Emplacement Temperatures of Boiling-Over Pyroclastic Density Currents from Tungurahua and Cotopaxi Volcanoes, Ecuador

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Re-heated lithic clast yields a Te of 210°C for one deposit.

Summary

Eighteen lithic and juvenile clasts from Cotopaxi and Tungurahua volcanoes were thermally demagnetized to obtain emplacement temperatures of boiling-over pyroclastic density currents (PDCs). We found that:

1. Most lithic samples have cold (<90°C) emplacement temperatures.
2. Most juvenile clasts have high (>590°C) emplacement temperatures.
3. This dichotomy suggests strongly heterogeneous temperatures at the time of deposition: the bulk of the flow is cool, but some fragments are very hot. Models of flows that average the temperature throughout the flow might be missing some of their most crucial properties.
4. Boiling-over PDC deposits can be distinguished from other types of PDC deposits by low emplacement temperatures of the lithic clasts, but can be distinguished from lahar deposits by juvenile clast emplacement above 590°C.

Figure 1. Ecuador is located in the Northern Andes. Tungurahua and Cotopaxi are located in the eastern Cordillera of Ecuador. Both volcanoes have similarly interesting deposits from pyroclastic density currents (PDCs).

Figure 2. Tungurahua volcano, 5,923 m, is one of Ecuador’s most active stratovolcanoes. Sequences of lava flows, PDCs, and ash fall are followed by sector collapse over a span of 175,000 years. The most recent activity began in 1999 and continues today with explosions, ash plumes, lava flows and boiling-over PDCs. Unexplained aspects of these flows include odd socio-economic flows, bread-plumes, lava flows and boiling-over PDCs. Unexplained aspects of these flows include odd socio-economic flows, bread-plumes, lava flows and boiling-over PDCs. Unexplained as-

Figure 3. Cotopaxi volcano is 5,897 meters high, with a circular glacial cap. Previous eruptions melted the glacier and resulted in numerous voluminous lahars. Some of the largest lahars occurred in 1877, when PDCs mixed with rain or melt water morphing into lahars, making deposits difficult to interpret. Modern activity includes seismicity and gas emission.

Boiling-over pyroclastic flows typically are cool, between 90-210°C and Tu-02 was emplaced above 590°C. Tu-02 volcanoes have similarly interesting deposits and lithic clasts give a Te of >570°C. This is consistent with the observations from Cotopaxi and Tungurahua volcanoes points towards similar emplacement temperatures (Te), like unscorched wood.

Expected geomagnetic field at time of emplacement = ⭐ or ⭐

Par from star = Cold

Lithic Clasts

Clustered around star = Hot

Juveniles with Te > 590°C cannot be lahar deposits.

Figure 8. Clasts were sampled in a core perpendicular to the surface of the rock to assess the thermal history of the entire clast.

Figure 9. The magnetic intensity and paleomagnetic direction of each sub-sample was measured after each subsequent heating step, which ranged between 50-80°C, starting at 25°C and ending at 810°C. This shows a change in the paleomagnetic data at 210°C, which when modeled, translates into a deposition temperature of 230°C (see Fig. 10).

Figure 10. Numerical modeling of the conduction of heat from the matrix of the flow to a lithic clast gives the temperature of the flow required to achieve the temperature recorded by the paleomagnetism.