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Petrology and geochemistry of a Cratonic mantle-derived Eclogite Xenolith Suite from the Balmoral Kimberlite, Kimberley Region, South Africa

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This study presents the first comprehensive investigation into the petrography, major and trace element mineral chemistry of a mantle-derived eclogite xenolith suite from the Balmoral kimberlite. Most of the eclogite xenoliths from the Balmoral kimberlite pipe are bimineralic (garnet and clinopyroxene) rocks with a substantial number of corundum-bearing xenoliths also recognised. The bimineralic eclogites are classified into low MgO (<15 wt% MgO) and high MgO (<15 wt% MgO) varieties. Mica with average modal abundances ≤10 vol% is observed as an accessory phase in bimineralic xenoliths. Modal abundances of corundum in corundum-bearing samples range between 1 and 6 vol%. Textures are ambiguous in Balmoral eclogites, while the chemical criteria of McCandless and Gurney (1989) place all of them into Group II. The temperature range of Balmoral eclogites (at an assumed pressure of 50 kbar; Ellis and Green, 1979) is between 1046 and 1311 °C. The low-MgO bimineralic eclogites are characterised by relatively higher temperatures than the high-MgO variety. Corundum-bearing eclogites have the highest equilibration temperatures. Based on calculated temperatures, corundum-bearing eclogites have the highest inferred pressures of equilibration with the high-MgO eclogite variety having the lowest. The reconstructed Balmoral major element bulk compositions are characterised by variations in MgO, CaO and Al_2O_3 contents, with less variation in FeO contents. Reconstructed major element bulk compositions from bimineralic eclogites coincide with those of tholeiitic basalts, and to a lesser extent, basalts from mid-ocean ridges and oceanic gabbros. Corundum-bearing eclogites are similar to oceanic gabbros in general. The REE pattern of bulk eclogite commonly show humped-shaped REE_N patterns. High MgO eclogites have a slight enrichment in the $LREE_N$ pattern while low MgO eclogites have enrichment in $HREE_N$ patterns. These REE_N patterns are broadly comparable to those of oceanic gabbro and MORB. The protolith for these Balmoral eclogite xenoliths is thought to be a once composite oceanic crustal section which underwent partial melting during subduction and/or dehydration and, subsequent metasomatic re-enrichment in incompatible trace elements.