Eclogites in the SCLM: The subduction myth

W.L. Griffin[1,2] and Suzanne Y. O'Reilly[1]

[1] GEMOC, Dept of Earth and Planetary Sciences, Macquarie University, NSW 2109, Australia
[2] CSIRO Exploration and Mining, North Ryde, NSW 2113, Australia

It has become conventional wisdom that eclogite and garnet pyroxenite xenoliths 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 implied 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 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 nearly all cratonic eclogites; both rock types are distinct in composition from clearly metabasaltic eclogites in HP/UHP metamorphic belts.

Simultaneous solutions of cpx-gnt thermometers with the equations for xenolith-derived geotherms show 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. 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. Many eclogites may also have experienced ≥1 episode of metasomatism, making bulk compositions (especially trace element patterns) an unreliable guide to their origin.

The strongest argument for a crustal origin for cratonic eclogites is the large spread in $\delta^{18}O$ observed in *some* suites; such fractionation is commonly thought to require a low-T origin. However, 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-$\delta^{13}C$ carbon; this has been interpreted as biogenic in origin, but this model is not consistent with N-isotope data. The $\delta^{13}C$ variation can instead be explained by Rayleigh fractionation during redox reactions. In framesites, the tight covariation of $\delta^{13}C$ in diamond and $\delta^{18}O$ in cogenetic silicates suggests that similar redox-related fractionation mechanisms are involved; the O-isotopic signatures thus are not *prima facie* evidence of a shallow origin for SCLM eclogites. 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 phases, and may simply reflect redox processes during metasomatism.

Some SCLM eclogites carry "crustal" radiogenic-isotope signatures -- but so do many intraplate magmas. These signatures may reflect derivation of parental magmas from deeply subducted crust, rather than the direct emplacement of ocean floor into the SCLM. The cratonic eclogites, like the Tecton pyroxenites, may be telling us about the growth or erosion of the SCLM from below, through magmatic processes, rather than from the side, through shallow subduction.