Geophysical Research Abstracts,
Vol. 10, EGU2008-A-07441, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-07441
EGU General Assembly 2008

Experimental investigation at high pressure – high temperature of structures and rheology of crystal-bearing magmas deformed in simple shear

D. Picard (1), L. Arbaret (1), M. Pichavant (1), R. Champallier (1) and P. Launeau (2)

1. Institut des Sciences de la Terre d'Orléans, Université d'Orléans, FRANCE (David.Picard@cnrs-orleans.fr / Fax : (33) 02 38 63 64 88 / Phone : (33) 02 38 25 78 68)
2. Laboratoire de Planétologie et Géodynamique, Université de Nantes, FRANCE

Structures such as mineral fabrics and mechanical anisotropies, together with rheological properties, are key parameters to constrain the flow mechanism of crystallising magmas. Cooling magmas are thought to undergo a transition from a viscous suspension whose rheology is mainly controlled by the liquid to an interconnected framework capable of transmitting deviatoric stresses. Despite recent works, the crystal fraction that corresponds to this transition domain remains poorly defined between 0.4$< \Phi <$0.8. To better constrain this transition from liquid-like to granular medium-like behaviour and to characterize the associated microstructures, we performed HP-HT torsion experiments on partially crystallised silicic magmas.

The starting products were synthesised by crystallizing a haplotonalitic glass + 3% wt. H_2O at T=800˚C, 300 MPa during 7 days. The 20 μm long plagioclases are randomly distributed and oriented in both synthesised suspensions composed of respectively 52% and 58% of crystals. Torsion experiments were performed using a Paterson HP-HT apparatus, at a confining pressure of 300 MPa, a temperature of 800˚C, a shear strain rate 9.5x10^{-6} s^{-1} $< \dot{\gamma} <$ 9.2x10^{-4} s^{-1} and a shear strain 0.5$< \gamma <$4. Plagioclase shape fabrics have been determined by using both Inertia tensor and Intercept methods applied in [X, Z] sections.

For 52% crystals, the rheological behaviour is characterised by a peak in differential shear stress at γ = 0.1. It is followed by a nearly steady state evolution with little evidence of weakening with increasing strain. The apparent viscosity measured for $\dot{\gamma}$=1x10^{-4} s^{-1} is 10$^{10.40}$ Pa.s. At low strain rate ($\dot{\gamma}$=9.5x10^{-6} s^{-1}) a pervasive and homogeneous shape fabric develops over the section. The average fabric orientation is at 45° from the shear direction. At high strain rate ($\dot{\gamma}$=4.02x10^{-5} s^{-1}), rare thin synthetic normal shear zones bordered by shear gradients and oriented at about 40° clockwise from the shear direction are evidenced.

For 58% crystals, the differential stress reaches a peak at γ=0.1 more marked than for 52% crystals. It is followed by an important weakening until $\gamma \approx$ 0.6. For higher strains a stabilisation of the stress is observed at $\gamma \sim$ 4. The apparent viscosity measured for $\dot{\gamma}$=1x10^{-4} s^{-1} is 10$^{10.70}$ Pa.s. For all applied strain rates, strain localisation is evidenced with initiation and propagation of synthetic normal shear zones that crosscut the nearly undeformed initial texture. They lie at about 10° clockwise from the shear direction.

Our experimental results demonstrate a strong change in both rheology and microstructures with emergence of softening behaviour between 52% and 58% crystals. This evolution possibly originates from a change in solid framework behaviour between the two suspensions. Shear strain accommodation by rigid grain rotation and relative translation of plagioclases is possibly easier at the lower crystal concentration resulting in a pervasive SPO even if shear zones locally develop. At the higher concentration, the apparent hardening of the solid framework, could favour the initiation of shear zones since 0.1γ whose development with increasing strain accommodate the entire deformation and, in turn, produce the measured weakening.

Further experiments at lower and higher solid fractions that investigate a larger domain of crystallisation will be presented. They will specify the exact role of strain localisation on the rheological behaviour of these suspensions and constrain the implications on magma transfer processes.