ECLOGITES IN THE SCLM: ARE ANY SUBDUCTED?

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It has become conventional wisdom that xenoliths of eclogite and garnet pyroxenite derived from cratonic subcontinental lithospheric mantle (SCLM) represent fragments of subducted ocean floor, implying that the SCLM has grown by a lithosphere-stacking mechanism involving repeated shallow subduction beneath cratons. However, the inferred behaviour of these ancient “slabs” is markedly different from what we observe in the modern Earth; seismic-tomography images clearly show slabs descending steeply to at least 660 km depth, rather than layering at shallow depths beneath the continents.

Xenolith suites in basalts from young terrains (Tectons: eg E. China, E. Australia, western USA, Hawaii) commonly contain garnet pyroxenites that display exsolution microstructures clearly reflecting their origin as high-T cumulates or crystallised melts. Similar microstructures, though less common, also occur in cratonic eclogites. The compositional field of Tecton garnet pyroxenites can be expressed by mixing of high-T, high-Al cpx ± opx ± gnt. This compositional field is coincident with that of cratonic eclogites; both rock types are distinct in composition from the clearly crustal eclogites found in HP/UHP metamorphic belts.

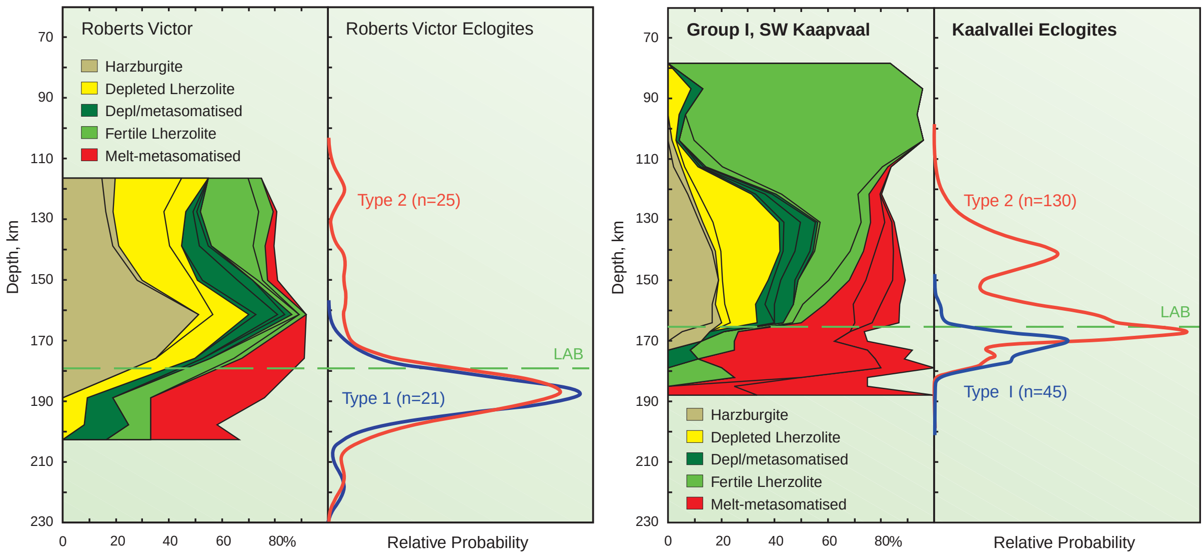

__Fig. 1.__ Depth distribution of eclogites beneath the SW part of the Kaapvaal craton at ca 125 Ma (left) and ca 90 Ma (right), compared to SCLM "stratigraphy" (left column of each frame) derived from analysis of xenocrystic garnets. In each case eclogites are concentrated neat the base of the depleted SCLM, associated with significant melt-related metasomatism. The depleted layer of the SCLM was significantly thinned, heated and refertilised in the time interval between the intrusion of these two groups of kimberlites, and eclogites were emplaced into the base of the thinned SCLM. However, there was no subduction beneath southern Africa during this time.

Simultaneous solution of cpx-gnt thermometers with the equations for xenolith-derived geotherms shows that rather than being widely distributed in the SCLM as implied by lithosphere-stacking models, eclogites from many cratonic areas are concentrated in layers <20 km thick, co-spatial with a strong signature of metasomatism in the surrounding peridotites (Fig. 1). In many cases this combination of features defines a “lithosphere-asthenosphere boundary” marking the transition from depleted SCLM to more fertile underlying mantle. This pattern strongly suggests that the eclogites reflect the intrusion of asthenosphere-derived melts near compositional/rheological boundaries, causing metasomatism in their peridotite wall-rocks (Griffin and O'Reilly, 2007).

The strongest argument for a crustal origin for cratonic eclogites is the large spread in □^{18}O observed in *some* suites; such fractionation is commonly thought to require a low-T origin. However, studies of Mg isotopes in high-T peridotites show equally large fractionation even within single xenoliths; significant isotopic fractionation clearly can take place at T >1000°C. SCLM eclogites commonly host diamonds with low-□^{13}C carbon; this was originally interpreted as biogenic in origin, but this model is not consistent with N-isotope data. The □^{13}C variation can be explained by Rayleigh fractionation during redox reactions. In framesites, the tight covariation of □^{13}C in diamond and □^{18}O in cogenetic silicates (Fig. 2) suggests that similar redox-related fractionation mechanisms are involved; the isotopic signatures are not *prima facie* evidence of a shallow origin for SCLM eclogites.

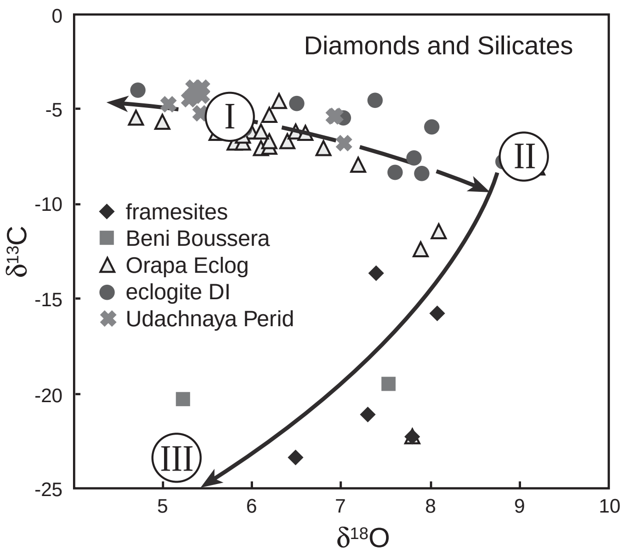

***Fig. 2**. Covariation of C and O isotopes in diamonds and related silicate phases. Component I represents the "average mantle" values of both parameters. Component II represents the mean isotopic composition of many mantle-derived carbonatites. We suggest that trend II-III is produced by Rayleigh fractionation as carbonatitic fluids precipitate diamonds, and trend I-II reflects mixing processes in the SCLM. These two processes can account for the observed variation in δ^{13}C and δ^{18}O in cratonic eclogites. Shallow (sea-floor) processes are not required.*

Eu anomalies in cratonic eclogites also have been presented as evidence of the previous presence, or fractionation, of plagioclase. However, similar anomalies are found in peridotitic garnets from the SCLM, and probably reflect redox processes during metasomatism, similar to those that produce isotopic fractionations in carbon and oxygen. Some SCLM eclogites carry "crustal" isotopic signatures - but so do many intraplate magmas. These signatures may reflect the derivation of parental magmas from deeply subducted crust, rather than the direct emplacement of ocean floor into the SCLM.

Most of the "evidence" for a subducted-ocean-plate origin of cratonic eclogites is readily explained by magmatic processes; in particular, the distribution of eclogites in the SCLM (Fig. 1) argues against the subduction hypothesis. The cratonic eclogites, like the Tecton pyroxenites, reflect the growth or erosion of the SCLM from below, through magmatic processes, rather than from the side, through shallow subduction.

Griffin, W.L, and O'Reilly, S.Y., 2007. Cratonic lithospheric mantle: Is anything subducted? Episodes (in press).