Helium and argon solubility in silicate melts: Relationship between solubility and liquid structure

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The interpretation of elemental noble gas ratio in magmatic rocks requires the knowledge of the solubility of these elements in silicate liquids and crystals. Argon solubility in silicate melts appears to be controlled by tetrahedral units rather than oxides as previously reported (Marrocchi and Toplis, 2005). This model successfully accounts for reported argon solubility in Al-free systems, in simple Al-bearing systems and in natural liquids. It strongly suggests the link between melt structure and noble gas solubility.

In order to test this predictive model, we computed helium data available from the literature (Jambon *et al*., 1980; Shibata *et al*., 1998). As for argon, helium solubility is controlled by the molar silica content, whatever the nature of the network modifying cations. However, we did not observe the two linear segments with a break in slope at ≈ 67 mol% SiO_2 reported for argon (Marrocchi and Toplis, 2005). Such an observation suggests than helium solubility is less sensitive than argon to the polymerization state of the liquid but might be predicted using this parameter. We define partial molar helium solubility of Q_4 (-11.16) , Q_3 (-13.87) and Q_2 (-15.11) MMR species as used in the argon model. Such species corresponds to fully polymerized units (Q_4), sheet lik units (Q_3) and chain like units (Q_2).

In Al-bearing systems, the nature of the low-field strength cation plays an important role. Determination of helium solubility in such systems is underway in order to define the partial molar helium solubility of the $NaAlO_2$, $Ca_{0.5}AlO_2$ and $Mg_{0.5}AlO_2$ components. Comparison of the He and Ar solubility parameters will allow us to assess differences (if any) between the solubility mechanisms for both gases and thus, develop a predictive model for He/Ar fractionation during magmatic degassing.

References

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Heavy lithium in subducted slabs

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Modelling of the Li budget of subducting oceanic crust during dehydration completed previously [1], suffered from a poor constriction on essential input data, such as the Li isotopic fractionation as a function of temperature, the partition coefficient between metamorphic rocks and fluids and the representative range of Li abundances and Li isotopic compositions of altered oceanic crust (AOC) and sediments. These values have been quantified since [2,3,4,5] and were used in this study to revisit the impact of dehydration on the Li isotopic composition of AOC. The results show that dehydration can account for a decrease in δ^7Li of only ≤3 ‰, including the entire prograde metamorphic process up to the unhydrous eclogite stage. Dehydration can, therefore, *not* account for light Li in high-pressure metamorphic (HPM) rocks. Eclogites in subducting slabs are predicted to contain Li at MORB-like concentrations and to be moderately enriched in the heavy isotope. The fore-arc mantle will be strongly enriched in Li with a heavy Li isotopic composition.

We analysed Li abundances and Li isotopic compositions of 56 orogenic HPM rocks from 8 different localities. The investigated samples (together with eclogite samples from [1]) show a wide range in Li abundances from 1 to ~50 µg/g (one sample 77 µg/g). Li isotopic compositions of the rocks display both very heavy (δ^7Li > +6 ‰) and very light (δ^7Li < 0 ‰) compositions, as low as -21.9 ‰. However, the δ^7Li histogram displays a strong peak between 0 and +4 ‰.

Li abundances in excess of 20 µg/g in orogenic HPM rocks of basaltic composition (eclogites) can only be explained by addition of Li after the onset of subduction, most probably during eclogitisation or exhumation. Light-δ^7Li values are probably generated by kinetic fractionation of the Li isotopes during diffusive influx of Li from the country rocks into the exhuming eclogite bodies. The consequence of this hypothesis is that Li found in orogenic eclogites is not representative of rocks within subducting slabs. The investigation of subduction-related HPM rocks has always suffered from retrogression of the natural rock samples during exhumation. In the case of Li, this problem seems to be particularly vicious, due to the high diffusivity of Li, its fluid mobility and its liability to kinetic isotope fractionation. On the other hand, Li and its isotopes may be highly sensitive tools to detect HP and retrograde metasomatism in eclogites and peridotites.

References

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