ORIGIN OF ECLOGITE NODULES FROM THE MBUJI MAYI KIMBERLITES (KASAI, ZAIRE) : SUBDUCTED ANCIENT OCEANIC CRUST ?

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Kimberlites often contain both mantle- and crustal-derived xenoliths. Although ultramafic xenoliths (mainly lherzolites) are common, eclogite nodules (group A eclogites of Coleman et al.,1965) are only found in some kimberlites (i.e. Roberts Victor, Bellsbank, Zagadochnaya, Udachnaya).
The origin of these eclogite nodules is still largely debated : two contrasting petrogenetic models have been proposed :

1) high pressure igneous cumulates formed from basaltic magmas in the upper mantle (O'Hara and Yoder,1970; Hatton, 1978; Smyth and Caporuscio, 1984).
2) metamorphic recrystallization of subducted oceanic crust (Helmstaed and Doig, 1975; Jagoutz, 1984; Shervais et al., 1988)

This study is focused on the eclogite nodules carried by the Mbuji Mayi kimberlites (Kasai, Zaire) which intrude the Archean Congo-Kasai Craton 71 Ma ago (U-Pb zircon and baddeleyite lower intercept ages; Schärer and Demaiffe, 1991). Besides the eclogite nodules (~90 % of the xenolith population), the kimberlites also contain the typical megacryst suite (Cr-rich and Cr-poor diopside, garnet, Mg-ilmenite, rutile and cm-sized zircon and baddeleyite), chlorite nodules (2 to 10 cm) and crustal nodules.
More than 150 eclogite nodules (C. Fieremans collection) have been studied. The nodules have rounded to ellipsoidal shapes and typically range in size from 3 to 5 cm, except two large nodules up to 10 cm.

The Mbuji Mayi eclogites have been subdivided petrographically into two main groups :
1 - **the typical bimineralic eclogites** which consist mainly of garnet and omphacitic clinopyroxene; they sometimes contain minor accessory phases (rutile, phlogopite, quartz, amphibole, zoisite, apatite).
2 - **kyanite-bearing eclogites** (30 samples) which contain kyanite (1 to 25 modal %) either as laths locally included in garnet, as intergrowths with clinopyroxene or as large (3 mm) poikiloblastic crystals including other minerals.

Most eclogites display granoblastic textures, with well-developed triple junctions (120°) between grains. Tightly interlocking and banded textures have been observed in some nodules.
In the bimineralic eclogites, garnet occurs as equant grains or as exsolution lamellae in the clinopyroxenes. Locally, garnet blebs form a rim (necklace structure) around the pyroxene, which could result from the migration and recrystallization of the lamellae.
Some clinopyroxenes exhibit a "spongy texture", which consists of symplectitic intergrowths of diopside + plagioclase (An15) and could result from the breakdown of omphacite during decompression Patches of pale-brown, largely devitrified, glass are locally associated with those symplectites.
Rutile appears as small grains in many eclogites or as acicular inclusions (exsolutions ?) in garnet and omphacite.

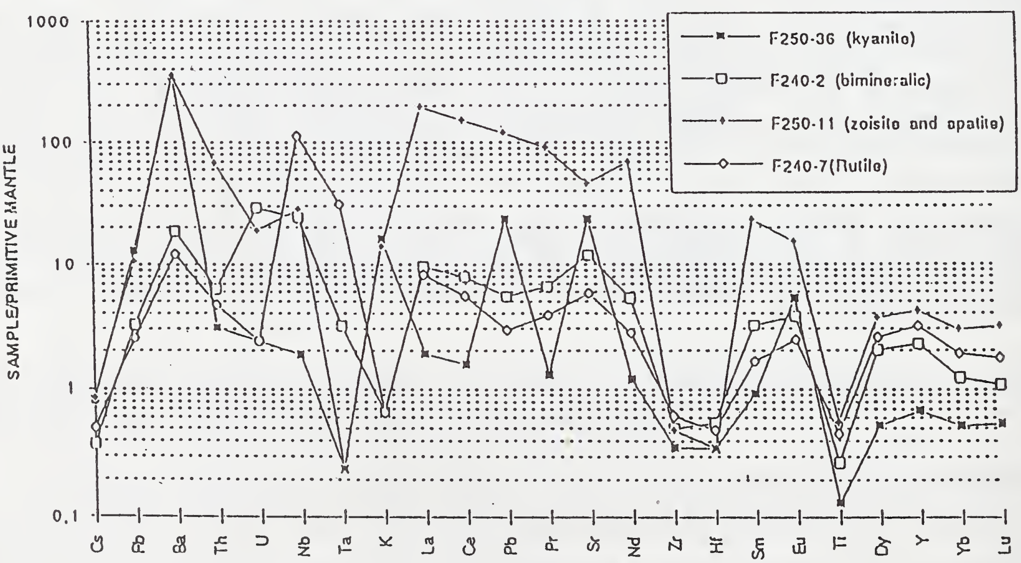
Quartz inclusions in omphacite and garnet are often surrounded by radial cracks suggesting the existence of former coesite.
Phlogopite is common in bimineralic eclogites but is rare in kyanite-bearing ones. "Primary" phlogopite occurs as euhedral flakes between other phases or as inclusions in clinopyroxene. In several samples, secondary phlogopite occurs along fractures and locally at the margins of garnet grains.
Amphibole (pargasite) occurs either as poikiloblasts replacing omphacite (preserved as relic inclusions) or as fibrous laths in kelyphitic rims around garnet and along garnet-garnet and garnet-pyroxene boundaries.
Few eclogites contain large poikiloblastic zoisite with pyroxene and kyanite inclusions. In one sample, zoisite occurs as euhedral (primary ?) laths; this sample also contains apatite
Some nodules show evidence of partial melting. The partially devitrified melt (which can represent more than 30 vol. % of the nodule) occurs as patches (more rarely as veins) : it contains relics corroded grains of garnet, omphacite and phlogopite. Plagioclase (An90) microlites and small anhedral zoisite crystals are often present in the glass.

Garnets and clinopyroxenes are compositionally homogeneous, no appreciable zoning was detected. Clinopyroxenes from bimineralic eclogites have uniform Mg number (89-91) with variable jadeite contents (19 to 40 mole %). Clinopyroxenes from kyanite-bearing eclogites have significantly higher jadeite contents (37 to 48 mole %). Garnet compositions range from Py47 Al41 Gro12 to Py57 Al24 Gro19. Garnet from kyanite-bearing samples is slightly more grossular-rich (20-29 mole %), than those of bimineralic eclogites (9-24 mole %).
The temperatures of equilibration of the eclogites can be estimated from the Fe-Mg partitioning between the garnet and clinopyroxene. The calibration of Ellis and Green (1979) gives, at an assumed pressure of 30 Kb, temperatures between 820 and 1100° C (Fe^{2+} content has been estimated following Clarke and Papike, 1968). Minimum pressure for quartz-bearing eclogites (Holland, 1980) ranges from 17 to 20 Kb. P estimates for kyanite-bearing eclogites can be obtained from the Ca-Al partition between garnet and clinopyroxene (Banno,1974; Lappin,1978) : from 22 to 29 Kb. Direct P estimates for most eclogites are not possible; moreover, they do not contain diamond. When plotted along the Precambrian shield geotherm of Pollack and Chapman, the calculated T° yield P estimates of 32 to 51 kb.

Whole rock chemical compositions of bimineralic eclogites are broadly basaltic (43-53 % SiO_2; 8-17 % Al_2O_3; 10-12 % CaO; Mg number = 46-73) with low K_2O (avg. 0.2 wt %) and TiO_2 (avg. 0.15 wt %) contents, suggesting subalkaline affinity. Kyanite-bearing eclogites are peraluminous (17-28 % Al_2O_3) with high CaO content (up to 15 %).
The trace elements contents of the eclogites do not appear to have been contaminated by kimberlitic magma. Whole rock REE concentrations of both eclogite groups are low (ΣREE = 11-47 ppm) and there is no significant relationships between Mg number and ΣREE. The REE patterns of the Mbuji Mayi eclogites are all grossly similar to those of E-type MORB. Bimineralic eclogites are however more fractionated ($(La)_N$ = 2-60 and $(La/Yb)_N$ = 2-30), than kyanite-bearing samples ($(La)_N$ = 5-20, $(La/Yb)_N$ = 2.1-8). Kyanite eclogites display larger positive Eu anomalies (Eu/Eu* = 1.66-1.88), than bimineralic ones (Eu/Eu*= 1.06-1.25).
Spidergrams (fig) show enrichment factors for incompatible LILE comparable to E-type MORB. Positive Ba, Sr, Eu and Pb anomalies are conspicuous; they are higher for kyanite-bearing samples (average. Ba/Ba* = 21, Sr/Sr* = 6.5, Eu/Eu* = 5.8 and Pb/Pb* = 6.3), than for bimineralic eclogites (average. Ba/Ba* = 8.6, Sr/Sr* = 4.9, Eu/Eu* = 3.5

and Pb/Pb* = 2.8). The high Ba content is not related to the modal proportions of phlogopite. A Nb enrichment is observed for all rutile-bearing eclogites. Zr, Hf and Ti depletions (average. Zr/Zr* = 0.42, Hf/Hf* = 0.47 and Ti/Ti* = 0.19) occur for most samples and could result from the destabilisation of some Ti-bearing minerals during eclogite formation or from HFSE mobility in subduction zones.
Zoisite and apatite-bearing eclogite (16.5 % Al_2O_3, 12.3 % CaO, Mg number = 64) is globally enriched in most LIL elements, including the REE (ΣREE = 548 ppm) with $(La)_N = 370$ and $(La/Yb)_N = 66$, but no positive Eu anomaly.
The high Al_2O_3 and CaO content of kyanite-bearing eclogites correlates with the positive Ba, Sr, Eu and Pb anomalies, which suggests that the protolith was a feldspar-rich rock (anorthositic gabbros ?). In contrast, the geochemical characteristics of bimineralic eclogites are consistent with a basaltic origin.

The Mbuji Mayi bimineralic and kyanite-bearing eclogites are tentatively interpreted as the metamorphosed equivalent of basaltic lavas and gabbroic anorthosite cumulates, both resulting from the recrystallization of subducted ancient oceanic crust beneath the Archean Congo Craton.



PRIMITIVE MANTLE NORMALIZED PATTERNS FOR SOME REPRESENTATIVE SAMPLES OF THE DIFFERENT POPULATION OF ECLOGITES.