Geophysical Research Abstracts,
Vol. 11, EGU2009-10171, 2009
EGU General Assembly 2009

Rheology of the 2006 eruption at Tungurahua volcano, Ecuador

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During August 16th to 18th 2006, the eruptive crisis at Tungurahua volcano (Ecuador) culminated in VEI 2 eruption with tens of pyroclastic flows and the extrusion of a lava flow. The nearly simultaneous occurrence of a lava flow and a pyroclastic flow from a single vent deserves attention. Generally, the rheology is a chief determinant of eruption style. Specifically, magmas are ductile (effusive) at low strain rates whereas they are brittle (explosive) at high strain rates. Although this distinction has been extensively described for single-phase magmas, there remain many questions as to the rheological implications of crystals and bubbles present in magmas. Here we present preliminary characterizations of the complex rheology of the magma involved in the 2006 eruption at Tungurahua volcano.

The magma present in this eruption was andesitic with an interstitial melt composition averaging ∼58 wt.% SiO2. The bombs present in the pyroclastic deposit show an open porosity ranging from 15 to 35 vol.% and a crystallinity generally greater than ∼30 vol.% and occasionally up to 60 vol.% in samples affected by microlite growth. Petrographic analyses revealed magma batches with different crystallization histories. In high-porosity samples containing microlites, a recrystallization rim around clinopyroxene and resorption of the plagioclase were observed. In contrast, the dense samples show pristine, euhedral crystals and a near absence of microlites. The heterogeneous petrographic structures suggest the possibilities of mingling in the conduit or of magma batches with different decompression rates.

Dilatometric analyses suggest glass transition temperatures (Tg) of ∼974 °C for the dense material (porosity∼15 vol.%) and as high as ∼1060 °C for the high-porosity bombs (porosity∼35 vol.%). Successive series of heating and cooling of the glass reveal an increase of Tg by as much as 60 °C indicative of significant water left in the melt. Preliminary analyses of images obtained via high-resolution neutron tomography also suggest the remnant of water in the bombs.

This work in progress suggests that the large eruptive event in mid-August 2006 were caused by recharge in the magma reservoir or possibly in the conduit. Subsequently, both magma batches ascended through the pipe-like conduit, but rheological differences and possibly different ascent rates impeded complete mixing. This distinction may also explain the simultaneous occurrence of a lava flow and pyroclastic flows.