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The brittle-ductile transition in crystal- and bubble-bearing felsic magmas

Mattia Pistone (1), Luca Caricchi (2), Peter Ulmer (3), and Luigi Burlini (4)

(1) (mattia.pistone@erdw.ethz.ch), (2) l.caricchi@bristol.ac.uk, (3) peter.ulmer@erdw.ethz.ch, (4) luigi.burlini@erdw.ethz

Torsion experiments at high temperatures (673-1023 K) and high pressure (200 MPa) were conducted using a HT-HP internally-heated Paterson-type rock deformation apparatus (Paterson and Olgaard, 2000) in order to investigate the brittle-ductile transition and, thus, the viscoelastic response of crystal- and bubble-bearing silicic melts while subjected to progressive deformation. The strain response of magma is critically dependent upon its viscosity and the magnitude and time-scale of the application or release of the stress (Dingwell, 1997); therefore, the response of magma may either be ductile or brittle.

The experimental results reveal a clear strain rate and temperature dependence of brittle-ductile behavior of deformed magmas. The failure onset divides the two different regimes (brittle and ductile) and corresponds to the failure of a hydrous crystal- and bubble-free haplogranitic melt at the glass transition temperature (673 K), considered as reference material. The samples deformed and fractured during the experiments are characterized by variable degrees of crystallinity (24-65 vol.%), but identical bubble contents (9-12 vol.%). Samples deformed at strain rates exceeding 5•10-4 s-1 are liable to fracture, with an apparent viscosity (ratio between the viscosity of the mixture and the viscosity of the pure melt phase) ranging between 10ˆ9 and 10ˆ12 Pa•s. Fractures are distributed according to an antithetic trend with respect to shear strain markers, they crashed quartz crystals and many of them even passed through gas-pressurized bubbles, where CO2-rich gas evidently prevented melt from closing the fractures under high confining pressure.

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