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# Ferropericlase crystallization under upper mantle conditions: implications for inclusions in diamond

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Ferropericlase, occurring as inclusions in diamond is generally believed to originate in the lower mantle or transition zone, (e.g. Kaminsky, 2012). This is based mostly upon the fact that ferropericlase cannot coexist with low-Ca pyroxene in a peridotitic bulk composition. However, unlike other high-P phases, ferropericlase has no intrinsic limitation to its P-T stability, as it is even stable at 1 bar. This provides the possibility for stabilizing ferropericlase in localized environments with lower $SiO_2$ activity at shallower depths within the upper mantle. One potential scenario involves the redox reaction of slab-derived carbonate melt with reduced peridotite (Thomson et al. 2016). To further pursue this hypothesis, we have undertaken ferropericlase crystallization experiments at 5–12 GPa and 1500–1700°C, using two configurations: (1) equilibrium experiments with Ca–Mg–Fe carbonate + MgO + olivine mixtures and (2) “sandwich” experiments containing a layer of olivine between a layer of metallic iron and one of carbonate. In this way, the Fe serves as an “external reducer” and oxygen sink, being physically separated from the carbonate.

The equilibrium experiments produced carbonate-silicate melts saturated in olivine and ferropericlase. Melt $SiO_2$ contents were 2–12 wt% and inversely correlate with CaO and $CO_2$ contents and positively with T. Comparing our carbonate-silicate melt compositions with literature data for melts saturated in olivine and low-Ca pyroxene reveals that ferropericlase-saturated melts cannot be produced by melting of carbonated harzburgite or lherzolite at upper mantle conditions. On the other hand, the sandwich experiments indicate that ferropericlase and diamond (or metastable graphite) can crystallize simultaneously during the reduction of carbonate-silicate melt following the reaction: $MgCO_3$(melt) = MgO(periclase) + C(graphite/diamond) + $O_2$, as long as no low-Ca pyroxene is present (i.e. a dunitic bulk composition). The lack of direct contact between the Fe and melt means that our observed reduction process is independent of the presence of metallic Fe and is also valid for reduced conditions without metal saturation. Ferropericlase crystallizing in equilibrium with olivine will be richer in Fe compared with lower mantle ferropericlase in equilibrium with bridgmanite. Thus, the considerable variation in mg# values observed for some suites of natural diamond containing ferropericlase inclusions could in part be attributable to ferropericlase (and diamond) formation in the upper mantle.