

Deep Carbon Cycle : The obvious and the weaker aspects of its cycle

P. CARTIGNY

IPG-Paris, Stable Isotope Laboratory, Paris, France
(cartigny@ipgp.fr)

Carbon is massively exchanged between the Earth's surface and the deepest part of the mantle so that, on billion years time scales, it is at, or close to, steady state (= amounts and isotope compositions of carbon being degassed and subducted being balanced). This is best evidenced by constant C-isotope compositions, over nearly 3.5 Gy, in both sediments (typically 20% organic matter, 80% carbonates with $\delta^{13}\text{C}$ -values of) and mantle-derived samples (diamonds, carbonates, carbonates from kimberlite) averaging $\delta^{13}\text{C} \sim -4 \pm 1\%$. This can also be inferred from the short residence time of surface carbon, close to 1.5 Gy. The implication is that modern recycled carbon flux equals degassed carbon flux at about 2×10^{12} mol/y.

Owing to mantle carbon steady-state, there is *a priori* little chance for mantle (= *cycled*) and primordial (= *uncycled yet*) carbon to be isotopically distinct, but the longer residence time of mantle carbon, ca. 4-6 Gy suggests that such a primordial C-reservoir might exist. Our best estimate, based upon the diamonds having the most primordial (= *lowest*) N-isotope compositions, favors a primordial C-isotope composition close to -3.5% . The size of the primordial carbon reservoir remains however elusive.

If subducted carbon has a $\delta^{13}\text{C}_{\text{average}} \sim -4\%$, it is originally both chemically and isotopically heterogeneous; so there is some chance (despite isotope re-equilibration with increasing metamorphism) that some deep mantle domains would record subduction-related heterogeneity.

Such a heterogeneity cannot however be inferred from mid-ocean ridge or ocean island basalts; the C-isotope variability mostly reflect degassing processes (= lowering residual $\delta^{13}\text{C}$). This is best illustrated by the lack of relationship between volatile heterogeneity (e.g. $\text{H}_2\text{O}/\text{Ce}$ and D/H-ratios) rather showing relationships with degassing proxies (e.g. $^{40}\text{He}/^{40}\text{Ar}^*$). So, if any, mid-ocean ridge basalt bear very small C-isotope heterogeneity.

Many authors ascribe low $\delta^{13}\text{C}$ -diamonds (typically in the range of -15 to -25%) to mantle carbon isotopic *heterogeneity* related either to subduction and, in particular to redox-freezing reactions. This model can account for associated ^{18}O -enrichment in diamond inclusions but bear significant difficulties.

Yet, several diamond populations (from komatiites in French Guyana and from Jericho kimberlite in Northern Slave with $\delta^{13}\text{C}$ -modes $\sim -28\%$ and -38% respectively) are unique and difficult to interpret in the light of subducted or mantle-processed carbon heterogeneity (i.e. there is almost no sediment with $\delta^{13}\text{C}$ as low as -40%): there is the possibility that deep mantle domains with odd C-isotope characteristics indeed exist. If correct, this would have very strong implications when considering sedimentary C-isotope excursions associated with the emplacement of large igneous provinces: their C-budget would not need to be close to $\delta^{13}\text{C}$ of -5% .