Products of littoral explosions and their formation conditions: A case study from episode 58 of Pu‘u ‘Ō‘ō, Kīlauea Volcano, HI

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Interactions between fluid lava and the ocean can be explosive and thus hazardous to nearby communities. These eruptions can be difficult to study as at least half of the deposit is lost to the sea. During 2008, lava flows from episode 58 of Pu‘u ‘Ō‘ō entered the ocean near the town of Kalapana. The deposits are well-preserved, not covered by subsequent lava flows, and well-documented by photography; therefore, eruptive products can be tied to observed processes, making this event an ideal case study.

We identified four different pyroclast categories on and around the preserved half-cone: Pele’s hair, Pele’s ‘locks’, fluidal spatter, and dense blocks. Photography reveals that steam generated from entrained sea water produced bubble-like bursts of juvenile material. This process is likely responsible for the first three pyroclast types, as all three require the material to still be fluid at time of formation. The blocks, however, are more ambiguous as to whether they represent fragmentation of lava tube walls or lava that drained back to the explosive vent.

The fluidal spatter is crystal-poor and displays a distinct pattern between bubble texture and aspect ratio (AR; here, defined as the ratio of length to thickness) that implies a relationship between in-flight time and relative viscosity. Proximal spatter has very high ARs (max: 454), but the bubbles are small and spherical, suggesting that the spatter cooled very rapidly due to its thinness. Just a few meters from the cone summit, the AR rapidly decreases to <100, and bubble textures indicate that these thicker spatter clasts were still fluid enough to continue vesiculating, outgas, and partially collapse. More distal ejecta was likely too cool and viscous to continue vesiculating enough to outgas.

In contrast, the dense blocks are microlite-rich with ragged bubble shapes that indicate either bubble growth in a crystal-rich melt and/or partial bubble collapse after outgassing. Likely, these clasts represent brittle fragmentation due to the high crystal content increasing viscosity. Thus, both brittle and ductile fragmentation regimes are present during such littoral explosions.