CAVES IN THE MARTIAN REGOLITH AND THEIR SIGNIFICANCE FOR EXOBIOLOGY EXPLORATION. E. A. Grin, N.A. Cabrol, and C. P. McKay, NASA Ames Research Center, Space Science Division, MS 245-3. Moffett Field, CA 94035-1000 (egrin@mail.arc.nasa.gov).

Rationale: Though the direct observation of caves on Mars is unlikely with current data, their existence from microscale to megascale structures can be predicted according to Mars geological, and climatical history. A first global approach is to consider caves as a result of underground water activity combined with tectonic movements. Caves can be formed by: 1) diversion of channel courses in underground conduits, 2) fracture of surface drainage patterns, 3) chaotic terrain and collapsed areas in general, 4) seepage face in valley walls and/or headwaters, 5) inactive hydrothermal vent.

Classification of Martian Caves: Based on terrestrial analogs, we describe in Table I the types of caves that could be formed on Mars, by the joined action of tectonic, thermal, chemical, aeolian, and hydrological activities.

Table I

Type	Process	Morphology	Host environment (regolithe material)
A - *Mechanical Formation independent of host environment chemical composition*			
Tectonic	Mass mov. of regolith	Fossae	cohesive with low-water content
Sinking	Soil piping	Chamber	Fine-grained non-cohesive
Subsurf. erosion	Water drainage	Underground conduit	Water-rich porous
Valley and Rampart Talus	Piling of slope material	Intercon.d holes	Coarse-grain
Channel bank	Flow scouring	Longitudinal excavation	Cohesive
Lake shoreline	Wave-scouring, Ice-push	Leveled shore excavation	
Aeolian	Wind scouring	holes	loosely cohesive
B - *Chemical/Thermal Formation dependent of host environment composition*			
Dissolution	Chemical	Holes, chambers	Soluble
Lava •Blister	•pushed-away gas	•small empty pockets	• Basalt
•Fracture •Lava Tubes	• Mech. pressure •roof cooling	• ridges •shallow-depth conduits	 • Pahoehoe
Ice cave	•steam from volc. origin	•opening in dynamical equilibrium	ice mat.
Ice cave (cont.)	•tension •wind ablation	•ice cracks • grooves	• ice • ice
Pseudo-Karsts •glacial potholes	•thermo karsrt •ice melt block	•collapsed structures, chaos... •isolated cavities	•poorly consolidated sediment •ancient segregated ice env.

Caves, like other depressions, are favorable environments for the deposition of sediments. The processes of sediment deposition can be classified [1] according to: (a) the way of transportation, and (b) the chemical deposition/erosion by the weathering of the cave structure. Entrapped sediment may keep unaltered records of their sedimentation sequence, and provide favorable environments for exobiology exploration. In Table II, we describe the most likely sediments that could be observed with Martian caves.

Table II

Type	Sediment	Surface equivalent
Clastic • autochtonous • allochtonous • transported	 •weathering detritus • infiltrated • fluvial dep. • glacial mat. • aeolian mat.	 • eluvium soils • colluvium • alluviums
Chemical Hydrothermal	Evaporites • Tufas • Travertines	Evaporites
Ice	Ice	Ice

Martian Hydrology as a Major Trigger for the Generation of Caves: The above classification tables show that water activity on Mars has to be considered as a predominant factor in cave formation. In addition, the variety of hydrological processes observed, and/or predicted on Mars, may have led to diverse cave environments that have specific relationship with the aquifer. By analogy with Earth, we propose in Table III a description of plausible cave settings on Mars. It is also predictable that the location of such environments may have been modified through time, following the subsurface aquifer location.

Table III: Setting of Caves in the Aquifer

Surface Features	Subsurf. Location	Aquifer Zone	Expected Morphology
Hole	Vadose Zone	Above permafrost	Chamber
Collapsed Ground	Unconf. Aquifer	Above water table	Sink, Conduit
Channel Bank Piling	Conf. Aquifer	Below water table	Seepage Face Hole
Depression	Vadose Zone	Above permafrost	Fractured Evaporites
Lake	Vadose Zone	Above permafrost	Shoreline Scouring

The table III points out that the channel bank piling leading to seepage face hole formation is the only case where the cave will be potentially located below the water table. In all other configurations, the caves will be between the water table level and the surface. Valley walls, crater ramparts will provide wide exposed surface, where seepage caves may be identified on at the foot of debris slopes, and on terraces. Along the course of channels, the seepage caves are closely related to the drainage pattern, such as headwaters. The seepage face is located at the base of the drained aquifer. It is the result of the underpressure expelled water that has extracted the fine-grained material, leaving the coarser and larger blocks of the regolith at the seepage face (figure 1).

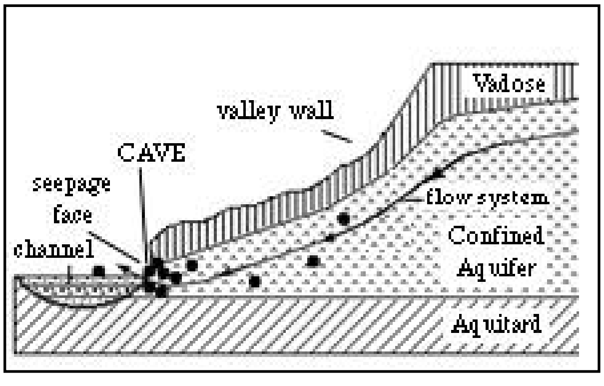

Figure 1: Cave formation in seepage face configuration.

The high-pressure flows converging toward the emergence construct conduits in the regolith, by extracting the fined-grained material. The result is a pile-up of blocks, with void interstices. In pile-up blocks, the interstitial surface is much larger relatively to the void volume than in chamber caves. The sliding of the slope material stops when the water content is unable to sustain the lubrication of the material. However, the cessation of the sliding does not imply that all the water was expelled The remaining water will then remain in the pore interstices. It can be predicted that the seepage faces were flooded by the latest channel flows, and water may have been entrapped, and ice-covered in the deepest portions of the caves, even during the Late Amazonian. Caves have benefit of water ponding, and sedimentation protected from wind, dust, strong evaporation, and surface UV bombardment. Therefore, they are plausible environments to explore in the search for life on Mars.

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