5.4.21

Using textural analysis techniques to quantify magmatic processes: 2D sections to 3D crystal populations

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Crystal populations provide valuable information to help understand magmatic processes. It is possible to characterise crystal populations found in igneous rocks in terms of the size variation (Crystal Size Distribution CSD) and their spatial packing arrangement (Spatial Distribution Pattern - SDP). In both cases, 2D rock textures are digitised into Image Analysis packages providing statistical data on crystal sizes and positions. CSD studies provide insight into the growth history of the crystal population and can identify mixed populations of crystals from different parts of the magma system and potentially timescales. SDP analysis can define if crystals are forming touching frameworks in 3D and the nature of packing arrangements which has implications for magma rheology. Recently work has moved into the 3D reconstruction of crystal populations using 3D visualisation of digitally reconstructed crystal populations from 2D serial sections (figure1). This approach allows full quantification of the CSD and SDP in 3D and can also examine in detail the crystal shapes at different size intervals. A combination of this 3D approach with micro-analytical geochemistry will allow the full assessment of growth histories, magma residences times and fluxes in volcanic systems.

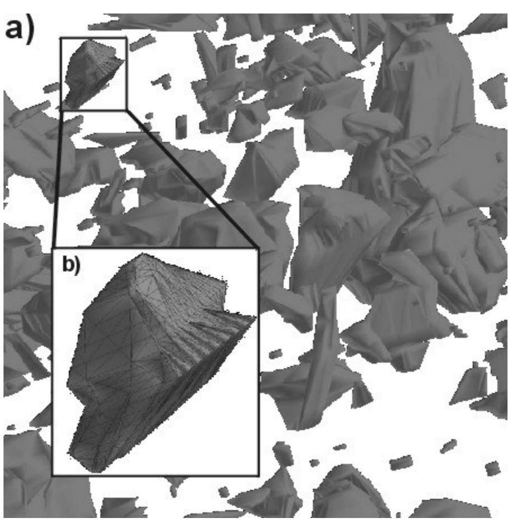

Figure1, a) Crystal population in 3D; b) individual crystal morphology reconstructed from serial sections.

5.4.22

Windows into an open-system magma chamber: Cognate inclusions from the Kameni Islands, Santorini, Greece

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The composition of the dacite lavas that form the Kameni Islands (the active portion of Santorini volcano, Greece) have been relatively uniform over the last 2200 years. This homogeneity attests to the significance of mixing processes in this shallow, open-system chamber. Further insights into chamber evolution can be gained from the abundant cognate cm- to dm-scale inclusions in the dacite. These inclusions include both cumulates from the chamber floor and quenched enclaves of replenishing magma. They fall into four groups, distinguishable by differences in their chemistry, texture and mechanical behaviour.

Mapping of the inclusion types shows that each flow forming the Kameni Islands has a distinct inclusion population, reflecting the changing state of the emptying magma chamber. Groundmass textural information obtained from the quenched inclusions can be used to determine the relative volumes of replenishing magmas injected into the host chamber before each eruption. A large gradation in groundmass texture is observed when the volume of replenishing magma is large; in contrast, when the volume of replenishing magma is small, groundmass textures are essentially uniform. By comparing the volumes of erupted magma with the relative volumes of the corresponding replenishing magma, we find that the erupted magma volume is directly proportional to the volume of replenishing magma.

The varying groundmass textures of the different inclusion types are also reflected in their contrasting spatial distribution patterns. Inlcusions with a coarse groundmass are found as large isolated blocks randomly dispersed throughout the host lava. Converesly, inclusions with a finer groundmass are much smaller and often occur in tight, elongate clusters aligned in the direction of flow. The groundmass texture places a significant control on the rheological properties of the inclusions, which in turn controls the ease with which batches of replenishing melt disperse and interact with the cooler host dacite magma.