

Grain boundary diffusion in the lower crust: Low temperature applications of TitaniQ thermobarometry

GEOFF BROMILEY^{1*} AND MATTHEW HISCOCK¹²

¹School of GeoSciences, Univ. Edinburgh, Edinburgh EH9 3FE, UK (*geoffrey.bromiley@ed.ac.uk)

²Oxford Instruments Nanoanalysis, High Wycombe HP12 3SE, UK

The high concentration of defects in grain boundary regions means that they provide fast, alternative pathways for diffusion of chemical species, especially towards lower temperatures where lattice diffusion (LD) is thermally inhibited. However, although the importance of grain boundary diffusion (GBD) is widely recognised there remains a lack of experimental data on the relative importance of this mechanism in key geological systems.

We present results of a study of Ti diffusion in polycrystalline quartz. As well as providing a general model of cation diffusion in the lower crust this system is of considerable interest in thermobarometry as concentration of Ti in quartz (TitaniQ) is commonly used to determine crystallisation temperatures [1-3]. Diffusion experiments were performed at 1 GPa, 1000-1600°C using a Ti capsule source and fine-grained, synthetic quartz aggregate as both sink and matrix phase. Resulting diffusion profiles are complex and demonstrate operation of fast GBD and slower LD. Using the approach of LaClaire (1963) [4] we derive grain boundary diffusivities and demonstrate that GBD is 2-6 orders of magnitude faster than LD.

Based on these results we present a model which considers the weighted influences of LD vs GBD of Ti in polycrystalline quartz of variable grain size. Our results support the increasing use of the TitaniQ thermometer in diverse, low temperature applications, and suggest that effective closure temperature for Ti diffusion in fine-grained quartz-rich material is as low as 350-400°C. More broadly, results from this study indicate that the importance of GBD as a transport mechanism in the Earth has been underestimated considerably, especially in the lower crust where it may have a major influence on geochemical processes.

[1] Wark & Watson (2006) *Contrib. Min. Pet.* **152**, 743-754.

[2] Thomas et al. (2010) *Contrib. Min. Pet.* **160**, 743-759. [3]

Huang and Audetat (2012) *Geoch Cosmoch. Acta* **84**, 75-89.

[4] LaClaire (1963) *J. App. Phys.* **14**, 351-356.