



## Redox-dependent formation and destruction of eclogite-hosted diamond as part of the deep carbon cycle

Sonja Aulbach (1), Alan Woodland (1), Prokopy Vasilyev (2), Larry Heaman (3), and Fanus Viljoen (4)

(1) Goethe University, Institut für Geowissenschaften, Fachinheit Mineralogie, Frankfurt am Main, Germany (s.aulbach@em.uni-frankfurt.de), (2) John de Laeter Centre, Curtin University, Perth, Western Australia, (3) Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton AB, Canada, (4) Department of Geology, University of Johannesburg, PO Box 524, Auckland Park, 2006, Johannesburg, South Africa

In the Archaean continental lithosphere (cratons), mantle eclogite is the source of a disproportionate amount of gem-quality lithospheric diamonds (~33%) compared to its subordinate volume (1-5 vol%) [1]. As a consequence, eclogite may be disproportionately responsible for carbon storage in the mantle lithosphere, warranting a closer look at the processes leading to eclogitic diamond formation and destruction as part of the deep carbon cycle.

The coincidence of eclogitic diamond formation ages with craton amalgamation or growth [2] suggests that initial diamond formation in metabasaltic substrates is closely associated with eclogitisation during subduction. Using new and published data, we find that most mantle eclogites (~80-90%) have  $fO_2$  that are too low to stabilise pure carbonatite or carbonate ( $\Delta \log fO_2 \sim -1.5$  relative to the fayalite-magnetite-quartz buffer FMQ) or  $CO_2$ -dominated fluid ( $(\Delta \log fO_2 \text{ (FMQ)} \sim -2.0$  at 5 GPa). Thus, carbonate inherited from seafloor alteration and  $CO_2$ -bearing fluids mobilised from deeper lithologies during subduction [3] will be reduced and sequestered in oceanic crust via diamond formation. This process may have been more efficient in Archaean oceanic crust, which was more reduced than today, and which is further reduced upon recycling [4, this work]. Later interaction with carbonated silicate melts, which are stable with peridotite to lower  $fO_2$  than pure carbonatite [5], a relationship assumed here to also hold for eclogite, may cause additional diamond precipitation in eclogites with  $\Delta \log fO_2 \text{ (FMQ)} < \sim -2.5$  (~35%). Interaction with oxidising small-volume carbonated silicate melts, typically formed during incipient lithosphere extension, eventually also causes diamond resorption and associated carbon remobilisation at mantle depth [6]. In some xenolith suites this is evidenced by the association of diamond with high-Ca and low-Mg eclogites but its absence in LREE-enriched high-Mg eclogites and pyroxenites, suggesting that ~30 to 50% of the diamond inventory was destroyed. Most of this carbon would have been re-stored and focused as carbonate-phlogopite-rich metasomes in the more oxidising shallower lithosphere, now observable as ubiquitous mid-lithospheric discontinuities (e.g.[7]). These metasomes are reactivated not only during extension [8], but also due to deep lithosphere foundering during collisional processes, as applies to the Mesozoic and Neoproterozoic decratonisation of the eastern North China and Saharan craton, respectively [7]. Attendant volcanism and crustal high-temperature metamorphism and degassing may have had non-negligible effects on atmospheric  $CO_2$  levels.

[1] Stachel & Luth (2015) *Lithos*; [2] Aulbach & Jacob (2016) *Lithos*; [3] Vitale-Brovarone et al. (2018) *Lithos*; [4] Aulbach et al. (2017) *EPSL*; [5] Stagno et al. (2013) *Nature*; [6] Fedortchouk et al. (2019) *EPSL*; [7] Aulbach (2019) *Geophys Monogr*; [8] Foley & Fischer (2017) *NatGeosci*.