

127. *Experimental Investigations on Some Synthetic Leucite Rocks under Water Vapor Pressures*

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Holmes and Harwood (1937) called attention to the close genetic connection between leucite rocks and mica peridotite, followed by Yagi and Matsumoto (1966), Tilley and Yoder (1968) and Cundari and Le Maitre (1970). Except for some studies at or below 10 kb by Yoder (1973) direct experimental investigations of leucite-bearing assemblages at pressures equivalent to the upper mantle condition (above 10 kb) have not been made to elucidate the origin of potassium-rich magma at great depth.

Two synthetic assemblages corresponding to a leucite basanite and a melilite-nepheline leucitite were studied in presence of excess water up to 25 kb.

The composition of the starting material for leucite basanite was $\text{Fo}_{20}\text{Di}_{30}\text{Lc}_{30}\text{An}_{20}$ and that of melilite-nepheline leucitite was $\text{Di}_{28}\text{Ne}_{29}\text{Lc}_{43}$ (Fo, Di, Lc, Ne and An are abbreviations for forsterite, diopside, leucite, nepheline and anorthite, respectively). Both starting materials, crystallized from glasses at 900°C, contained abundant leucite crystals. Investigation below 5 kb, were made with cold seal pressure vessels, whereas those above 10 kb, were performed on wet samples (water: sample=1:4) in sealed platinum capsules by a piston cylinder apparatus. Reversed runs were made across phase boundaries to establish that equilibrium was attained. Special care was taken to distinguish quenched phases from equilibrated phases. Results between 5 to 10 kb are not given because of uncertainty in pressure calibration.

Fig. 1 shows that leucite basanite is represented at low temperatures and at pressures between 10 and 25 kb by garnet phlogopite pyroxenite. Garnet solid solution was the last phase to crystallize, whereas diopside solid solution was the primary phase. In the leucitite mixture melilite appears in the starting materials as a reaction product of diopside and nepheline (Bowen, 1922, Schairer *et al.* 1962) at or below 3 kb (CD, Fig. 2). Breakdown of leucite occurs at slightly higher pressures (AB, Fig. 2). Disappearance of phlogopite at low $P_{\text{H}_2\text{O}}$ by reaction with liquid (below DEF) sup-

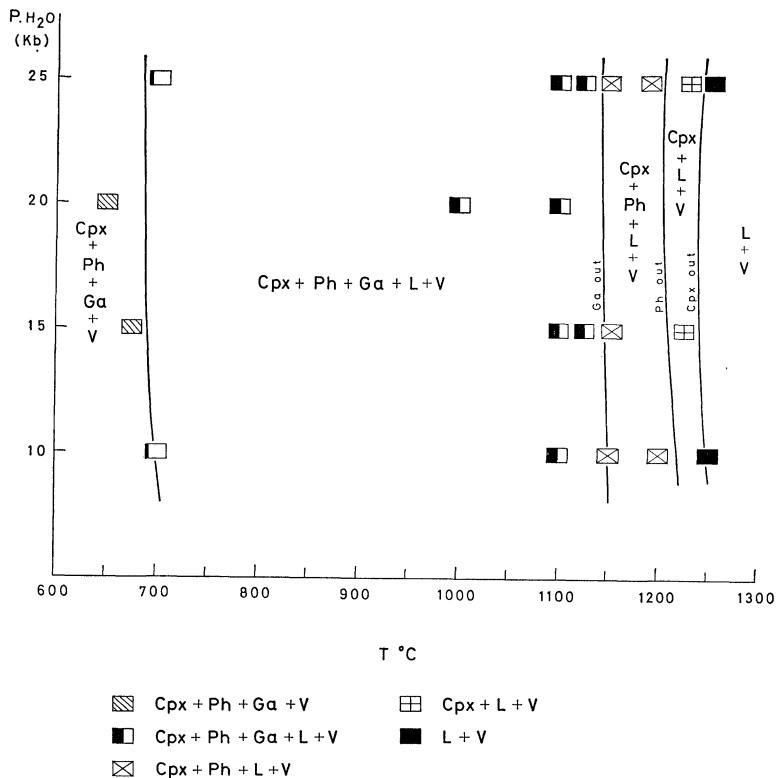


Fig. 1. P_{H_2O} - T diagram of the synthetic leucite basanite ($Fo_{20}Di_{30}Lc_{30}An_{20}$). All phases are solid solutions. Abbreviations: See Fig. 2.

Table I. Cell parameters of the phases formed in the experiments

Starting material	Phase	a Å	b Å	c Å	β degree	V (Å) ³
$Fo_{20}Di_{30}Lc_{30}An_{20}$	Clinopyroxene	9.7235	8.8893	5.2530	106.0197	436.4258
$Fo_{20}Di_{30}Lc_{30}An_{20}$	Phlogopite	5.3029	9.1831	10.1363	99.9698	486.1566
$Fo_{20}Di_{30}Lc_{30}An_{20}$	Garnet	11.8530	—	—	—	1665.2617
$Di_{28}Ne_{29}Lc_{43}$	Clinopyroxene	9.7706	8.9309	5.2350	105.8960	439.3263
$Di_{28}Ne_{29}Lc_{43}$	Phlogopite	5.3014	9.0636	10.1828	100.1691	481.5938
$Di_{28}Ne_{29}Lc_{43}$	Amphibole	10.0178	18.0347	5.2849	104.8796	922.7886

ports the findings of Luth (1967). The reaction leucite \rightleftharpoons kalsilite + K-feldspar (CE, Fig. 2) was noted by Scarfe *et al.* (1966).

Fig. 2 shows that melilite-nepheline leucitite and olivine-melilite leucitite are restricted to volcanic and subvolcanic conditions. They are represented at 25 kb by amphibole- and phlogopite-bearing pyroxenite. Liquidus temperature of 1197° at 1 atm. is lowered by $82^\circ \pm 5^\circ C$ and $64^\circ \pm 5^\circ C$ at 25 and 10 kb, respectively. The cell param-

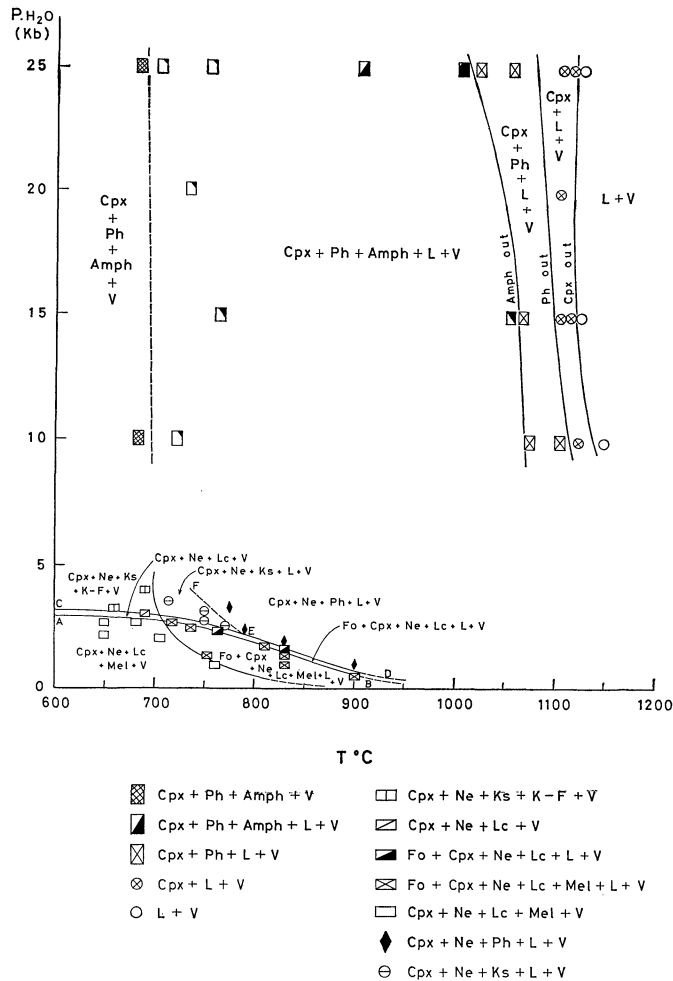


Fig. 2. P_{H_2O} - T diagram of the synthetic melilite-nepheline leucite ($Di_{28}Ne_{29}Lc_{48}$). All phases are solid solutions.

Abbreviations: Amph: amphibole, Cpx: clinopyroxene, Fo: forsterite, Ga: garnet, K-F: kali-feldspar, Ks: kalsilite, Lc: leucite, Mel: melilite, Ne: nepheline, Ph: phlogopite, L: liquid, V: vapor.

ters of amphibole (Table I) indicate that it is richterite solid solution. Clinopyroxene is the primary phase again, whereas richterite solid solution crystallizes last. Actually richterite is observed as a late-crystallizing phase in the olivine leucitites from New South Wales (Cundari, 1973).

Although mineral assemblages at high P_{H_2O} - T region for both compositions are similar, at high P_{H_2O} and low temperatures, garnet is present in the basanite, whereas amphibole appears in the melilite-nepheline leucitite. This may suggest that the amount of amphibole

determines the nepheline content of the magma near the crust, whereas that of garnet controls the plagioclase content.

The results of the present investigations support the view that potassium in the upper mantle is present mostly in mica (Yagi and Matsumoto, 1966, Yoder and Kushiro 1969, Kushiro 1970, and Modreski and Boettcher, 1973), and partly also in amphiboles (Oxburgh, 1969, Hariya *et al.* 1974, and Allen *et al.* 1976).

It is concluded that mica-bearing ultramafic cognate xenoliths associated with leucite-bearing rocks from many localities of the world may indeed be of mantle origin, and have genetic relations with the leucite-bearing rocks.

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