Isotopic evidence for the coupled recycling of carbon and boron to lower mantle depths

M.E. REGIER[1*], T. B. CHALK[2], R.A. STERN[1], K. SMIT[3], E.M. SMITH[3], T. STACHEL[1], G. L. FOSTER[2], Y. BUSSWEILER[1], J.W. HARRIS[4], D.G. PEARSON[1]

[1]Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta Canada T6G 2E3 (*correspondence: margo@ualberta.ca)

[2]School of Ocean and Earth Science, University of Southampton, National Oceanographic Centre, University of Southampton, Southampton SO14 3ZH, UK

[3]Gemological Institute of America, New York 10036, USA

[4]School of Geographical and Earth Sciences, University of Glasgow G12 8QQ.

Type IIb blue diamonds are of intense scientific interest due to their inferred lower mantle and transition zone origin, and thus, their ability to illuminate deep and ancient subduction and differentiation processes [1]. While the inclusions in Type IIb diamonds are indicative of both peridotitic and eclogitic parageneses [1], the origin of the boron impurities have not yet been established. Deep mantle-derived boron may be sourced from undegassed primitive mantle reservoirs, subducted oceanic lithopshere, or from the prograde metamorphism of mantle wedge serpentinite. The large natural variation in boron isotopes allows for the discrimination of these reservoirs. Here we present a carbon and boron isotopic study, combined with nitrogen and cathodoluminenscence (CL) analyses on a suite of Type IIb diamonds from the Cullinan mine, South Africa.

The 22 blue diamonds in this sample suite have extremely negative $\delta^{13}C_{VPDB}$ (Cameca IMS1280) of -14 ‰ to -20 ‰ with little $\delta^{13}C$ zoning. Nitrogen and boron contents are low (<10 ppm N, <0.4 ppm B), with the majority of samples having lower than detection limit (<0.5 ppm) nitrogen. Where zoning occurs, higher boron concentrations correlate with weaker CL emission in the visible wavelengths. Using a closed-cell laser-ablation system, ~2.5 ng of boron was collected in dilute nitric acid. Subsequent analyses (Neptune MC-ICPMS) yielded higher than mantle $\delta^{11}B$ (> -7 ‰). The heavy boron and light carbon isotopic composition of these blue diamonds suggests that surface-derived volatiles are effectively transferred into transition zone and lower mantle phases, such as dense hydrous magnesium silicates, during the prograde metamorphism of serpentinite.

[1] Smith *et al.* (2018) Nature **560**, 84-87.