Bioalteration of ocean floor pillow lavas through time – 3.5Ga to present

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The microbial etching or bioalteration of volcanic glass creates micron-sized cavities [1]. These microborings are commonly found in the glassy rims of oceanic pillow lavas and volcanic breccias and can be regarded as trace fossils [2]. Numerous examples have been described from pillow lavas of the upper *in-situ* oceanic crust, spanning the youngest to the oldest oceanic basins (0 to 170 Ma). These trace fossils include granular and tubular forms, the latter with twisted, branched and spiraled morphologies. These bioalteration traces locally contain nuclei-acids localized at the interface between fresh and altered glass, and sequence analysis suggests that Fe and Mn oxidizing bacteria are principally involved [3].
Comparable, mineralized micro-textures are also found in meta-volcanic glasses from Phanerozoic to Proterozoic ophiolites and Archean greenstone belts [4, 5]. Multiple lines of evidence suggest that these Archean micro-textures were also formed by the microbial etching of formerly glassy lavas, and thus they provide an important new tracer for the emergence of life on earth. Firstly, there are striking morphological similarities between Archean tubular structures and bioalteration textures in modern glasses. Secondly, X-ray mapping indicates trace amounts of carbon enriched along the margins of the Archean tubular structures. Thirdly, disseminated carbonates in the pillow rims have C-isotopes depleted by as much as –16‰ which is consistent with microbial oxidation of organic matter. These isotopic signatures are preserved even up to blueschist facies metamorphism that destroys all textural traces. Fourthly, direct in-situ U-Pb dating of titanite ($CaTiSiO_4$), which infills the bioalteration textures using LA-ICP-MS (laser ablation inductively coupled mass spectrometry) confirms a late Archean age. This finding provides the first direct radiometric age determination of an Archean biosignature and suggests that seafloor volcanic glasses are an important habitat for the origins and evolution of life on the planet Earth and beyond.

Key words: *volcanic glass, microborings, deep biosphere, emergence of life*

References:
[1] Thorseth et al. (1992). The importance of microbiological activity in the alteration of natural basaltic glass. Geochim Cosmochim Acta 56: 845-850
[2] McLoughlin et al. (2009). Ichnotaxonomy of Microbial Trace Fossils in Volcanic Glass. J. Geol. Soc. London 166: 159-170.
[3] Santelli et al. (2008) Abundance and diversity of microbial life in ocean crust. Nature 453: 653-657
[4] Furnes et al. (2004) Early life recorded in Archean pillow lavas. Science, 304: 578―581
[5] Furnes et al. (2008). Oceanic pillow lavas and hyaloclastites as habitats for microbial life through time – A review "In: Links between Geological Processes, Microbial Activities, and Evolution of Life " (Ed) Y. Dilek, H. Furnes and K. Muehlenbachs Springer Book Series, pp1-68.