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# Volcanic glass shards as substrates for microbial life: A case study from an alkaline caldera lake (Niuafou'ou, Tonga)

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Impacts and volcanism dominated early Earth, producing masses of glass shards. These provide enormous surface areas and readily available nutrients advantageous for early microbial life. We investigated volcanic glass shards from Vai Lahi, a 121 m deep alkaline caldera lake on Niuafo‘ou Island (Tonga)[1]. The shards are basaltic and contain phenocrysts of forsteritic olivine, spinel, calcic plagioclase and pyroxene. Shoreline deposits consisting of Holocene volcanic glass shards (ca. 0.37 ka) are in contact with the alkaline caldera lake water which is highly supersaturated in alkaline-earth carbonate minerals. Alkalinity increases from 15.7 to 18.6 meq/l with depth (cf. seawater alkalinity of 2.3 meq/l) and $Ca^{2+}$ concentrations increase from 0.71 to 1.15 meq/l while SI (saturation index) of calcite decreases from 0.64 to 0.13 due to an increase in $pCO_2$ down-depth. The shoreline shards are coated with laminae of fibrous aragonite alternating with microporous aluminosilicate. The coatings contain mineralized mucilage sheaths (glycocalyx) of benthic coccoidal cyanobacteria. Biofilms of alkalophilic cyanobacteria cover the shards and are thought to have induced the precipitation of mineral envelopes that resemble the cortex of oncoids.

We used imaging (SEM, TEM), spectral (Raman) and geochemical (LAICPMS, EMPA) methods to analyze composition of glass shards and their coatings. Shard surfaces show signs of dissolution (irregular texture, etching pits) as well as carbonate-silicate envelopes that we interpret as bio-textures. Both abiotic weathering and microbial activity may contribute to the alteration of the shard structure and composition.

We propose that glass shards were abundant in Earth's early oceans where they served as habitats for microorganisms. These microbes thrived by utilizing the essential elements present in the shards (e.g., P, K, Na, Mg, Ca, Fe, Mn, Co, Cu, Zn, as detected in our studies), thereby playing a role in the emergence and evolution of early life.

[1] Kempe, & Kazmierczak, (2012), Caldera lakes of Niuafo‘ou Island, Tonga: Hydrochemistry and carbonate deposits. – In: Hanselmeier, A., Kempe, S. & Seckbach, J. (eds.) “Life on Earth and Other Planetary Bodies”, Springer, 197-234.