The speciation of carbon with respect to the redox state of the mantle

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Carbon is exchanged between the surface and the interior as a result of volcanism and subduction. In order to understand how carbon is cycled through the interior and its likely residence time, information is required on the forms in which carbon exists under various conditions. When bonded to oxygen in the form of carbon dioxide or carbonate melt components, carbon behaves as a volatile element lowering the melting temperatures of rocks and forming melts and fluids, which can migrate and rise out of the mantle. It can, on the other hand, also exist in reduced form as diamond and graphite where it behaves as a refractory element.

Experiments and modelling has been performed to understand the conditions in the mantle under which carbon transformations between reduced and oxidized species. The effect of pressure on ferric-ferrous equilibria involving mantle mineral components will result in the tendency for carbon to favour reduced forms at depth. However, such an influence can only operate when carbon is relatively evenly distributed. Local enrichments of carbonate, that may occur within subducting lithosphere, will be too oxygen rich to completely pass into the diamond stability field. Such regions will instead be buffered at the oxygen fugacity where carbonates reduce to produce diamond or graphite over significant depth intervals. The higher ferric iron content and carbonate content of subducted mafic rocks allows carbon to remain mobile to greater depths and probably explains why such lithologies appear to be more represented within deep diamond inclusions. Increasing pressure during subduction will favour the oxidation of ferrous to ferric iron but this can only account for the reduction of a few 100 ppm carbon. The remaining carbonate may then be dispersed by melting, limiting the deep subduction of carbon.