Evolution of the phreatomagmatic Cova de Paul eruption, Santo Antao, Cape Verde Islands: links between the development of the eruption and the growth of the crater.

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Episodes of hazardous phreatomagmatic explosive activity that excavate large deep craters occur within otherwise less dangerous effusive to mildly explosive magmatic eruptions at high-elevation vents on many oceanic island volcanoes. The water driving these explosions is sourced from freshwater aquifers within the volcanic edifices, whose location and other characteristics will influence crater growth and final geometry. Here we describe crater wall sequences and near-vent deposits around the large Cova de Paul crater on the island of Santo Antao, Cape Verde Islands, which provide some insights into a transition from mild magmatic to violently explosive phreatomagmatic activity in one such eruption. This pre-historic but well-preserved crater formed in a single eruption that produced extensive low-temperature, lithic-rich phreatomagmatic ignimbrites and surge deposits; these are interbedded in proximal outcrops with airfall to mixed fall and flow breccia and ash beds containing varying proportions of lithic and juvenile clasts, pointing to a series of climactic explosions within an extended period of milder phreatomagmatic explosive activity.

Prior to the transition to phreatomagmatic activity, the eruption had been characterized by mild Strombolian activity that produced scoria and spatter deposits of broadly tephritic composition. The upper parts of the Strombolian sequence contains distinctive flow-banded angular sub-glassy juvenile clasts, compositionally identical to the Strombolian scorias, that become larger and more abundant just below the transition to phreatomagmatic activity. We interpret these as fragments of flow-banded chilled margins from the walls of the eruptive conduit. Thermal shattering of these margins to produce the angular sub-glassy clasts may have allowed increased groundwater flows into the conduit, attainment of a critical coolant input ratio, and the onset of the phreatomagmatic explosions. The lack of angular sub-glassy clasts in the rest of the eruptive sequence suggests that the chilled margins never re-established and that subsequent variations in the intensity of phreatomagmatic activity were controlled by water flow to the conduit as the crater was excavated to deeper levels and different aquifers were tapped and depleted. We find that whereas most of the lithic clasts in the mixed units can be matched with rock units in the exposed crater walls, implying widening of the crater during periods of low-level explosivity, the ignimbrite and surge units contain hydrothermally altered clasts that appear to have originated from deeper in the volcanic edifice implying that during these climactic episodes the crater vent walls were being actively excavated to as much as several hundred metres below the surface of the volcano.