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In-situ thermal emissivity of silicate melts: an example from Erebus phonolitic volcano

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Real time thermal remote sensing of active volcanic systems is a crucial technique for understanding the behavior and eruptive activity of hot magmatic bodies. By determining the temperature of an erupting magma, researchers can have a better understanding on the rheology of active lava flows and domes, and have a first approach to the composition, flow pattern and cooling rate of the melt. Such measurements rely on determining the thermal infrared emissivity of the magma, a parameter that is crucial for understanding the heat transfer and radiative cooling of the system. Nevertheless, previous works have shown that the thermal emissivity of a silicate melt is strongly affected by changes in the composition, melt structure, presence of crystals or existence of a glassy crust. Hence, small changes on these parameters will have an important impact on retrieved temperatures (i.e. Lee et al. 2013). Within this context we have performed in-situ thermal emission spectroscopy measurements on two different samples: 1) a natural phonolitic glass/melt from Erebus and 2) an haplo-phonolitic synthetic glass/melt. We used a direct method to obtain a spectrum in the wavenumber range from 400 to 13000 cm-1; the samples were heated up from room temperature to 1600K with a CO_2 laser and data were collected during all the heating stage with a FTIR spectrometer. The first results show that both samples have a different emissivity response while being heated up. Whereas the synthetic sample shows no-variation in emissivity while heated, the natural Erebus glass sample, however, experienced a sudden jump in emissivity (from 0.7 to 0.95) beyond 2000 cm-1 near the glass-transition temperature. After this point, emissivity decreases with increasing temperature (to 0.8). We have also explored the thermal behavior of the natural phonolite during cooling. A low cooling rate increases sample emissivity to values that are similar to those at the glass transition (from 0.8 to 0.95) but beyond this temperature, emissivity remains constant at 0.95 and does not decrease further, even if temperature is still lowered. In contrast, with a high cooling rate from 1500K to 700K the final emissivity is equal to that obtained before the heating process (0.7).

Our results thus indicate that thermal emissivity is affected by changes in melt composition but also that silicate melts have a different emissivity behavior depending on the cooling rate. These are important observations since different emissivities will lead to different temperature determinations and hence, an erroneous interpretation on the rheology and thermal efficiency of the magmatic body.

References

Lee et al. 2013. Journal of Geophysical Research: Solid Earth. 118, 1968–1983