BASALTIC CAVES AND LAVA TUBES: ASTROBIOLOGICAL TARGETS ON EARTH AND MARS. Richard J. Léveillé[1], Saugata Datta[2]. [1]Canadian Space Agency, 6767 route de l'Aéroport, St-Hubert, QC, Canada, J3Y 8Y9 (richard.leveille@space.gc.ca), [2]Georgia College and State University, Department of Biological and Environmental Sciences, Milledgeville, Georgia, USA, 31061 (saugata.datta@gcsu.edu).

Introduction: Caves are unique systems where the protected, stable environment favors both secondary mineral precipitation and microbial growth wherever liquid water is present. This combination leads to formation and preservation of microbial biomarkers in mineral deposits. Thus cave minerals provide a record of aqueous processes and microbial activity. Caves likely occur on Mars as well, and the minerals they contain may provide useful information on past aqueous activity and perhaps even Martian life. Therefore, caves represent excellent targets for the search for traces of ancient life.

Basaltic caves and lava tubes: Basaltic caves are found in most of the large basaltic provinces on Earth where they originate either as cooling structures in lava flows (e.g., lava tubes) or as erosional features (e.g., sea caves). Lava tubes generally form when the outer surfaces of lava channels cool more rapidly forming a hardened crust; subsequently the remaining lava flows out of the tube, leaving a void space.

Lava tubes have also been recently putatively identified on Mars based on orbiter-based imagery [1]. In many case, the lava tubes appear to be collapsed, leaving channel like features (Fig. 1).

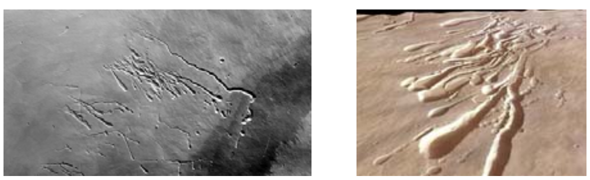

Figure 1: Mars Express HRSC images of Pavonis Mons, with linear channel like features believed to be collapsed lava tubes. Credits: ESA/DLR/FU Berlin (G. Neukum)

Geomicrobiology of Caves: Caves provide protection from ultraviolet radiation and, to some extent, dust and wind. They also tend to maintain stable environmental conditions that can be quite different from those at the surface. This combination favors both secondary mineral precipitation and microbial growth wherever liquid water is present. Typically, caves host an abundant and diverse assemblage of microbial communities [2-5]. As a consequence, caves are excellent locations where the formation and preservation of microbial biomarkers in alteration minerals can be studied [6].

In contrast to carbonate caves, few detailed studies of secondary minerals in basaltic caves have been undertaken so far, although several minerals, including carbonates, silicates, and sulfates, are commonly present in basaltic caves [7]. Microbial activity (e.g., photosynthesis, methanogenesis, sulfate reduction, metal binding and concentration by cell walls and extracellular material) has been implicated in the formation of secondary minerals in various basaltic caves [3-6, 8-10]. For example, the concentration of Mg and Si in extracellular polymeric substances (EPS) of microbial mats in Hawaiian caves was shown to lead to the formation of a Mg-Si gel like phase that subsequently dehydrated to form a poorly ordered Mg-clay in microstromatolitic structures [8]. In many cases, microorganisms are not well preserved in cave deposits [3, 9]. The past presence or activity of microorganisms is thus inferred by physical, chemical and isotopic biomarkers preserved in the minerals [6]. For example, in these same Hawaiian caves, elevated carbon isotope ratios were used to infer that photosynthesis by cyanobacteria in mats led to the precipitation of Ca-carbonates [10].

Caves as Astrobiological Targets: The study of caves on Earth informs us on the diversity and resilience of microbial life and how traces of such life are recorded in mineral deposits. In addition, it helps to provide informed suggestions of where life could have existed elsewhere in the Solar System. By analogy, basaltic caves on Mars likely contain a record of secondary mineralization that contains information on past aqueous activity (duration and environmental conditions). Such caves may also provide the best evidence for past life in the form of biomarkers preserved in the cave minerals. Finally, subsurface caves may provide a more habitable environment for extant microbial life than the current Martian surface [6]. Caves on Mars are thus prime exploration targets for future robotic and manned missions.

Future work: More detailed efforts to identify lava tubes on Mars by orbiter data should be undertaken in conjunction with Earth-based remote-sensing of basaltic areas where caves are known to exist. We expect to embark on a systematic study of basaltic caves from basaltic provinces of different ages and in different climates (e.g., India, California, Hawaii) in order to elucidate the geomicrobiology and geochemistry of basaltic caves and cave deposits. Results from this work may help to constrain future exploration targets on Mars as well help to define future mission design and infrastructure requirements.

References: [1] Wyrick D. et al. (2004) *J. Geophys. Res. [Planet.]*, *109*. [2] Barton H. A. (2006) *J. Cave Karst Studies*, *68*, 43-54. [3] Jones B. (2001) *Geomicrobiol J*, *18*, 345-357. [4] Northup D. E. et al. (1997) *Cave Minerals of the World*, 261-266. [5] Northup D. E. and Lavoie K. H. (2001) *Geomicrobiol J*, *18*, 199-222. [6] Boston P. J. et al. (2001) *Astrobiology*, *1*, 25. [7] Forti P. (2005) *J. Cave Karst Studies*, *67*, 3-13. [8] Leveille R. J. et al. (2002) *Clays Clay Min.*, *50*, 514-524. [9] Leveille R. J. et al. (2000) *Chem. Geol.*, *169*, 339. [10] Leveille R. J. et al. (2004) *Eos Trans. AGU, 85(17), Jt. Assem. Suppl., Abstract B43B-03*.