The formation and hydration of cracks in cooling volcanic glass

Felix W von Aulock[1], Ben Kennedy[1], Christopher Oze[1], Yan Lavallee[2], Alexander RL Nichols[3], Kai-Uwe Hess[4], Paul A Ashwell[1]

[1]University of Canterbury, Christchurch, New Zealand, [2]University of Liverpool, UK, [3]IFREE, JAMSTEC, Yokosuka, Japan, [4]Ludwig-Maximilians-Universitaet, Munich, Germany

E-mail: felixv.aulock@gmail.com

Volcanic domes, plugs and lava flows often show intricate, small-scale, geometric crack patterns. These cracks act as pathways for fluids and may jeopardise the structural stability of the dome, plug or flow. The circulation of volatiles allows crystal growth and surrounding glass hydration. Here, we study the cracking of magma directly or indirectly caused by cooling, based on analyses of textural, chemical and physical properties of natural samples and experimentally altered volcanic glasses.

Rhyolitic volcanic glass from the Ngongotaha dome (New Zealand) shows different generations of cracks, which we infer to reflect correspondingly different cooling history. Cooling from a temperature slightly higher than the glass transition interval (ie., from a relaxed state) spherulitic, anhydrous minerals crystallised. Spherulite growth produced cracks that served as channels to redistribute water. After further cooling below the glass transition temperature, perlitic cracks formed allowing water to flux through the dome. At ambient temperatures (10℃ average), additional cracks opened that were not subsequently hydrated. From examining hydration patterns in these natural samples, we conclude that hydration occurred only at temperatures between the glass transition temperature and $\approx$ 400℃ over timescales of days to months. Rapid quenching of rhyolitic volcanic glass from 900℃ induced fractures. X-ray computed tomography imaging of the fracture pattern shows a comparable texture to that characteristic of natural perlites. This similarity suggests that perlitic cracks form in tension as a result of thermal stressing during the cooling phase. The permeable network of perlitic cracks allows the circulation of fluids, which favours hydration and/or formation of hydrous minerals. We are currently investigating the effects of crystal growth by combined thermo-gravimetric analysis and differential scanning calorimetry of glass in situ in a water-saturated atmosphere. This on-going study promises to resolve the mechanism underlying the development of cooling structures commonly present in volcanic rocks as well their influence on permeable gas flow and the structural stability of lava domes, plugs and flows