

PECULIARITIES IN THE FLUID AND MELT COMPOSITIONS OF THE LAMPROITES
AND KIMBERLITES BASED ON THE STUDY OF INCLUSIONS IN OLIVINES

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The discovery and study of the province of diamondiferous ultrapotassic lamproites in Western Australia (Atkinson et al, 1984) has posed a series of problems, which firstly include the following:

the relationship between the various lamproite types and between lamproite and kimberlite;

the conditions of their formation and crystallisation, and the composition of the original lamproite melt and fluid content.

The present contribution deals with the results of direct determination of both the melt and fluid compositions, the liquidus assemblage and crystallisation temperature in olivine lamproites from the Ellendale field (pipes 11, 9, 4, 7) and in diopside-olivine-leucite lamproite from Mt. Cedric, as established from study of magmatic inclusions. The results of studying inclusions in olivine lamproite from the Ellendale 11 pipe were published earlier (Sobolev et al, 1985). For comparison, we have also worked on typical diamondiferous kimberlite from Udachnaya kimberlite pipe, Yakutia, USSR, and lamproitic rock of the hypabyssal facies from Prairie Creek, Arkansas, USA, described by Scott Smith and Skinner (1984). In most cases small (less than 0.5mm) second generation olivines (olivine-2) were studied and found in all cases to be of Fo₈₇₋₉₃ composition.

The primary inclusions (trapped during crystallisation) in olivine-2 from olivine lamproites from Western Australia are represented by partially crystallised melt, fluid, chromite, orthopyroxene and a combination of the above-mentioned phases. Microprobe analysis of crystallised melt inclusions shows the presence of calcilite, picroilmenite, apatite, perovskite, phlogopite, K-richterite, residual glasses and probable fluorite (from optics). From microthermometric data (20 determinations) fluid inclusions are represented by practically pure CO₂ (triple point -56.5 to -58.3°C) of various density ($\rho = 0.88 - 0.20 \text{ g/cm}^3$). No additional phases such as liquid H₂O or reactionary phases around the fluid inclusions were observed up to 2000 x magnification. The position of inclusions within olivine crystals, and their composition, are indicative of simultaneous crystallization of olivine-2, orthopyroxene, chromespinel and possibly, clinopyroxene, from a melt saturated in fluid whose major component was CO₂ (Sobolev et al, 1985).

Inclusions in olivine-2 from kimberlite are represented mainly by decrepitated (exploded) melt and fluid inclusions and chromite. The scarce primary fluid inclusions are also represented by CO₂ (the temperature of the triple point was -56.5 to -58.0°C from 10 determinations) with maximum density 0.75 g/cm^3 . Similar fluid inclusions have been fixed also in olivine-2 from lamproitic rocks from Prairie Creek. From 4 determinations they are characterised by a triple point within the temperature range -56.6 to 57.5°C, $\rho = 0.85 \text{ g/cm}^3$.

The high temperature microscopic study of melt inclusions in olivines from olivine lamproites of Ellendale field has been carried out in an atmosphere of extra pure helium. From 55 runs only 5 show a homogenisation of small (5-15 microns) melt inclusions at 950 - 1050°C. In all the remaining cases the inclusions were decrepitated at 650 - 800°C or were found to be decrepitated in natural conditions. A distinct visible melting of the hermetic melt inclusions has been established to take place at a temperature from about 600°C. At 800°C the melt has a low viscosity as evidenced by a visible sudden rapid movement of the fluid phase inside the inclusions.

The composition of a melt at the moment of trapping, estimated from the compositions of quenched homogenised melt inclusions, is close to typical leucite lamproite, but with higher concentration of Na_2O (up to 2.4 wt %), BaO (up to 3.3 wt %) and exceptionally high concentration of F (up to 1.4 wt %). Evaluation of the crystallisation temperature of olivine-2 obtained by homogenisation of the melt inclusions (950-1050°C) permits one to estimate the pressure of crystallisation of the association of subphenocrysts by the use of syngenetic inclusions of highest density ($\rho = 0.88 \text{ g/cm}^3$) and P-V-T of pure CO_2 . The pressure thus evaluated was up to 5 kbars. This is the minimum estimation as one cannot exclude a denser fluid when carrying out further examination.

The study of the composition of the fluid inclusions in olivines from both lamproite and kimberlite rocks was carried out using the Raman microprobe technique (Touray et al, 1985). In order to fix H_2O we used the technique of heating the inclusions up to 350°C (Sobolev, Clocciatti, Damelincoourt, 1985). It has been found that the fluid inclusions of all the studied rocks consist of CO_2 (90-95% mole), N_2 (up to 3.5 mol %) and CO (up to 2.5 mol %) occur as trace components of fluid from Australian lamproites. The upper limit of H_2O contents for the fluid phase has been fixed to be below 5% mol for lamproites (3 analyses) and below 7 mol % for kimberlites (2 analyses). Thus the partial pressure of H_2O in magmatic fluid seems to be not higher than 0.5 kbars. Such contents of H_2O cannot explain an exceptionally low temperature for lamproite melt. It seems that the essential role here belongs to the HF- component.

Thus from the reported data it may be concluded that olivine-2 from olivine lamproite had crystallised together with orthopyroxene, chromspinel and, possibly, clinopyroxene from a melt similar in composition to coexisting leucite lamproite at a temperature of about 1000°C and a pressure of near 5 kbars. The major component of the fluid, as also for kimberlite, was CO_2 . The variations in CO_2 concentrations in kimberlitic and lamproitic rocks may be explained rather by the difference in the CaO concentration in the magmas and the possibility or impossibility of CO_2 bonding in magmatic or early-postmagmatic calcite.

In conclusion, one must stress the exceptional activity of F in lamproite melt in the Upper Mantle conditions that has to be taken into account when postulating a hypothesis on lamproite rock formation.

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