He and Ar diffusivity in naturel MORB glasses

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Diffusion in glasses

Given the short timesacales implied for the creation and seperation of a volatile phase during magmatic degassing, it seems likely that disequilibrium processes could fractionate the noble gases as well as other volatiles [1, 2, 3]. In order to document the diffusivity of noble gases in basaltic systems, we present a study of He and Ar diffusion by stepwise degassing. He and Ar analyses were performed on natural fresh MORB glasses (*AMK 3375*, mid-Atlantic Ridge).

Results

The results produce linear trends in a plot of ln(D) vs. 10000/T (Fig. 1). We observe high Ar diffusivity at low temperature. This behaviour is not well understood but may reflect a specific diffusion path of Ar into MORB glass. Further work is planned to determine the origin of this behaviour. Nevertheless, there is a convergence of He and Ar diffusivities consitent with a 'compensation' temperature [4] where He and Ar diffusivities are equal.

Implications

The experimental data show a compensation temperature for He and Ar diffusion at ~750°C. The implications of this are that there will be no kinetic fractionnation during magmatic processes. From Fig. 1 Ea = 192,16 kJ.mol^{-1} and Do = 9,91E^{-4} cm^{2}.s^{-1} for He and 67.73 kJ.mol^{-1} and Do = 1.68E^{-4}cm^{2}.s^{-1} for Ar in natural MORB glasses. In order to apply these results to natural magmatic systems there are two important caveats to consider:- 1) In our samples, He and Ar were originally present predominantly as gases in vesicles, and therefore extraction consists of two steps: solubilisation of vesicle gases into the glass and then volume diffusion of dissolved He or Ar through the glass itself. The diffusivities measured (Fig. 1) will reflect the slowest of these processes, and it seems possible that this is the reason behind rapid Ar diffusion at low T. 2) Our experiments were carried out below the glass transition temperature and diffusivities may be different in true liquids. Further work is planned to constrain both of these issues.

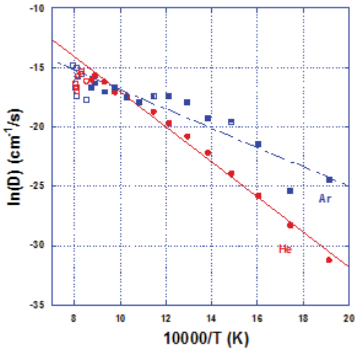

Figure 1 : **He** (circles) and Ar (squares) diffisivities in MORB glass which was heated between 150 and 950°C for 20 mins; diffusivities are for spherical geometry. The compensation temperature is estimated at ~1000K where ln(DHe) = lnD(Ar)

[1] A. Paonita (2006) *Earth Planet Sci. letts* **241** 138-158. [2] C. Aubaud (2004) *Earth Planet Sci. letts* **222** 391-406. [3] H.M Gonnermann (2003) *Earth Planet Sci. letts* **238** 1-16. [4] S.R. Hart (1981), G.C.A. **269**, 507 - 516

Cosmogenic ^{3}He in calcite: under what conditions is it useful?

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Abstract

Spallation produced ^{3}He has recently been explored as a dating tool in a variety of non-traditional mineral phases, including apatite, garnet, hornblende, titanite, and zircon. Three problems limit the utility of these phases to differing degrees: 1) nucleogenic Li-produced ^{3}He, 2) redistribution of Li-produced ^{3}He between small crystals, and 3) presence of large amount of radiogenic ^{4}He. Calcite is less vulnerable to these problems because it is generally very low in Li, U, and Th, it has a very low He closure temperature, and it occurs in very large crystal sizes. Here we build on recent work[1] by exploring the apparent retentivity of calcite formed in different aqueous environments. Results comparing ^{36}Cl against ^{3}He in micritic limestones from the Dead Sea and Aegean regions show that ^{3}He is not quantitatively retained in calcite from these limestones over 10 kyr timescales. In contrast, results from hydrothermal vein calcite from multiple sites on the Pamir and Tibetan Plateaus suggests quantitative retention over at least 20 kyr timescales. Cross-calibration of ^{3}He against ^{36}Cl in these sample suggests reasonable ^{3}He production rates between 130-160 at g^{-1} yr^{-1}. Step-wise diffusion experiments of the same vein calcite reveals complex arrhenious relationships characterized by a decrease in diffusivity during successive degassing steps at the same temperature. This behavior is consistent with the presence of multiple diffusion domains, which may reflect the size of calcite growth pyramids or "hillocks." [1] Ongoing work seeks to establish whether diffusivity of ^{3}He depends on the size of calcite growth pyramids, which are in turn dependent on the CO_3 saturation level and the presence of impurities in the crystallizing fluid. Ultimately, we hope to define a set of growth conditions under which the resultant calcite crystal is likely to be retentive to ^{3}He over timescales and surface temperatures suitable for cosmogenic dating.

[1] Copeland et al., (2007) *Geochimica et Cosmochimica Acta* **71** 4488-4511