FORMATION, MODIFICATION, AND PRESERVATION OF MICROBIAL ENDOLITHIC BORINGS IN HYALOCLASTITE FROM HAWAII: CLUES FOR PETROGRAPHIC RECOGNITION OF MICROBIAL TRACES IN BASALT GLASS OF ANY PROVENANCE AND STAGE OF ALTERATION. A. W. Walton, Department of Geology, The University of Kansas, (1475 Jayhawk Blvd., Lawrence, Kansas. TWalton@KU.edu)

Introduction: Endolithic microborings, presumably the work of Archaea, are common in basalt glass from ocean basins [1],[2],[3]. Hyaloclastites sampled in the Hawaii Scientific Drilling Project #2 Phase 1 core (HSDP #2_1), contain numerous such microborings [4],[5]. The samples from the HSDP core and samples taken by submersible from the Hilina slope of Hawaii [6] display the modification of the features of the microborings over time and document their preservation during some kinds of alteration. Such preservation indicates that features of the initial form of the microborings and its modification may be used as evidence of organic origin of tubules or mineralization patterns in basalt glass of any provenance and at various stages of alteration [7].

Initial character: Endolithic microborings in Hawaiian hyaloclastites are initially about 1 μm wide and extend to be 10 μm to >100 μm long (Figure 1). They extend into the glass from free surfaces of the glass, such as margins of hyaloclasts, fractures, and vesicle walls. In samples from the Hilina slope and in contact-metamorphosed samples from the HSDP core, microborings extend into fresh glass cores of hyaloclasts from the interface with either palagonite or smectite alteration. Many microborings follow straight to curving to irregular courses into the glass, and some divide into many smaller tubules.

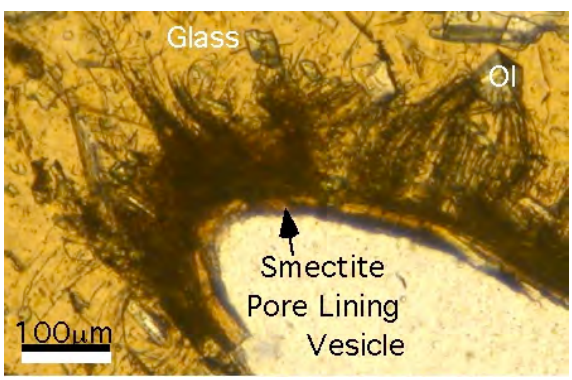

Figure 1. Numerous microborings extend into basalt glass from the margin of a vesicle. Note microborings bending around plagioclase and toward olivine crystal (Ol) in upper right.

Seeking olivine and avoiding plagioclase: A characteristic feature of the microborings is that they curve toward adjacent phenocrysts and microlites of olivine (Figure 1). In fact microborings curve toward olivine crystals even when they are not long enough to touch them. Nearly all microborings that extend to the surface of the olivine crystals simply stop. They do not bend or branch to follow the surface; they do not enter the olivine, and normally do not turn back from it. The question of whether the curvature is the result of strain within the glass established by differential contraction of the glass and the olivine or whether it is related to a gradient of nutrients is currently open. The behavior is obvious and very common. Complementary behavior but less common in the olivine-rich Hawaii samples, is avoidance of plagioclase crystals.

Smectitic grain replacement: HSDP #2_1 samples contain several varieties of smectite, including two that form isopachous grain coatings; smectites formed by metamorphic alteration of shard margins; smectite filling microborings; and a variety that replaces glass and is highly associated with microborings. This last variety may either be a passive result of increased permeability and reactivity associated with microborings or it may be a direct product of microbial activity. The smectite in question characteristically contains grains of a Ca-Ti-Si-rich material and has some degree of staining by iron hydroxides [5]. Geochemically, this replacive clay resembles nearby isopachous clay coatings on hyaloclasts [8]; P. Schiffman, personal communication). The concentration of Ti is interesting in light of observations of Ti-rich tubules in Archean pillow basalts [6].

Branching, flared, steep, smectite-filled cones: In hyaloclastites in the HSDP core, beginning with the first rocks that accumulated in a submarine environment (at 1080 m below sea level, mbsl) the length and complexity of microborings increases downward to 1570 mbsl, the depth below which palagonitic alteration [5] predominates. The microborings display three characteristic changes over that depth interval, in addition to becoming longer and being associated with smectite grain replacement: 1) The microborings become steeply conical, rather than irregularly cylindrical, with flared outer orifices, similar to the bell of a trumpet. The diameter may increase to several micrometers or more, in the outer reaches, and the flared orifice is distinctly larger, but the effects extend only a few micrometers into shards. 2) The microborings become filled with smectite. 3) The microborings develop tiny branches, small tubes that extend micrometers to tens of micrometers laterally, but irregularly, from the main axis of the microboring (Figure 2).

Palagonitization does not efface the features of the microborings: Only one of 35 samples of hyalo-

clastite from below 1570 mbsl, that at 1607.1 mbsl, does not display palagonitic alteration as previously described [5], with margins of shards, or entire mass of small shards, converted to palagonite and with chabazite filling pores. Even samples that experienced contact metamorphism display post-metamorphic palagonitization of larger shards. Microborings in palagonitized rocks are generally smectite-filled and are enlarged from their initial 1 μm diameter (Figure 3). However, they are continuous, they display their cylindrical to conical shape, they bend toward olivine crystals, and they may display the characteristic branching that develops late in their history.

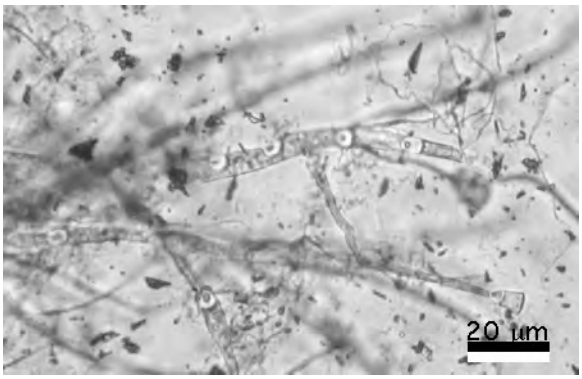

Figure 2. Small, irregular branches extend into basalt glass from enlarged smectite-filled microborings. HSDP #2_1 1607.1 mbsl

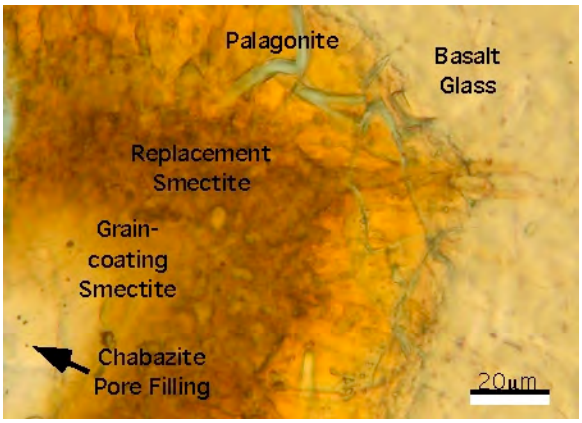

Figure 3. Portion of a hyaloclasts shard and adjacent filled pore showing charateristic palagonitic alteration and modified but preserved microborings. HSDP #2_1, 2004.8 mbsl.

Summary: Endolithic microborings, which extend into basalt glass from any free surface, display characteristic features including an irregularly cylindrical to flared, steeply conical shape, a tendency to bend toward olivine and loop around plagioclase, a filling of smectite, an association with smectitic replacement of glass (with Ca-Ti-Si grains), and the distinctive branching. These features are preserved during palagonitization of the samples. Presence of most or all of these features, or altered remains of them, in fresh or altered basalt glass can be taken as indication of the former presence of boring microorganisms.

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