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Late magmatic strain localization: An experimental approach

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The transfer and emplacement dynamics of highly crystallised ($\phi >\sim 0.6$) magmas are mostly dependent on the interconnected crystal-framework controlling the tortuosity of the residual melt flow and capable of transmitting deviatoric high stresses. Crystal fraction, size distribution, and strain rate control the development of crystal fabrics and strain localisation. How localised structures potentially promote the transfer of residual gas and melts in hardly moveable late magmatic mushes is a critical question that remains largely undocumented.

We present high temperature (650° to 750°C) and high pressure (P=300 MPa) deformation experiments on both natural and synthetic dioritic, hydrous (3 wt% H_2O) suspensions with markedly euhedral anisometric crystals ($0.43> \phi >1$) submitted to simple shear. Quantitative structural analysis, including grain shape fabric, clusters formation, and shear zones geometry, were performed by 2D SEM imagery and by 3D high resolution X-ray Computed Tomography.

Crystal fraction $\phi <\sim 0.75$ exhibit a glomeroporphyritic texture compose of a mixed population of isolated grains and clusters of touching grains. Development of clusters induce a dramatic increase in tortuosity of melt flow leading to a significant increase of the apparent viscosities of the shear-thinning suspensions.

At $\phi >\sim 0.75$, a modification of the mechanical behaviour is evidenced with a nearly solid like behaviour associated with a dramatic change of the microstructures. Strain localisation leads to the development of S/C' like structures progressively replaced by tensions gashes and Riedel cataclastic shears when approaching the full crystallization stage. Residual melt, and fluids when present, migrate from compressive regions to transtensive zones favouring potential outgassing and residual melt escape at near-solidus conditions.

Our results stress the importance of strain localisation structures for residual fluids and melt transfers in magmatic suspensions submitted to high stresses.