Multiple Origins of Eclogitic Diamonds from the Jericho Kimberlite, Nunavut

Smart, K.A.*, Chacko, T., Heaman, L.M., Stachel, T., Muehlenbachs, K.
Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, AB – kasmart@ualberta.ca

Understanding the origin of diamonds and the processes that surround their formation in the Earth's mantle is hampered by a scarcity of diamond-bearing xenoliths. These xenoliths provide direct information on the composition and origin of the diamond source rocks, while carbon and nitrogen extracted from the diamond population is invaluable to determining the mode of diamond formation. Although single diamonds extracted from kimberlites during processing can also be linked to source rocks (through diagnostic mineral inclusions), diamond-bearing xenoliths provide a more direct link to diamond genesis in the lithospheric mantle. Here we present compositional data for silicate minerals in two compositionally distinct diamond eclogite suites from the Jericho kimberlite in the northern Slave craton, complemented by nitrogen and carbon data for the diamonds and mineral composition data for silicate diamond inclusions. These initial results indicate that eclogitic diamonds from Jericho have multiple origins.

Jericho diamond eclogite xenoliths can be separated based on mineral composition into Mg-rich Group A and Fe-rich Group B, the former being the dominant suite (85%) and the latter being compositionally similar to diamond eclogites worldwide. Compared to Group B diamond eclogites, garnets from Group A diamond eclogites have high Mg#'s (0.82 vs. 0.65), Cr_2O_3 (0.56 vs. <0.1wt.%), Sc (103 vs. 46 ppm) and Zr (33 vs. 7.9 ppm) and low Na_2O (0.05 vs. 0.11wt%) contents and have highly fractionated HREE ($[Lu/Gd]_N$=5.5 vs.1.03). Clinopyroxene from Group A diamond eclogites is Na-poor (1.7 vs. 4.9 wt.%), and LREE- enriched relative to clinopyroxene from Group B eclogites. Temperatures calculated at a fixed pressure of 5 GPa for Group A eclogites (970-1015^{o}C) are lower than those for the Group B eclogites (1080^{o}C). Interestingly, the garnet inclusions liberated from Group A diamonds contrast compositionally with garnets from the host Group A eclogites and have lower Mg #'s (0.54 vs. 0.82), Cr_2O_3 (0.1 vs. 0.56 wt%), higher CaO (7.6 vs 4.3 wt%), Na_2O (0.1 vs. 0.06 wt%). Clinopyroxene inclusions in these diamonds are similar to the host Group A clinopyroxene, but have distinctly lower Mg-#'s (0.78 vs 0.93) and Cr_2O_3 (0.05 vs. 0.33 wt%), and higher Na_2O (2.4 vs. 1.9 wt%) and FeO (6.3 vs. 2.1 wt%). Garnet and clinopyroxene inclusions have higher TiO_2 compared to the host eclogite minerals.

Diamonds from Group A eclogites have low N contents (<10 to 81 atomic ppm) and aggregation states (all are Type IaA). In contrast, diamonds extracted from the Group B eclogites have extremely high N contents (1300 to 5200 ppm) and exhibit moderate aggregation states, from 23 to 56%B (i.e., they are Type IaAB). Our carbon isotope data for Group A eclogitic diamonds overlap the results reported by De Stefano et al. (2009), and record the lowest $\delta^{13}C$ values (-35 to - 41‰) known from any diamond suite worldwide. This contrasts strongly with the carbon isotopic compositions of Group B diamonds, which cluster at -4.5‰.

The different equilibration temperatures of the two diamond eclogite groups suggest that they

resided in different parts of the Slave lithospheric mantle, and may have separate origins. We previously proposed that the Group A eclogites formed via partial melt extraction from Group B type eclogite coupled with partial equilibration between eclogite and adjacent peridotite. This model is supported by the observation of Group B-like garnet inclusion compositions in the Group A eclogites. We speculate that, like many other eclogite suites, the Jericho Group B eclogites represent subducted oceanic crust. Group A and B diamond populations also have separate origins, forming from distinct carbon sources and/or by different processes. Further isotopic and geochemical investigations will help determine the origin of eclogitic diamonds at Jericho.

References

De Stefano et al. (2009). Diamonds and eclogites of the Jericho kimberlite (Northern Canada). Contrib. Min. Pet. 158, 295-315.