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Shallow magma-mingling-driven Strombolian eruptions at Mt. Yasur volcano, Vanuatu

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Mt. Yasur volcano (Tanna, Vanuatu) has been increasingly recognized for its high-frequency Strombolian eruptions for the last 300 years. Currently, this activity takes place at three vents with highly varying recurrence rates, denoted as A, B and C from south to north, respectively. During a 6-week field campaign in August-September 2008, we installed four seismic and four infrasound arrays at site to record seismic and acoustic signals. Two Doppler-Radars measured the exit velocities of the erupted material, and a thermal camera was used to determine the temperature at the vent mouth. At the time of the fieldwork, the three active craters showed very different styles of activity. Crater A, the most active vent, had an eruption recurrence of under a minute. Crater B showed very irregular ash-venting with variable periodicity ranging between minutes and days, while crater C was producing the strongest eruptions approximately every 10 minutes. We sampled the eruptive products of craters A and C for further analysis in the lab. In total, three bombs were collected, two were juvenile and one exotic lithic material, in order to investigate the chemical, physical, rheological and textural variations in the erupted products from the different craters.

The collected basaltic-andesite scoria bombs exhibit a relatively constant whole rock major element geochemistry (∼56 wt.% SiO_2). Petrographic texture and structure analysis revealed a large variation in porosity (∼30 - 78 %) and microlite content.

Both juvenile bombs revealed bimodal textures; that is, they contain regions of microlite-free glass (sideromelane) and regions of microlite-rich groundmass which suggests the occurrence of mingling and mixing of magma batches with different crystallization histories. In the exotic sample, almost no regions of sideromelane are observed; instead, the sample is nearly entirely crystallized. Interstitial glass chemistry from electron microprobe analysis shows a range of glass chemistry from 59-63 wt.% SiO_2, with less-evolved glass generally being associated with areas of higher crystal content. Analysis of the bubbles reveals a bimodal size distribution for each sample, reflecting the differences between the sideromelane and the crystal-rich area. Thermal analyses were performed to characterize the stability of the eruptive products as well as the physico-chemical character of the glass phase. Thermogravimetric measurements show no mass loss (within the detection limit of the method – 0.1 wt.%). Complementary analysis of the heat capacity (Cp) reveals intricacies in the glass transition temperature (Tg) locked in during quenching of the products. Here instead of showing a single, clear peak at the glass transition, the Cp curves of samples produced during the burst of lava bubbles reach a plateau at around 650-800 °C. For the sample of crater A the plateau further evidences the extraordinary presence of two distinct peaks at 690 and 800 °C, whereas sample of crater C reveals Cp peaks at 690 and 735 °C. An explanation of the dilemma of a double peak in the glass transition area was sought in the possible rheological influence of iron oxidation state, if it differs locally, as might be expected from a case in which magmas from different depths mingle with one another on short timescales. The anomalous nature of the measured glass transitions is used to infer that mingling is rapid and thus accommodated in the shallow parts of eruptive conduits, perhaps due to rejuvenation of material slumped from the crater walls into an open conduit system.