THE PETROLOGY AND MINERALOGY OF ECLOGITE XENOLITHS FROM THE ROBERTS VICTOR KIMBERLITE

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The Roberts Victor kimberlite is well known for its abundant eclogite xenoliths, twenty-five of which have been examined by the author. The ellipsoidal or discoidal xenoliths often display a rudimentary layering, are medium to coarse-grained and show a variable mozaic-like fabric. Four primary eclogite-mineral assemblages have been recognised, namely, the basic garnet-clinopyroxene assemblage (21 xenoliths) with additions of kyanite (2 xenoliths), kyanite-corundum, and diamond (one xenolith each). Primary rutile and sulphides are common trace constituents.

On petrographic grounds a broad distinction can be made between three groups characterised by the following general features:

Group I: garnets dark reddish to brown, bright and clear, tend to be rounded to elongated, occasionally subhedral, clinopyroxene dark green, only partially altered (10 specimens).

Group II: garnets pale orange to pink, turbid and fractured, tend to be rounded to irregular or angular, rarely subhedral; clinopyroxene pale green, extensively altered (12 specimens).

Group III: garnets bright orange, clear, rounded to irregular; clinopyroxene completely altered; kyanite always present (3 specimens).

The amount of garnet present varies tremendously, ranging from 14% to 74%, but showing a bimodal distribution with maxima at 45% and 65%. These two maxima show some correlation with the Group I and Group II eclogites respectively. In several specimens the garnet has been largely altered to secondary fine-grained micaceous material. Kyanite ranges between 3,3% to 9,0%.

Normally the xenoliths are extensively altered and also show distinct signs of undergoing tectonic deformation before incorporation into the kimberlite. Careful microscopic examination also reveals that almost every eclogite displays evidence of partial melting of the clinopyroxene (and possibly also the garnet) with the formation of secondary amphibole, feldspar crystallites and zeolite, usually in a vitreous matrix. This unusual feature is interpreted as resulting from the incongruent melting of the primary constituents on a sudden relief of pressure and while at a considerable depth. This probably took place at the time of kimberlite emplacement.

Chemical analyses of nine selected xenoliths show their variable composition; two specimens are alkalic, the remainder being tholeiitic. They are all undersaturated and three are nepheline normative. Complete melting of these rocks would not produce typical basaltic liquids but rather liquids of picritic character. This clearly indicates that the eclogite xenoliths do not represent isochemically transformed gabbroic material.

The garnets, which are distinct from those found in peridotite xenoliths, are pink, orange or brown. The majority of garnet compositions, estimated from refractive index and unit cell size, ranges from 40% to 60% pyrope with an appreciable content of almandine and grossularite. Four analysed garnets also show a significant andradite but neglible uvarovite content. Garnets from the kyanite eclogites are pyrope-poor and grossularite-rich. On the basis of estimated garnet compositions two fairly distinct groupings can be made (but with several widely scattered compositions) which show some correlation to the Group I and II eclogites, the former being slightly richer in the pyrope and grossularite end-members. The bulk of the garnet compositions are typical of those from eclogites belonging to high-grade metamorphic complexes and are not at all similar to those from kimberlites or ultrabasic rocks. Their pyrope content suggests formation at lower pressures than typical kimberlitic or peridotitic garnets.

Chemical analyses of two pure blue-green clinopyroxene (omphacite) separates reveals its jadeite-rich nature and its clear distinction from chrome diopside. The omphacite has invariably been altered by a process of incongruent melting and is therefore not normally suitable for conventional chemical analyses. Kyanite, found in three xenoliths, occurs as bright blue platey grains and is in no way different to that from high-grade regionally metamorphosed rocks. The minor amount of corundum seen in one kyanite eclogite may be of secondary origin. Diamond is the only other constituent of significance and occurs both as colourless, well-formed crystals and as blackish granular aggregates of diamond and graphite. In general diamonds found in eclogites probably formed under conditions similar to those diamonds found in kimberlite. The question of diamond formation in natural silicate systems is still unanswered but conditions need not necessarily be as severe as often thought.

In general eclogites occur in five petrologically distinct environments, namely, lenses in ultramafic masses, masses associated with high-grade metamorphic complexes, lenses in Alpine-type orogenic zones, inclusions in alkali basalts and finally as inclusions in kimberlites. It is clear that the name eclogite can refer to a number of distinct garnet-pyroxene rocks of differing origin. Numerous origins have been suggested for those found in kimberlite. They have been considered to be samples of an eclogitic upper mantle, to be cognate with the kimberlite, to represent accidentally incorporated crustal eclogite from high-grade metamorphic complexes, or to originate from eclogite lenses within an ultrabasic upper mantle.

Normally kimberlites are extremely poor in eclogite xenoliths. The abundant eclogite xenoliths in the Roberts Victor kimberlite indicates that this pipe cannot be considered typical. This suggests that these xenoliths are probably not related to the kimberlite genesis. The Roberts Victor eclogites are of variable mineralogical and chemical composition and their constituent minerals are in no way similar to those of kimberlite or its peridotite xenoliths. Garnet compositions are very similar to garnets from eclogites typical of high-grade gneissic complexes.

From this study it has been concluded that: 1. The Roberts Victor eclogites are not cognate with the kimberlite host and are probably in no way related to it. The possibility of the eclogites representing a high pressure cumulate of a fractioning liquid, which would also produce a residual kimberlitic liquid, appears highly improbable. 2. Their origin, as material from a primary eclogite upper mantle, cannot, in the light of present day ultrabasic upper mantle concepts, be supported, neither can the hypothesis that they are samples of simple eclogite segregations derived purely from the partial melting of primary garnet lherzolite. 3. Their source is most probably from within the upper mantle or lower crust where pockets of heterogeneous, partly fractionated basaltic magma have been trapped and solidified within an eclogite-stable region. Samples of this material have been fortuitously brought to surface by the ascending kimberlite intrusion. 4. The fact that the Roberts Victor eclogites are very similar to eclogite from regionally metamorphosed complexes suggests that a possible source, for at least some of the material, is within some high-grade metamorphic zone hidden beneath the sedimentary cover of the Roberts Victor area.