A PHYSICS AND CHEMISTRY BASED FRAMEWORK FOR SPELEOGENESIS IN THE SOLAR SYSTEM. P.J. Boston[1,2], [1]Earth & Environ. Sci. Dept., New Mexico Institute of Mining & Technology, 801 Leroy Place, Socorro, NM 87801; pboston@nmt.edu, [2] National Cave and Karst Research Institute, 1400 Commerce Dr., Carlsbad, NM 88220

Introduction: Multiple schemes exist for the classification of cave types on Earth. Some of these take their inspiration from the dominance of carbonate caves on this planet and divide those (known as *karst*) from every other cave type, sometimes called *pseudokarst*. Other schemes rely on inferred formative mechanisms, e.g. dissolution by waters from above, *epigenesis,* or from below, *hypogenesis*. Other schemes rely on naming caves by their bedrock type, e.g. marble caves, carbonate caves, gypsum caves, etc. Yet other attempts involve designation of where a dissolved cave was formed with respect to a water table (e.g. *phreatic* indicates formation below the water table while *vadose* refers to formation at or above the water table). Passage morphology is sometimes used to name caves, e.g. *maze* or *anastomosing* referring to a cave in plan view, or terms like *elliptical* referring to the shape of the cross-section. More exotic cave circumstances are sometimes indicated by special chemical or thermal properties, i.e. sulfuric acid caves, ice caves, or glacier caves. While all these appellations have their uses, they are limited in perspective because they have grown out of our experience here on Earth and reflect that history. As we begin to contemplate cavities in crustal materials on other planets and moons, it is time to broaden and generalize our categorization to get away from a terrestriocentric stance to one which is more flexible and can be applied to a greater variety of potential cave-forming and development mechanisms on bodies with radically different lithologies, temperature regimes, atmospheres, and fluid behavior.

Framework Overview: A scheme first proposed in 2004 [1] and later expanded for purposes of assessing microbial inhabitants of caves [2] is revisited in light of further developments in our understanding of Solar System bodies that may house caves (Table 1). The scheme involves primary physical and chemical processes that can lead to speleogenesis both in the way we experience it on Earth and potentially future experience beyond Earth. Primary categories include: 1) solutional caves (dissolution of bedrock with or without chemical enhancement), 2) erosional caves (mechanical breakdown and removal of bedrock), 3) tectonic caves (cavity formed solely by crustal motions in response to tectonic forces), 4) phase transition caves (melting and refreezing, or sublimation and reprecipitation of any bedrock material), 5) suffosional caves (sapping of particles by fluid flow), and 6) constructional caves (cavities whose "bedrock" is formed around primary space by biological processes).

Conclusion and Consequences: The classification proposed here will not necessarily displace older speleological terms which still have utility in common parlance and amongst those whose sole concerns are Earth caves of a particular type. However, such a scheme can facilitate a more precise scientific approach to the fundamental mechanisms of extraterrestrial speleogenesis that we may expect to discover as we go forth to explore the geology of our neighbors in the Solar System.

References: [1] Boston P.J. (2004) *Encyclopedia of Cave and Karst Science*. Fitzroy-Dearborn Publishers, Ltd., London, UK. Pp. 355-358. [2] Boston P. J. et al (2009) In, A.B. Klimchouk & D.C. Ford, eds., *Hypogene Speleogenesis and Karst Hydrology of Artesian Basins. Special Paper 1:*51-57. Ukrainian Inst. Speleology & Karstology, Simferopol, Ukraine. 280 pp.

CAVE TYPE	Dominant Processes	Parent Materials	Earth Examples	Possible Extraterrestrial Variations
Solutional	Dissolving rock by solvent	Soluble solids plus a solvent	Classic karst, gypsum, halite	Non-water solvents, different thermal regimes
Erosional	Mechanical abrasion via wind, water, grinding, etc.	Any solid	Sea coast caves, Aeolian undercuts, etc.	Non-Earth erosional processes, e.g. radiation sputtering, frozen volatiles
Tectonic	Fracturing due to internally or externally caused earth movements	Any rocky solid	Seismic caves	Tidal flexure from a massive primary, crater impact fracturing
Suffosional	Cavity construction by the fluid-borne motion of small particles	Unconsolidated sediments	Mud caves	Ground ice sublimation
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	Perihelionic sublimation of frozen volatiles in comets, frozen bubbles in non-water ices, non-basalt lavatubes
Constructional	Negative space left by incremental biological or accretional processes	Any solid capable of ordered or non-ordered accretion, or biogenic processing	Coralline algae towers, Antarctic fumarole caves	Crystallization in non-polar ices
	P.J. Boston 2004. Extraterrestrial Caves. In, *Encycl.opedia of Caves and Karst*, J. Gunn, ed.			

Table 1: Broad categories of speleogenesis by dominant physical or chemical processes. After Boston, 2004.