

The fate of carbon in deeply subducted oceanic crust

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The Earth's mantle is a potentially vast carbon reservoir. Ingressing and outgassing of carbon via the plate tectonic cycle modulates the evolution of surface carbon on timescales of millions to billions of years [1]. Although estimated carbon fluxes into and out of the mantle have large uncertainties [1,2], the mantle reservoir may be dominated by carbon recycled into the mantle at subduction zones [3]. The form of carbon in the mantle depends on oxygen fugacity, and will include carbon-rich fluid and melt, solid carbonate, diamond, Fe-rich alloy and FeNi-carbide. Estimates for mantle oxygen fugacity indicate that below ~150-250 km diamond or metal carbide should be the primary host of carbon [4,5]. This is consistent with diamonds that originate in the sub-lithospheric mantle, containing mineral inclusions that indicate an origin typically between ~200-700 km. Sub-lithospheric diamonds provide abundant evidence for subducted carbon and crustal components; their carbon isotopes are characteristically 'light' relative to mantle carbon, they contain silicate mineral inclusions dominated by non-peridotitic compositions, and many silicate inclusions contain isotopically 'heavy' oxygen [6,7]. Moreover, majoritic garnets and calcium silicate phases have major and trace element compositions best explained by equilibration with low-degree carbonate rich melts derived from oceanic crust [8,9]. Experiments show that carbonated oceanic crust subducted into the deep upper mantle and transition zone will melt along subducted crust geotherms, effectively limiting the deep carbon cycle to the transition zone and shallow lower mantle [8]. Mobile carbonate melts will react with mantle peridotite to form hybrid minerals similar to those found in diamonds. This process of deep carbonatite metasomatism may have operated since subduction initiated, with the potential to pervasively alter the chemical and isotopic character of the deep upper mantle and transition zone.

- [1] Dasgupta & Hirschmann (2010) *EPSL* 298, 1-13. [2] Kelemen & Manning (2015) *PNAS* 112, 3997 [3] Hirschmann & Dasgupta. (2009) *Chem Geol* 262, 4. [4] Rohrbach & Schmidt (2011) *Nature* 472, 209. [5] Stagno et al. (2013) *Nature* 493, 84. [6] Burnham et al. (2015) *EPSL* 432, 374. [7] Thomson et al. (2014) *CMTF* 168. [8] Thomson et al. (2016) *Nature* 529, 76. [9] Walter et al. (2008) *Nature* 454, 622.