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Double-diffusive-convection in alkaline silicate melts: new results from mixing experiments with natural volcanic glasses

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Convection due to a compositional, rather than a thermal gradient, occurs when concentration gradients of the components have opposing effects on the vertical density distribution of a fluid. This kind of instability is called double-diffusive-convection (DDC). A series of convective layers is then generated, leading to chemical fractionation. Although this is a very well known phenomenon for aqueous solutions, its onset in high temperature silicate glasses has been described from numerical modeling.

In order to study the rheology of a magmatic chamber (Phlegrei Fields Volcano, Naples, Italy) we performed short and long-lasting experiments using natural alkaline silicate melt compositions, which have been stirred together during a time series using a viscometer, at constant temperature (1300^{o}C), constant RPM and under very low Reynolds numbers, consequently very laminar flow.

After 16 and 25 hours decoupled convection cells originated. Electron microprobe microanalyses of the glasses indicate a complex layering of cells bounded by clear compositional gaps and gradients. At cell interfaces all analysed oxides exhibit spreading horizons, where oxide contents range over 2 wt% (SiO_2, Na_2O).

Rb/Sr isotopic measurements on the resulted experimental glasses (De Campos et al., in prep) are an additional unrefusable support for the decoupled dynamic-geochemical development of the obtained convection cells. From a 169-hours experiment, for most major oxides, the decoupled cells are still confirmed. They show more complex patterns, with local rhythmic layering, marked by contrasting well-mixed and diffusive layers. Perpendicular to the cell interface fine ($\sim$10 to 100 μm) parallel fingers may develop and seem to be the diffusive response to the compositional gradient.

In the absence of a significant temperature gradient, convection in our experiments was driven by the applied forced convection combined with the effect of local compositional gradients (diffusion) along the sample leading to a density distribution resembling a double diffusive system. According to our results, the combined effect of convection and diffusion plays an significant role to originate vertically and laterally zoned magma chambers, whose different models are discussed in the literature.