Evolution of magmatic volatiles during drilling into magma, Krafla, Iceland

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In 2009, the Iceland Deep Drilling Project (IDDP-1) unexpectedly drilled into a silicic magma body beneath Krafla volcano, temporarily creating the world's hottest geothermal well. The magma was hit three times between April and June at depths of 2101-2104.4 meters below the surface. During the third encounter cuttings were returned to the surface over a 9-hour period (15:17 to 00:50 on 26 June). These cuttings included glass, felsite and granophyre [1]. We examined the glass cuttings to investigate how the composition, particularly the H_2O and CO_2 content and speciation, evolved over the collection time and how the magma responded to being drilled into.

Major elements were analysed by electron microprobe and H_2O and CO_2 by synchrotron radiation Fourier-transfrom infrared spectroscopy. Two types of glass were recovered, a clear pumiceous glass (SiO_2=77.37 wt%) and a brown, poorly vesiculated rhyolitic glass (SiO_2=76.31 wt%) that only vary slightly in chemistry. Initially the clear glass was most abundant, but after 17:00 the amount of clear glass decreased significantly and the brown glass became dominant.

The total H_2O content of the glass (1.40±0.21 to 2.15±0.04 wt%) did not vary systematically over time, while CO_2 increased from 63±9 to 115±7 ppm after 17:30. Assuming saturation, H_2O-CO_2 suggest that the magma was experiencing pressures between lithostatic (~50 MPa) and hydrostatic (~16 MPa), in agreement with [1], and that the melt that formed the brown glass was coming from increasing depth. Accompanying the pressure increase, $OH/H_2O_{molecular}$ also increased (0.97±0.34 to 2.53±0.41), suggesting an increase in temperature. As a result, we hypothesize that hotter magma rose from (meters) deeper in the system after 17:00 and quenched to form brown glass.

[1] Zierenberg et al. (2013) *Contrib. Mineral. Petrol.*, 165, 327-347.