Microbial architects of anastomosing cave wall patterns in Frasassi, Italy

Z. CARDMAN[1*], S. LOVRINIC[1], I. SCHAPERDOTH[1], M. MAINIERO[2], S. MARIANI[3], J.L. MACALADY[1]

[1] Dept. of Geosciences, Pennsylvania State University, 16801 USA (*correspondence: zena@psu.edu)
[2] Studio Geologico, Via Francesco Podesti 8, 60122 Italy
[3] Gp. Speleologico CAI Fabriano, Via Alfieri 9, 60044 Italy

Vermiculations are visually striking cave wall formations, with anastomosing patterns and the texture of soft sediment. They are found globally, and are extensive in the sulfidic Frasassi cave system, Italy [1]. Their origins are uncertain, though biological influence has been hypothesized for decades. Our previous work revealed diverse Bacteria [2]. New data suggest roles for Archaea and Bacteria in vermiculation formation, drawing links between sulfur, nitrogen, iron, and methane cycling in a subsurface setting.

During a decade-long experiment, vermiculations regrew on cleared patches of cave wall (*Figure 1*). Regrowth was contiguous to intact vermiculations, and was faster at sites proximal to chemical energy sources (e.g. HS^- and NH_4^+ degassing from the aquifer). In vermiculations near the water table, $\delta^{15}N$ and $\delta^{13}C$ are isotopically depleted, and ammonium oxidizing Archaea, sulfur oxidizing Bacteria, and relatives of methanogenic Archaea dominate. Taxonomic groups enriched in vermiculations (relative to unvermiculated wall sediment) include ammonium and sulfur oxidizers, and iron and nitrate reducers. The C:N ratio is ~7 in vermiculations, while bare sediments have a higher ratio (~14) and an order of magnitude less organic C and N by weight.

The microbial assemblages in vermiculations are similar to those in many dark biosphere environments, offering an accessible system in which to study interconnected redox processes and self-organizational patterns in biofilms across a range of geochemical niches.

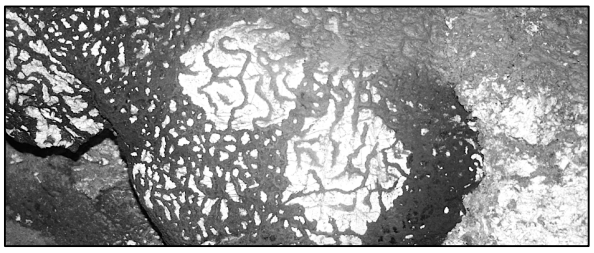

Figure 1: Vermiculations regrowing on the cave wall.

[1] Bini *et al*. (1978) *Int J Speleol* **10**, 11-33. [2] Jones *et al*. (2008) *J Caves Karst Stud* **70**, 78-93.