth movements	Any rocky solid	Seismic caves	Tidal flexure from a massive primary planet or sun, impact fracturing in craters
Suffosional	Cavity construction by the fluid-borne motion of small particles	Unconsolidated sediments	Mud caves, some thermokarst	Ground ice sublimation (?) pecking at Mars poles
Phase Transition	Cavity construction by melting, vaporization, or sublimation	Meltable or sublimable materials capable of solidifying at planet-normal temperatures	Lava tube caves, glacial caves (i.e. caves in ice as bedrock)	Perihelionic sublimation of frozen volatiles in comets (Temple), frozen bubbles in non-water ices, non-basalt lavatubes (io)
Constructional	Negative space left by incremental biological or accretional processes, often around an erodable template	Any solid capable of ordered or non-ordered accretion, or biogenic processing	Coralline algae towers, travertine spring mound caves	Crystallization in non-polar ices leaving voids?

Modified from P.J. Boston 2006, *Subterranean Caves: An Encyclopedia of Caves and Karst*, L. G. S. G. Titus, ed. Titus & Boston, 2012. Interdisciplinary research produces results in the understanding of planetary caves. *EOS Trans.* 93(20):196.

Figure 1. The cave classification scheme from the revised 2012 version [8].