

Noble gas solubility in silicate melts: Relation between the solubility and melt structure

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Because of inert nature and the existence of radiogenic isotopes noble gases serve as excellent tracers of mantle dynamics and atmospheric evolution. The noble gas solubility in silicate melt particularly provides one of the most important constraints on the degassing evolution from the solid earth during mantle melting. Therefore, it is imperative to understand the property of noble gas solubility in silicate melt.

Carroll and Stolper (1993) proposed ionic porosity model for noble gas solubility. The ionic porosity is mean proportion of hole space in the melt, and can generally explain the solubility in silicate melts. However, it can not indicate relationship between the solubility and melt structure. I confirmed how network forming and network modifying cations affect noble gas solubility in details (Shibata et al., 1996, 1998). I found a systematic relationship between the noble gas solubility and the network structure in melts, leading to quantitative and qualitative characterization of the solubility of noble gases as a function of melt composition.

The silicate melt is generally formed by limited anionic structural units. The proportion of the units in silicate melt is decided by NBO/Si (or NBO/T) ratio, the number of nonbridging oxygens per silicon (or tetrahedrally coordinated cation) in the melt. The solubility increases as the proportion of network units formed by bridging oxygens increases. Further, the noble gas solubility is estimated for each type of anionic unit. The estimated solubility for the units formed by bridging oxygens are higher than those by nonbridging oxygens, supporting that large portion of dissolving noble gases is coupling with bridging oxygens.

References

- Carroll M.R. and Stolper E.M. (1993) *Geochim. Cosmochim. Acta* **57**, 5039-5051.
Shibata T., Takahashi E., and Matsuda J. (1996) *Geophys. Res. Lett.* **23**, 3139-3142.
Shibata T., Takahashi E., and Matsuda J. (1998) *Geochim. Cosmochim. Acta* **62**, 1241-1253.

3.0 Ga ocean floor metamorphism in the Cleaverville area, Pilbara Craton, Western Australia

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Ocean floor metamorphism is an important process of interaction between sea-water and oceanic crust, namely surface environment and solid Earth. In this study, we will show that the metamorphism of the Cleaverville area in Pilbara granite-greenstone terrain, Western Australia, originates from the 3.0 Ga ocean floor metamorphism based on the geological mapping and detail sketches of some critical outcrops and that the metamorphism was caused by CO₂-rich hydrothermal fluid. The Cleaverville area is composed mainly of basaltic greenstones, over 2600 m thick, with subordinate amounts of chert and clastic rocks. The clastic rocks consist of mudstone, sandstone and conglomerate. The basaltic greenstone and the bedded chert have no clastic material, on the other hand the clastic rock is terrigenous sediment. The lithostratigraphy is quite similar to the oceanic plate stratigraphy in the Phanerozoic accretionary complex. In addition, duplex structures are also present at upper part of this unit. The presence of the duplex structure and the oceanic plate stratigraphy indicate that the mid-Archean Cleaverville Formation is an accretionary complex (Ohta et. al., 1996).

The greenstones in the upper 2200 m part of the basaltic flow unit include carbonate minerals. The extent of the carbonatization decreases stratigraphically downward. We detailedly investigate the presence and distribution of several to 30 cm wide quartz veins. The distribution of the cm-scale quartz veins is limited to the upper 1800 m of the greenstone sequence. In the upper 1800 m part, Ca-Al silicates including Ca-zeolite, prehnite, pumpellyite are almost absent in the metabasites. Instead, abundant carbonates are present with chlorite, suggesting high CO₂ content in the fluid. In the lower part below the upper 1800 m greenstone, fine amphiboles are present. The mineral paragenesis of the metabasites indicates that the metamorphic grade increases from sub-greenschist to greenschist facies stratigraphically downward.

The alteration and metamorphism of the Cleaverville area are not subduction-related because the isograds of carbonate-out, quartz veins-out and amphibole-in are parallel to the ancient seafloor. The greenstones underwent the alteration by high-XCO₂ hydrothermal fluid, because carbonate minerals are stable in the upper oceanic crust instead of Ca-Al silicates. The severe carbonatization of oceanic crust suggest high activity of CO₂ in the 3.0 Ga sea-water.

Reference

- H. Ohta, S. Maruyama, E. Takahashi, Y. Watanabe, Y. Kato (1996), *Lithos* **37**, 199-221.