A new CO_2 solubility model for silicate melts from fluid-saturation to graphite-saturation: Implications for the redox state of oceanic basalt source regions

JAMES EGUCHI*, RAJDEEP DASGUPTA

Department of Earth Science, Rice University, 6100 Main Street, MS 126, Houston TX, 77005, USA.
*correspondence: james.eguchi@rice.edu

The CO_2 content of natural silicate magmas influences many of their physicochemical properties. For this reason there have been several models developed to constrain the CO_2-H_2O solubility in fluid-saturated silicate magmas [e.g. 1]. However, most previous composition-dependent models of CO_2-solubility have been formulated to only treat fluid-saturated melts. With the growing number of experimental studies on CO_2 solubility at graphite-saturation, we developed a new model to quantify dissolved CO_2 contents at both fluid-saturated as well as graphite-saturated conditions over a wide range of P (0.05-3 GPa), T (950-1800 °C), and compositions (komatiite to rhyolite). The model is based on a thermodynamic framework that accounts for the effects of P, T, fCO_2, and compostion on the equilibrium constants of the CO_2 dissolution reactions.

Here, we use the model to investigate the redox state of oceanic basalt source regions that are deeper than the dry-peridotite solidus and may sample partial melts of enriched lithologies (e.g., eclogite, pyroxenite). We follow the approach of Eguchi & Dasgupta [2], who argued that CO_2 contents of many OIBs are too high to be explained by mixing with graphite-saturated partial melts of MORB-eclogite. This implies that MORB-eclogites are too oxidized for graphite to be the stable form of C at the depths where these rocks begin melt (>5 GPa). This is in contrast with cratonic xenolith records, which suggest that the redox state of the mantle should be within the graphite/diamond stability field at these depths [3]. However, MORB-eclogite produce relatively silica-rich melts, which dissolve less CO_2 compared to more silica-poor melts generated by some pyroxenites thought to contribute to oceanic basalt genesis [4]. Our new model predicts that at the same P, T, fO_2 conditions, graphite-saturated partial melts of pyroxenite dissolve $\leq\sim1$ order of magnitude more CO_2 than partial melts of MORB-eclogite. We use our new model to determine CO_2 contents at graphite-saturation for a range of partial melts thought to contribute to oceanic basalts. We then compare the results to geochemistries (e.g., CO_2 vs CO_2/Nb) of natural oceanic basalts to make inferences about the redox state of the regions of the mantle (deeper than the peridotite solidus) where partial melts of different enriched lithologies may be generated.

[1] Ghiorso, M., Gualda, G. (2015). *CMP* pp. 53. [2] Eguchi, J., Dasgupta R. (2017). *CMP* pp. 12. [3] Frost, D., McCammon, C. (2008). *Ann Rev Earth Pl Sci*. [4] Hirschmann, M., Stolper, E. (1996). *CMP* pp. 185-208.