Efficient carbon leaching in silicate through fluid/melt migration and implications for diamond formation

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Natural diamond forms in silicate metrix at depths great than 150 km. Carbon concentration in the mantle is very low and there must be an efficient process to concentrate carbon to form diamond. Carbon-bearing fluids and carbonates are considered to be the major carbon sources for diamond formation, and their migration in silicate rocks at high pressure and temperature could provide important clues for understanding the mechanism of carbon enrichment during diamond formation.

Fluid and melt migrations in the mantle are droven by tempertaure/pressure and chemical gradients and gravity. High-pressure experiments in silicate-fluid and silicate-carbonate systems were performed to examine migrations of C-saturated fluid and carbonate melt in silicate matrix. We start with homogeneous mixture of amorphous carbon and silicate minerals (olivine or pyroxene). With presence of fluids, we observed efficient separation of graphite/diamond from its matrix and it concentrated at the end of the capsule. We further examined the effect of thermal gradient and gravity on the separation by a multiple-capsule techniqued.

Carbon can exist in its reduced (e.g., elemental C and CH_4) or oxidized (e.g., CO_2 and CO_3^{2+}) forms. Redox reaction plays an crucial role in diamond formation process. It is important to determine if carbon enrichment is more efficient in its reduced form than in its oxidized form. We examine the CO_2-rich melt distribution in solid silicate phase by SEM imaging and 3D tomography. The carbon enrichment through oxidized melt is not as efficient as in the form of elemental carbon, indicating that efficient diamond growth may require reduction of carbon to its reduced form first.

Upper crustal overprinting of lower crustal processes at Maipo Volcano (34°10'S), Southern Volcanic Zone

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The Diamante Caldera – Maipo Volcanic Complex is situated in the northernmost part of the Andean Southern Volcanic Zone (SVZ), upon ~50 km thick continental crust. Receiver function data suggest magma stalling at the base of this thickened crust in the northern SVZ [1], which is consistent with along-arc trace element variations that show increasing evidence for equilibration with garnet in basalts and basaltic andesites erupted to the northern end of the SVZ [2]. In a suite of basaltic andesite to dacite lavas sampled at Maipo, we observe clear evidence of assimilation and fractional crystallzation (AFC) processes in the upper crust, overprinted upon the lower crustal, presumably garnet-equilibrated trace element signature. The basaltic andesites are characterized by Sr/Y = 35-40, Eu/Eu* >0.85, $^{87}Sr/^{86}Sr$ = 0.7045-0.7050, and $^{144}Nd/^{143}Nd$ = ~0.5126. These chemical characteristics reflect a significant lower crustal input relative to basalts and basaltic andesites from the central and southern portions of the SVZ, which sit upon much thinner crust and are characterized by Sr/Y = 15-30, Eu/Eu* ≈ 1, $^{87}Sr/^{86}Sr$ = ~0.7040, and $^{144}Nd/^{143}Nd$ = ~0.5129 [3]. The Maipo data show continuous geochemical trends from the basaltic andesites to the dacites, which are characterized by Sr/Y = 14-24, Eu/Eu* ≈ 0.50-0.75, $^{87}Sr/^{86}Sr$ = 0.7054-0.7057, and $^{144}Nd/^{143}Nd$ = ~0.5125. These dacites are consistent with differentiation from the basaltic andesites by AFC with a plagioclase-rich crystallizing assemblage in an upper crustal magma chamber. Constant Gd/Yb (2.5-3.1) in the lavas may reflect a buffering effect of amphibole during differentiation, although it is rarely observed in the phenocryst assemblage. The high Sr/Y in the more primitive magmas, which suggests garnet fractionation at depth, has been erased in the more evolved magmas. Thus we note that the absence of high Sr/Y in intermediate arc magmas does not necessarily indicate that the magma did not interact with garnet at depth.

[1] Gilbert *et al*., (2006) *GJI* **165**, 383-398. [2] Hildreth and Moorbath, (1988) *CMP* **98**, 455-489. [3] Hickey *et al*. (1986) *JGR* **91**, 5963-5983