Geophysical Research Abstracts
Vol. 19, EGU2017-13134, 2017
EGU General Assembly 2017

Flow behaviour of megacryst-rich magmas: the case of "cicirara" lavas of Mt. Etna volcano

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Multiphase magma rheological properties play a fundamental role on lava flow transportation, emplacement and morphology. To date, however, the three-phase (melt + crystals + vesicles) rheology of natural magma remains relatively understudied. We present here a series of high-temperature experiments designed to investigate the multiphase rheology of a mugearitic megacryst-bearing lava from Mt. Etna. A peculiar textural feature of this magma is the abundance of cm-size plagioclase crystals (megacrysts) together with smaller size crystals (phenocrysts and microlites), yielding a very wide crystal size distribution. We combined different experimental techniques (rotational and compressional rheometry) to investigate the rheology of this natural lava under different degrees of partial melting at subliquidus conditions. Results indicate that natural megacryst-bearing mugearite magmas from Mt. Etna display a wide range of behaviours as a function of temperature (T = 1000 – 1200 °C) and crystal content (phi = 0.2 – 0.7). In the investigated T range, the deformation mechanism of these magmas varies from mainly brittle (T < 1050 °C) to mainly ductile (T > 1085 °C). At T = 1075 °C, both ductile and brittle behaviour have been observed. In the ductile regime, these magmas behave as non-Newtonian fluids (at least up to T = 1100 °C) showing marked apparent shear thinning behaviour. The observed rheological behaviour is due to a complex response related to a non-homogenous deformation of the natural sample (e.g. viscous and/or brittle shear localization), favoured by the presence of vesicles. Consequently, the obtained flow parameters can be considered as representative of the bulk rheology of natural magmas, commonly characterized by similar non-homogeneous deformation styles. We applied the obtained data to discuss the flow and emplacement conditions of these peculiar lava flows. We demonstrated that at eruptive temperatures, the presence of a pre-eruptive crystal cargo and vesicles facilitates the achievement of critical crystal content during flow and cooling ultimately controlling the lava transport ability. Flow conditions can be maintained in the presence of an efficient insulation and, importantly, of deformable vesicles promoting and enhancing shear localization.