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# Roberts Victor Eclogites with a Spinel-Facies Mantle Signature

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The Roberts Victor kimberlite pipe, South Africa, is renowned for having yielded one of the worlds largest and most diverse suites of mantle derived eclogite xenoliths. These rocks have been subjected to detailed petrologic and geochemical investigation, but despite these efforts many aspects of the origin of the eclogite xenoliths have remained stubbornly enigmatic. The study of eclogite xenoliths has given rise to two major classes of models for their origin; namely that eclogite xenoliths either represent metamorphosed subducted oceanic crust (e.g. Jagoutz et al., 1984) which may have been partially melted to produce TTG suites (Rollinson, 1997), or that they have originated within the mantle (e.g. O'Hara & Yoder, 1967). In both cases the melts are of mantle origin, but in the first case the protoliths (original rocks) crystallised from the melt in the oceanic crust whilst in the second case they crystallised in the mantle. Clearly a key feature in unravelling the origin of various groups of eclogites lies in determining the pressure at which the protoliths crystallised. Potentially the origin or origins of eclogites can be elucidated by consideration of their bulk rock major and trace element chemistry, as one would do with a coherent suite of igneous rocks. This is the approach we have adopted utilising major element EMPA and SIMS trace element data, together with modal mineralogy to derive bulk rock compositions.

The eclogites can be divided into two principle petrographic groups; those with regular shaped grain boundaries (RGB) and those with irregular grain boundaries (IGB). Those with RGB can be subdivided into those that do not possess an obvious foliation (RGBa), and those that do possess a foliation (RGBb). No primary trace element rich accessory phases were identified. In terms of alkali and silica content all the eclogites are comparable to basalts or picrites. On variation diagrams, CaO, $K_2O$ and $Na_2O$ contents correlate positively with $SiO_2$ in undeformed Groups IGB and RGBa. The RGBb group does not show such correlations, generally clustering around a similar $SiO_2$ content. Whole rock trace element compositions mirror the petrographic groupings with IGB characterised by relatively flat LREE to HREE patterns, RGBa by slightly LREE depleted patterns, and RGBb by significantly depleted LREEs. Kyanite-bearing eclogite portions of the IGB composite eclogites bear a very small positive Eu anomaly.

When the bulk rock major element compositions are re-cast in to CIPW normative mineralogy, the eclogites are split between nepheline (mostly RGBb) and hypersthene normative (mostly IGB and RGBb). When these normative compositions are plotted on a diopside projection within the basalt tetrahedron (Falloon & Green, 1988), the majority of eclogites fall on a very well defined trend, suggesting their compositions are comparable with melts in equilibrium with peridotite at 15 kbar. The similarity between the eclogites and spinel facies peridotite melts is further emphasised when the eclogites are compared with the normative compositions of ophiolite suite lithologies which preserve a lower pressure signature and significantly more scatter due to extensive fractionation.

The major and trace element contents of the composite eclogites could not be modelled as recrystallised MORB and plagioclase cumulates. Relative to oceanic-basalts, the eclogites are severely depleted in HFSEs. Major element trends indicative of typical olivine-plagioclase ocean-floor basalt fractionation are not observed. These features together with the normative compositions of the eclogites suggest that at least the majority of these eclogites are not recrystallised subducted ocean floor. From consideration of the petrological and geochemical features preserved in the xenoliths it is proposed that the majority of the Roberts Victor eclogites represent recrystallised products of peridotite partial melt which initially crystallised at ~50 km as clinopyroxene-rich protoliths. These rocks were subsequently buried to depths within the diamond stability field. This increase in pressure induced recrystallisation to eclogite. We propose that the majority of these eclogites formed by a single process and the differences in chemical and petrographic features between the IGB, RGBa and RGBb groups have been induced by subsequent modification processes in the upper mantle.

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