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Dynamic interaction of molten andesite and ice raises heat transfer and meltwater production rates compared to static

Rosie Cole (1), James White (1), Tobias Durig (1), Ralf Buettner (2), Berd Zimanowski (2), and Hamish Bowman (1)

(1) Geology Department, University of Otago, Dunedin, New Zealand (colro756@student.otago.ac.nz), (2) Physikalisch Vulkanologisches Labor, Universität Würzburg, Würzburg, Germany

Coherent, ice-confined lava flows are the most commonly documented glaciovolcanic deposit at intermediate-composition volcanoes. The lack of fragmentation has been attributed to minimal water-magma interaction, resulting from andesite having a low ice-melting potential compared to basalt. Little experimental or observational data exists, however, to support this, and voluminous, hydroclastic breccias have been more recently mapped from numerous intermediate-composition volcanoes worldwide.

Here, we test the hypothesis that andesitic melt is less efficient at melting ice and contributing to meltwater retention. We performed calorimetric experiments to quantify the thermal properties, heat flux, thermal efficiency and meltwater production rate of andesite collected from Ruapehu volcano, New Zealand. In addition, the influence of andesitic lava that is flowing or inflating against a glacier was investigated by a novel dynamic experimental set-up, which involved squeezing molten andesite against an ice block. The dynamic element of the experiments has not been considered before, but may have a significant influence in the transfer of heat by advection and by increasing the lava-ice interface area by lateral spreading and the formation of cracks.

We calculated the specific heat capacity of the Ruapehu andesite to be between 861 and 1133 J kg-1 K-1, while the thermal diffusivity was 4.62-4.66 x10-7 m2 s-1 and the thermal conductivity was 0.9-1.1 W m-1 K-1. These values are only slightly lower than those published for basaltic lavas, and the calculated thermal efficiency for ice melting by andesite was 33-69%, consistent with the published range for basalt. A lack of meltwater retained at the interaction site at andesitic volcanoes is therefore, most probably, a result of the volcanic topography and volcano-ice configuration.

In addition, we observed increases in meltwater production and heat flux following increases in applied force during the experiments. This positive relationship shows the importance of considering the dynamic effect of flowing or inflating lava against a glacier in models for ice-melting and effects on the subglacial hydrology. Meltwater availability and its passage through a glacier can influence the continuing eruption style and potential hazards.