GEOCHEMICAL BIOSIGNATURES IN SUBSEAFLOOR BASALTS.
E. J. Knowles[1*] and A. Templeton[1], [1]Department of Geological Sciences, University of Colorado, UCB 399, Boulder, CO 80309; *knowlese@colorado.edu.

Introduction: The discoveries of intriguing tubular and granular alteration features in subseafloor basalt glasses, ophiolites, and ancient greenstones, and the suggestion that they could represent some of the oldest signs of life on Earth has sparked debate about their putative biogenicity. The initial clues that lead researchers to call these features biosignatures were their morphological characteristics. The tubules and granules are within the typical size ranges of bacterial and archaeal cells, often display branching morphology, and sometimes contain septate divisions [1-3]. Additional evidence comes from DNA staining tests, which show possible DNA remnants in the tips and along the walls of the tubules [4, 5], and chemical mapping of the features, showing accumulations of C, N, and P [1-3]. However, these data do not unequivocally demonstrate the biogenic origins of these features, nor provide information on the likely microbial metabolisms involved. Evidence of microbial geochemical processing within the tubular and granular alteration features would significantly strengthen their identity as biosignatures.

Results: Using a number of synchrotron-based X-ray microprobe and microspectroscopy techniques we have analyzed tubular and granular alteration features at the micron scale in numerous subseafloor basalt glass samples (ranging from ~2.3 to 110 Ma), and one ophiolite sample from the Troodos formation, Cyprus (~92 Ma). These samples were provided by collaborators Harald Furnes, Hubert Staudigel, and Nicola McLoughlin. We have mapped major and trace element distributions in and around the alteration features and analyzed the oxidation and coordination states of Fe, Mn, and Ti in potential biominerals. These data show that the effects of basalt glass alteration are significantly different in tubular and granular features than in regions of smooth “abiotic” alteration, and have lead to the identification of potential biominerals in the bioalteration regions, which likely formed as a result of microbial metabolic processes.

Figure 1 shows a transmitted light photomicrograph of a thin section of subseafloor basalt glass from the Costa Rica Rift and the associated total Fe, Mn, and Ca distribution maps. The tubular alteration features, extending from the crack on the lower left, are slightly enriched in Fe and Mn compared to the fresh glass (upper right corner), while the Ca map gives the best resolution of the tubular features with a distinct depletion in the whole alteration region. This pattern is common; all samples analyzed thus far have shown Ca depletions in the tubular and granular alteration features. The distributions of total Fe and Mn are more variable between samples, but there is a consistent change in oxidation state in the alteration regions. X-ray absorption near edge structure (XANES) spectroscopy has shown that the alteration features tend to be enriched in the Fe^{3+} and Mn^{3+} compared to the fresh glass. XANES analyses have also been used to determine the coordination chemistries of these metals, leading to the identification of target phases that are likely biominerals.

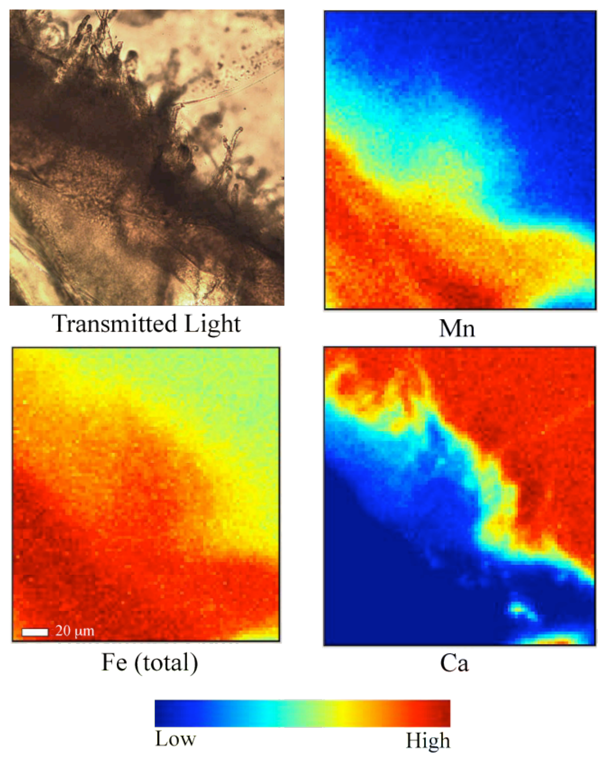

Figure 1. Transmitted light photomicrograph (upper left) showing tubular alteration features extending from a crack in a subseafloor basalt sample (148-896A-11R-1, Costa Rica Rift), and the associated Fe (total), Mn, and Ca distribution maps. The scale bar in the Fe map is 20 µm, and the colorscale is shown on the bottom.

Conclusions: Synchrotron-based X-ray techniques represent powerful new tools in the identification and categorization of biosignatures. They are particularly useful for mapping the distributions and determining the oxidation states and coordination chemistries of potential biominerals. Showing evidence of geochemical processing by microorganisms in subseafloor basalt glass is a significant step in establishing the biogenicity of features like tubular and granular alteration.

References: [1] Furnes H. et al. (2001) *Geochem. Geophy. Geosy., 2,* doi:10.1029/2000GC000150. [2] Furnes H et al. (2004) *Science, 304,* 578-581. [3] Staudigel H. et al. (2008) *Earth Sci. Rev., 89,* 156-176. [4] Banerjee N. R. and Muehlenbachs K. (2003) *Geochem. Geophy. Geosy., 4,* doi:10.1029/2002GC000470. [5] Torsvik T. et al. (1998) *Earth Planet Sci. Lett., 162,* 165-176.