Deep Carbon Through Time: The Diamond Record

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Earth's mantle is by far the largest silicate-hosted reservoir of carbon. Diamonds are unrivalled in their ability to record the cycle of mantle carbon and other volatiles over a vast portion of the Earth's history. They are the product of ascending, cooling, carbon-saturated, metasomatic fluids-melts and/or redox reactions, predominantly within peridotitic and eclogitic domains in the mantle lithosphere. This paper reports the results of a major secondary ion mass spectrometry (SIMS) carbon isotope study, carried out on 127 diamond samples, spanning a large range of geological time. Detailed transects across the incremental growth zones within each diamond were measured for C isotopes, N abundances and, for samples with N >~200 at.ppm, N isotopes. Given that all of the samples are fragments, recovered when the original crystals were broken to liberate their inclusions, 81 of the analytical traverses have confirmed growth direction context. 98 samples are from studies that have confirmed the dates of the individual diamonds through analysis of their silicate or sulphide inclusions, from source localities including Argyle, De Beers Pool, Jwaneng, Orapa, Udachnaya & Venetia. Additional samples come from Wawa (a minimum age) and Diavik where the samples are tied via inclusion paragenesis to published ages. The peridotitic dataset covers the age range of ~3.3 – 2.0 Ga, with the eclogitic data from 2.9 – 1.0 Ga.

In total, 751 carbon isotope and nitrogen concentration measurements have been obtained (425 on peridotitic diamonds, and 326 on eclogitic diamonds) with 470 nitrogen isotope measurements (190 P, 280 E). We attempt to constrain the diamond carbon isotope record through time and its implications for (i) the mantle carbon reservoir, (ii) its oxygen fugacity, (iii) the fluid / melt growth environment of diamonds, (iv) fractionation trends recorded in individual diamonds, and (v) diamond population studies using bulk combustion carbon isotope analysis.