



## Transcrystalline melt migration driven by natural thermal gradients

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Deciphering the physical processes by which melts and fluids form, migrate and interact is necessary to fully understand the dynamics of the Earth mantle and the processes involved in volcanism. Here, we present heating experiments performed with an imposed thermal gradient on olivine-hosted silicate melt inclusions collected at Piton Vincendo (Reunion Island) and La Sommata (Vulcano Island), showing that silicate melts in olivine crystals experience transcrystalline migration at a constant rate and without chemical modification. Qualitative observation and kinetic measurements, collated with a thermodynamic analysis, demonstrate that migration occurs by dissolution/precipitation controlled by interface kinetics, not chemical diffusion. The migration rate,  $V = k \theta L$  (where the kinetic constant  $k \approx 0.5 \text{ nm s}^{-1} \text{ K}^{-1}$ ,  $\theta$  is the thermal gradient and  $L$  is the inclusion length). In addition,  $\text{CO}_2$ -oversaturated melts experience phase separation, as the fluid fraction remains fixed and becomes isolated from the migrating melt. We thus suggest that melt inclusions in lava phenocrysts may have lost part of their volatile content by transcrystalline migration, and so not be fully representative of the parent magma for volatile budgets in volcano evolution models. Extrapolated to mantle conditions and geological timescales, our kinetic law indicates that thermal gradients prevailing in the Earth mantle provide a thermodynamic driving force for small-scale melt migration in an undeformed solid matrix. That this migration promotes isolation of  $\text{CO}_2$ -rich fluid inclusions from silicate melts also questions the very existence of a free, fluid phase that pervades the mantle, an hypothesis based on the belief that fluid inclusions in mantle minerals are remnants of such a phase. More technically, melt migration experiments allow to acquire basic quantitative data on crystal growth kinetics at very low undercoolings, i.e. in conditions much more appropriate to natural systems than classical crystal growth experiments.