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Investigating tension in the laboratory: Implications for volcanic processes

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Tensile fracturing is an important process that occurs at divergent plate boundaries and can also be observed at convergent plate boundaries, where it accommodates compression. Owing to the difficulty of simulating tensile loading in the laboratory very few data exist on how rock fails in this mode and how this process changes with temperature and strain rate. To address this issue we present the results from a range of experiments that examine direct tension under controlled conditions.

Experiments have been undertaken using basalt from the base of Eyjafjallajökull volcano and use a novel methodology of inducing tension through cooling. Initially, samples are heated above their solidus temperature and are allowed to expand within the apparatus. The samples are then locked in place and cooled at rates between 0.1 and 10 $^{\circ}$C.min^{-1}, inducing tension within the sample. We compare results from these direct tension test with indirect tension Brazilian tests, using the same rock type, at different temperatures (between room temperature and 900°C) and at a compaction rate of 4 x 10^{-4} mm.s^{-1}.

From Brazilian tests the tensile strengths of samples are between 10 and 20 MPa, with an overall increase in strength with increasing temperature. Cooling induced tension experiments show that direct tensile strength is commonly 50 to 75 % of the strength under indirect tension conditions and that an increase in cooling rate generally decreases the strength of the samples. These experiments show a complex stress history during cooling, from the onset to completion of fracturing. Complementary experiments have also been undertaken on Seljadur basalt from Iceland, where acoustic emissions and seismic velocities indicate that the magnitude of thermal cracking is greater during cooling than heating. These initial results have significant implications for understanding the conditions required for tensile failure in the field and the controls on the formation of the resulting fracture.