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From golden pumice to dense scoria and ash emission: tracing the complex degassing and fragmentation history of the Piton de la Fournaise September 2016 basaltic eruption (La Réunion Island, France)

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In September 2016, Piton de la Fournaise volcano, well-known for its Hawaiian/Strombolian and effusive activities, produced an unusual phase of pulsating ash emission. The September 11-18 eruption occurred on the NE flank of the volcano central cone and was well constrained by field monitoring networks, remote satellite, near field imagery and sampling of eruptive products. The eruption first produced high sustained lava fountains aligned on a 900 meters-long fracture and then rapidly focused on a set of closely spaced vents, which quickly built a single main cone. After four days of activity, only two vents remained active inside the cone: a main one producing lava fountains and a second one with weak and discontinuous activity. While intense fountain activity was still on at the main vent, rapid evolution was observed at the second minor vent. This latter one evolved from gas emissions, to pulsating explosions characterized by expulsion of large bombs to short-lived ash plumes. Field observations coupled with chemical, petrological and textural datasets permit to constrain the time and space evolution of eruptive dynamics and to correlate that with the degassing and fragmentation processes. Time-averaged lava discharge rate and fountains heights changed rapidly during eruption, together with SO_2 emissions, magma composition and crystal content. Grain size and componentry of the tephra bed evolve from unimodal at its base to bimodal on the last day of activity reflecting the contribution of both the Hawaiian fountaining (main vent) and the ash plumes (second/ash vent) deposit characteristics. The second vent emitted coarse and dense tephra (bombs and lapilli scoria) mingled with highly vesicular fragments (golden pumice). The golden pumice bomb, lapilli and minor ash from the main vent are more vesicular (70 vol.% in average) and crystal-poorer (<20%) than the scoria emitted from the second vent (55 vol.% of porosity in average; ∼100% of crystal content). The ash morphology performed on a large dataset allows us to discriminate and characterize the Hawaiian versus the second vent components. Permeability measurement (Darcian viscous permeability) on lapilli and bomb-sized components reveal different trends as well, golden pumice being more permeable (from 10-10 to 10-11 m2) than the second-vent derived scoria (from 10-11 to 10-13 m2). Our data support the hypothesis that the second vent material was dense and relatively less permeable. We suggest that the less active vent accumulated a plug of degassed, cool and low-permeable magma, and that this process modulated over-pressure pulses under the input of ascending undegassed magma. Unusually violent explosions at the end of basaltic eruptions are thus not necessarily related to late inputs of external fluids, but can be triggered by clogging of less active dyke paths and plug pressurization.