PSEUDOLEUCITE FROM HAMİTKÖY AREA, KAMAN, KIRŞEHİR OCCURRENCE AND ITS USE AS A PRESSURE INDICATOR

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ABSTRACT.— Kırşehir batholith outcropping over a large area in Central Anatolia consists mainly of coarse grained felsic igneous rocks. Around Hamitköy area the batholith seems to be syenitic in composition and is cut by silica deficient feldspathoid bearing microsyenitic dykes striking along E-W and NE-SW directions. Pseudoleucite occurs as large phenocrysts, however it is optically discontinuous and consists of discrete leucite crystals. Minor amounts of sericite and smectite are observed as alteration products of the pseudoleucite. Chemical analyses display the fact that Hamitköy pseudoleucites resemble to leucites, with their small amount of Na2O content, and to pseudoleucites in their total alkali deficiency. Phase study diagrams of the residue system suggest that the crystallization of pseudoleucite is a pressure sensitive phenomenon and that it may be possible to use the presence of pseudoleucite as a pressure indicator. It is tentatively suggested here by the authors that pseudoleucite forms from a volatile-rich, silica poor magma under approximately 2 kbars of pressure, which corresponds to a depth of approximately 7 kilometers in the crust.

INTRODUCTION

The results of chemical and mineralogical study of pseudoleucites obtained from microsyenite dykes of Hamitköy area, Kaman are presented in this paper.

Kırşehir crystalline massif as named by several authors (Arni, 1938; Bailey and McCallien, 1950; Egeran and Lahn, 1951; Ketin, 1953 and Seymen, 1982) consists of metamorphic basement rocks which are intruded by a heterogeneous batholith. Felsic intrusive rocks of the western part of the batholith around Kaman area were mapped by various workers (Baykal, 1941; Buchardt, 1956 and Seymen, 1982) and granitic, aplitic, grdnodioritic, monzonitic, syenitic and dioritic rock types were observed. The rocks of the metamorphic basement were studied in detail by Erkan (1975) and Seymen (1982) and were named as "Kaman Group" by Seymen.

Arni and Schroeder (1938) mentioned about leucite porphyry dykes around Kaman area. Intrusive rocks of Kaman region were named as Baranadağ and Buzlukdağ plutons by Seymen (1982) and he further mentioned that Baranadağ pluton consisted of quartz-diorite, granodiorite and quartz-monzonite, while Buzlukdağ pluton was mainly consisted of syenite, nepheline syenite, leucite syenite, trachyte and phonolite.

Age of the intrusive rocks of Kaman region is suggested to be of Eocene (Ayan, 1963), Paleocene (Ketin, 1963; Seymen, 1982) or Upper Cretaceous (Ataman, 1972).

The felsic intrusive rocks of Kaman-Keskin area constitute the northwestern part of the large Kırşehir batholith. There appears to be a rough zoning where outer parts consist mainly of oversaturated quartz-rich granitic rocks while in central parts occur saturated and silica deficient feldspathoid bearing syenitic rocks (Fig. 1) (Baykal, 1966 and Ketin, 1962, 1963).

The syenitic parts of the batholith around Kaman area are well known for their distinctive suite of potassium-rich pseudoleucite bearing microsyenitic dykes. They occur as a group of simple and composite dykes striking along E-W and NE-SW direction intruding both syenite and gabbroic rocks which are probably roof pendants of the batholith (Fig. 2). The dykes range in composition from amphibole phonolites, augite-biotite phonolites to a few syenite porphyries and late quartz porphyries. Some dykes are composite, with borders, consisting of mafic hornblende phonolite while central parts consist of leucocratic biotite phonolite. The thickness of the dykes range from few cm's to several 10's of meters.

The fractures into which the dykes were emplaced, were formed later than the intrusion of the syenite batholith. Many dykes show fine grained chilled margins. Phenocrysts of hornblende and feldspar, within the border zone, show parallel alignment to the walls of the dykes, which is presumably due to internal friction that developed during the flow of relatively viscous magma within the fracture.

MINERALOGY

Pseudoleucite occurs as large phenocrysts set in a fine to medium-grained groundmass (Plate I A). Size of the crystals range from 1 cm upto 15 cm in diameter. In altered upper parts of the dykes the pseudoleucite crystals are easily extracted from the groundmass.

Microscopically, optically discontinuous pseudoleucite phenocrysts display a well developed zoned structure. The contact between the phenocrysts and groundmass is sharp. In the border zone of the crystals there occurs a cryptocrystalline region of few mm's thickness. Next to the border zone, in the columnar crystalline part, elongated leucite crystals occur with their long axis perpendicular to the border zone. The thickness of this zone is upto 0.5 cm. The central part of the phenocrysts consist of coarse grained, unoriented, optically discontinuous mosaic of leucite crystals which sometimes display pseudo-graphic texture (Plate I B).

Sericite occurs as an alteration product of leucite. In the phenocryst, sericitization generally starts along the crystal boundaries and works its way to the centre of the leucite crystals. In extreme cases of alteration sericite replaces the entire phenocryst and produces secondary pseudomorphs of leucite.

X-ray diffractograms (Fig. 3) show also the presence of leucite and sericite-muscovite. There are two spurious peaks which are probably of leucite, occuring at 6.51 A° and 2.17 A° d-spacing. Samples prepared for clay analysis indicated the presence of minor amount of smectite.

COMPOSITION

Leucite is a highly characteristic igneous mineral that forms from potassium-rich, silica-poor magmas which solidify in extrusive and hypabyssal environment, it is not reported from deep seated plutonic rocks. Psedoleucite, on the other hand, is an aggregate of crystals consisting of potassium feldspar, nepheline and minor quantities of sodalite, cancrinite or a zeolite, that shows the crystal habit of leucite and occurs in both plutonic and volcanic rocks (Deer et al., 1965).

Leucite analyses generally conform the ideal formula $KAlSi_2O6$, where Si: Al ratio is very close to 2:1. Total alkalies ion-number on the basis of 6 oxygens approximates closely to 1.00. Only a limited amount (upto 13 %) of Na^+ substitution of K+ occurs. However, pseudoleucite analyses published in «Rock Forming Minerals (v.4, Table 34, p. 282)» of Deer, Howie and Zussman (1965), show that there are substantial amounts of Na^+ substituting K^+ and the total alkalies ion-number on the basis of 6 oxygens ranges from 0.68 to 0.93, which clearly indicates a striking alkali deficiency.

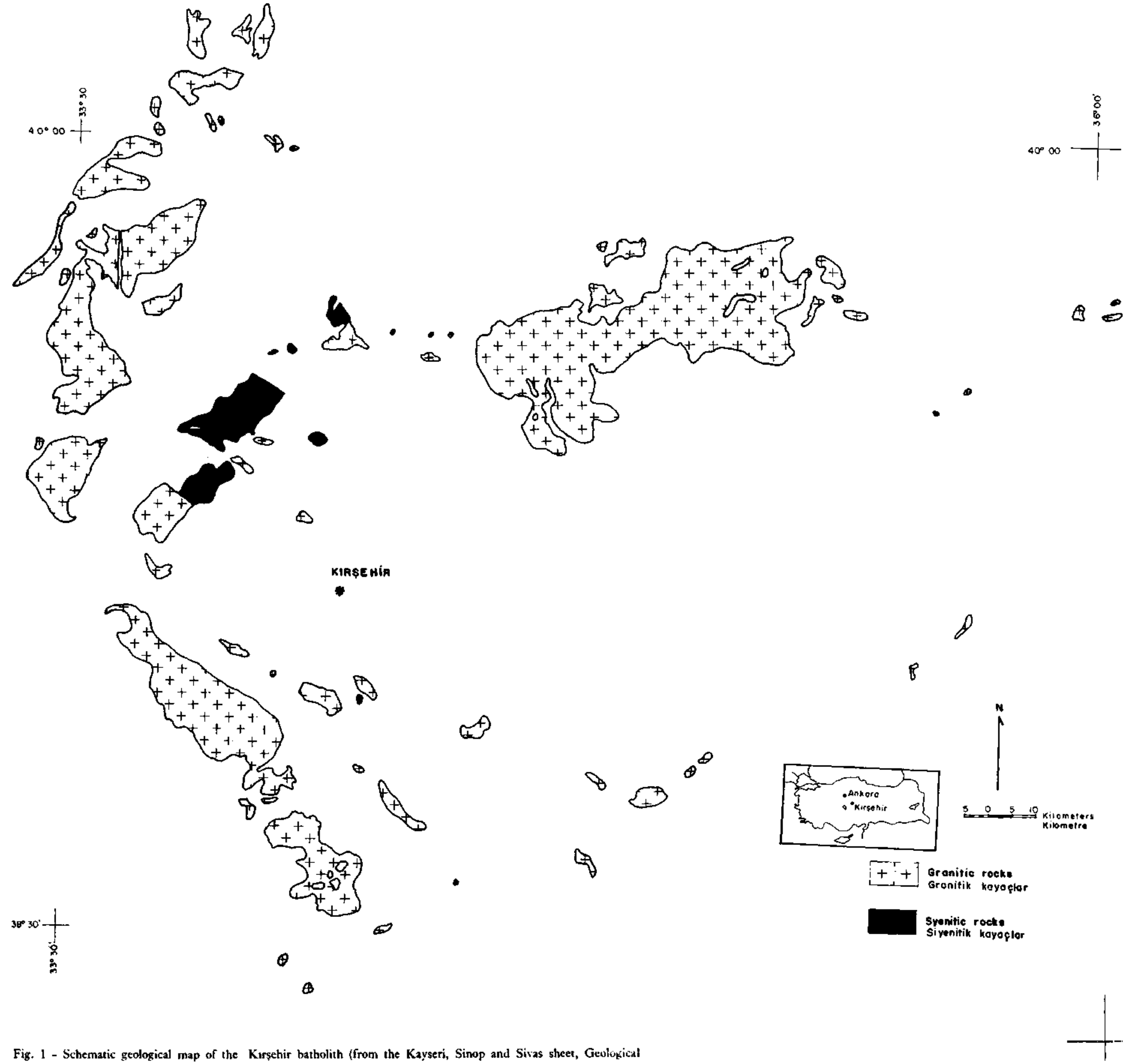

Fig. 1 - Schematic geological map of the Kırşehir batholith (from the Kayseri, Sinop and Sivas sheet, Geological Map of Turkey; Ketin, 1962, 1963 and Baykal, 1966).

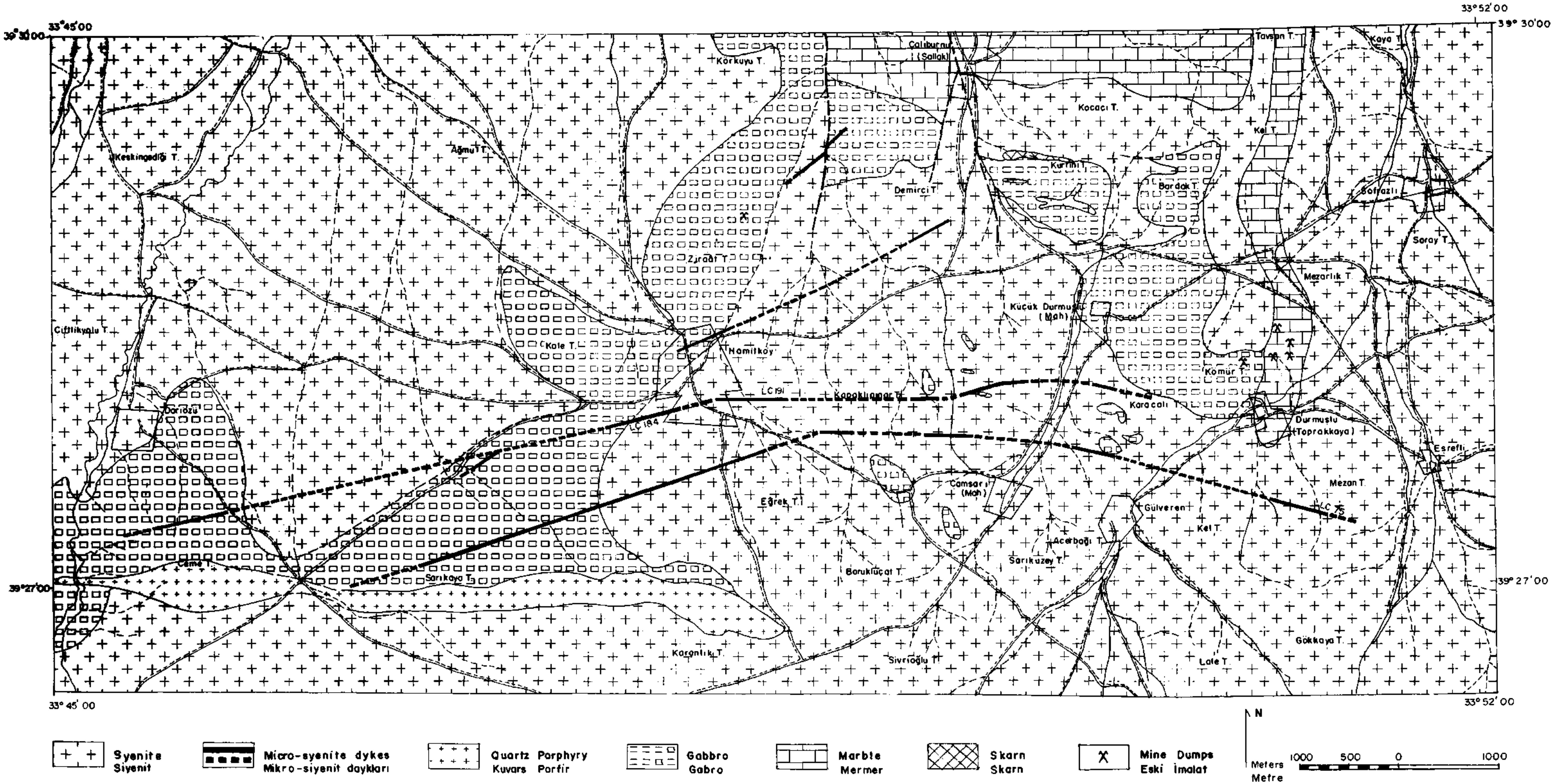

Fig. 2 - Detailed geological map of Hamitköy area, Kaman, Kırşehir (mapped by O. Akıman, on 1:25 000 scale).

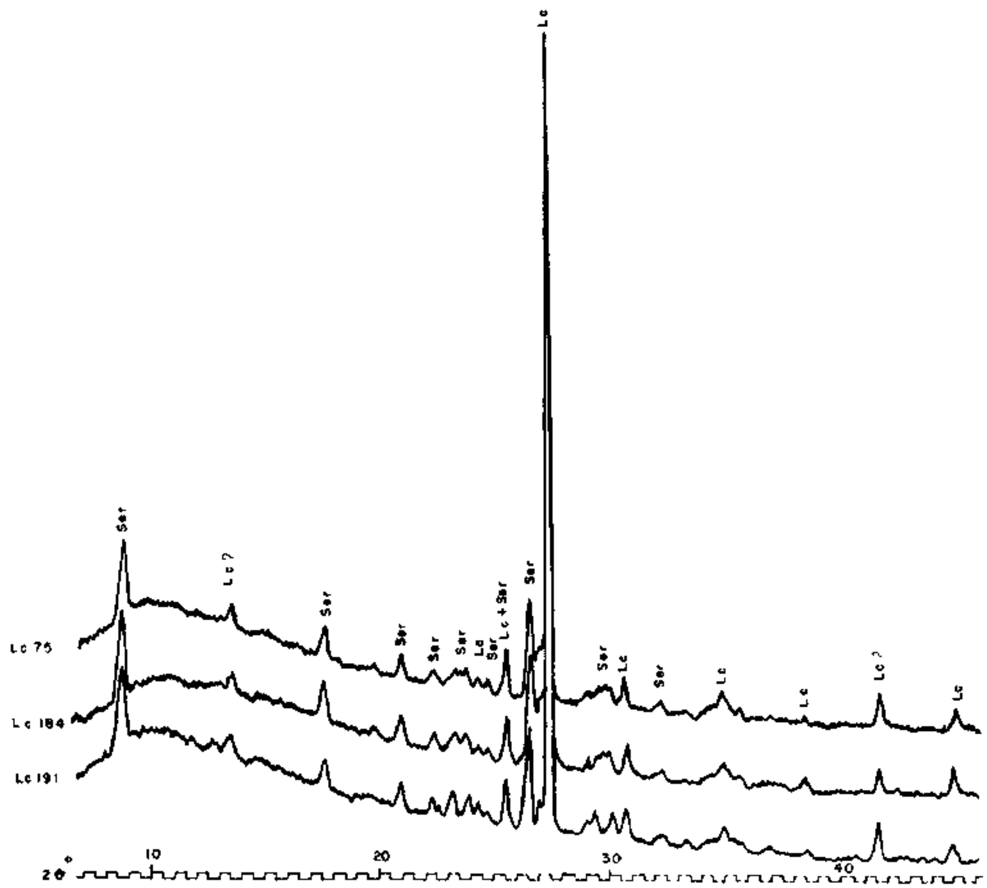

Fig. 3 - X-ray diffractograms of psedoleucite from Hamitköy. Cu-tube radiation, Ni-filter; 40 kV, 22 mA; Slits D 2°,R 0.1, S 1/2°; 4x10^3 .CPS;TC 2.

Chemical analyses of three pseudoleucites from two different dykes, from Hamitköy area (Fig. 2) are given in Table 1. Comparing, present analyses with that of Deer, Howie and Zussman (1965) indicates that Hamitköy pseudoleucites are similar to leucites in that there is a very limited Na^+ substitution in their bulk composition whereas they resemble to pseudoleucites in the deficiency of their total alkali content.

Chemical analyses of pseudoleucites and leucites are plotted in a SiO_2-NaAlSiO4-$KAlSiO_4$ triangular diagram (Gittings, 1979), where phase equilibria for P=l atm; PH_2O= 1 kbar, 2 kbar and 5 kbar (Schairer and Bowen, 1935; Schairer, 1950; Hamilton and MacKenzie, 1965; Taylor and MacKenzie, 1975; Morse, 1969; Roux and Hamilton, 1976) are also shown (Fig. 4). There is a very striking coincidence of location of pseudoleucite analyses of P_1, P_2, P_3 and P_5 with that of cotectic curve between Na-K feldspar and leucite field, for P=2 kbar. This probably suggests that the crystallization of pseudoleucite is a pressure sensitive phenomenon and that it is possible to use the presence of pseudoleucite as a pressure indicator. The plotting of points towards the low temperature-end along the cotectic probably indicates the control of temperature where Hamitköy pseudoleucite crystallizing at higher temperatures than Cnoc-na Sroine (P_3) pseudoleucite (Shand, 1910).

Table 1 - Chemical analyses of pseudoleucites from Hamitköy, Kaman

	Lc 75		Lc 184		Lc 191		Lc HK	
SiO_2	58.720		59.330		59.480		59.180	
TiO_2	0.040		0.040		0.033		0.038	
Al_2O_3	23.870		24.010		24.150		24.010	
FeO	0.540		0.520		0.690		0.580	
MnO	0.008		0.006		0.011		0.008	
MgO	0.130		0.040		0.050		0.070	
CaO	0.130		0.080		0.080		0.100	
Na_2O	0.240		0.260		0.300		0.270	
K_2O	14.200		14.630		14.430		14.420	
P_2O_5	0.013		0.011		0.010		0.011	
A.K. (LOI)	1.760		1.920		1.630		1.770	
Toplam (Total)	**99.651**		**100.847**		**100.864**		**100.457**	
Number of ions on the basis of 6 oxygens								
	Lc 75	Σ	Lc 184	Σ	Lc 191	Σ	Lc HK	Σ
Si	2.075		2.078		2.076		2.076	
Al	0.994		0.991		0.993		0.993	
Ti	0.001		0.001		0.001		0.001	
Fe^{2+}	0.016	1.023	0.015	1.012	0.020	1.020	0.017	1.019
Mg	0.007		0.002		0.003		0.004	
Ca	0.005		0.003		0.003		0.004	
Na	0.016	0.656	0.018	0.672	0.020	0.662	0.018	0.663
K	0.640		0.654		0.642		0.645	
Partial CIPW norms								
q	44.56		43.87		44.31		44.27	
kp	54.19		54.81		54.15		54.34	
ne	1.25		1.32		1.54		1.39	

Analyst: A.T. Lünel; LOI by A. Uyankaya.

Plotting of leucite analyses L_{1-7} (Deer et al., 1965) on the same diagram (Fig. 4) shows an interesting trend which is parallel to the cotectic curve between orthorhombic (K, Na) $AlSiO_4$ solid solutions—(Na, K) nepheline and leucite fields, for P=l kbar; but somewhat shifted to SiO_2-rich regions. This shift probably reflects a somewhat different PH_2O conditions and that leucite crystallization is also presumably a pressure controlled process. Pseudoleucite (P_4) from Bearpaw Mountains (Zies and Chayes, 1960) plots along the leucite trend and probably more closely related to leucites in its origin.

Chemical analyses of pseudoleucites and leucites are also plotted in a SiO_2-K_2O-Al_2O_3 triangular diagram (Deer et al., 1965), where phase equilibrium for P=l atm (Schairer and Bowen, 1955) is shown. Location of the points indicate a striking trend which is linearly aligned and roughly parallel to the K-feldspar-leucite cotectic curve which may support the above conclusions (Fig. 5).

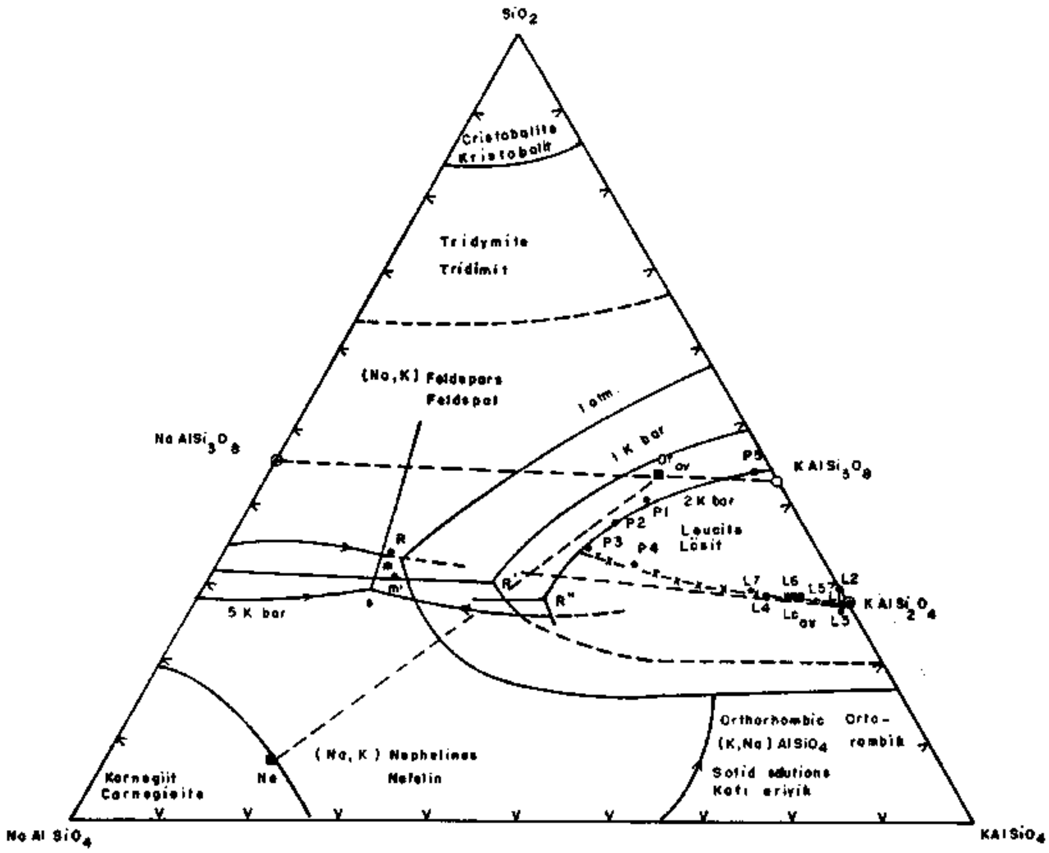

Fig. 4 - Phase equilibrium diagram of the system $NaAlSiO_4$-$KAlSiO_4$-SiO2-H_2O for P= 1 atm, PH_2O = 1 kbar, 2 kbar, 5 kbar (Deer et al., 1965; Gittings, 1979). R=Reaction point and m=Ternary minimum at 1 atm, R' and m' at 1 kbar, R" at 2 kbar; e=Ternary eutectic (undersaturated portion of the system); P_{1-4}: Pseudoleucite analyses from Deer et al. (1965, v. 4, p. 282), P_5: Average of Hamitköy pseudoleucites; L_{1-7} : Leucite analyses from Deer et al. (1965, v. 4, p. 280); Ne: Morozewicz nepheline composition; Lc_{va} :Average composition of leucites; Or_{av} : Average composition of potassiu mfeldspars.

CONCLUSION

Pseudoleucites obtained from microsyenite dykes of Hamitköy area are unique in their mineralogy and composition. In other natural rocks, pseudoleucites are generally described as an association of nepheline and alkali feldspar. Thus indicating an ion exchange phenomenon where potassium-rich magma initially crystallized potassic leucite that later changed into more sodic type with falling temperature. Subsequent cooling caused exsolution of nepheline and alkali feldspar where leucite structure is destroyed but retaining leucite crystal morphology (Gittings, 1979). However, in Hamitköy pseudoleucites, leucite is the dominant phase and nepheline occur only in very minor quantities, which probably indicates a higher temperature of crystallization that did not permit Na+ substitution. Chemically, Hamitköy pseudoleucite plot very close to potash-feldspar composition and is far removed from the positions of other pseudoleucites (P_{1-4}) and leucites L(1-7) (Fig. 4).

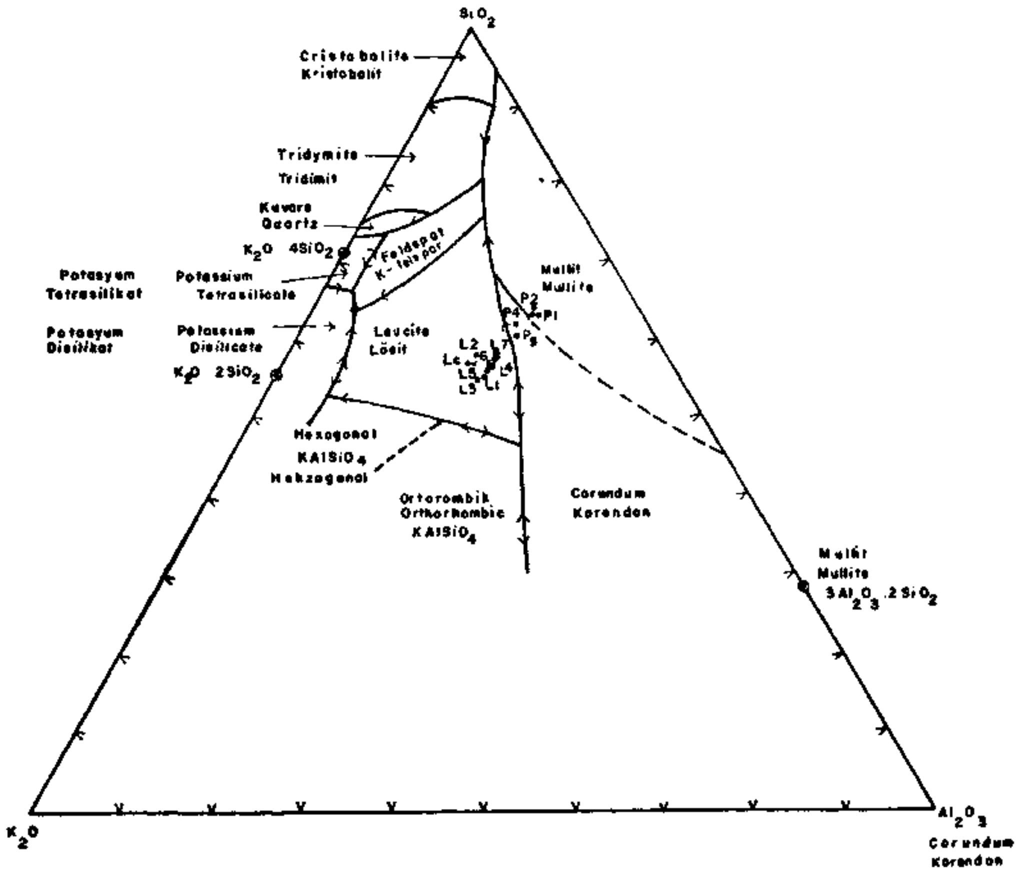

Fig. 5 - Phase diagram of the system K_2O-Al_2O_3-SiO_2 (after Schairer and Bowen, 1955, from Deer et al., 1965). P- Pseudoleucites; L- Leucites (as explained in Fig. 4).

The presence of pseudoleucite in igneous rocks may be used to indicate the pressure conditions prevailed during the formation of the phenocrysts. Although this should be proved by further experimental work at high pressure, it is tentatively suggested here that approximately a pressure of 2 kbars, which corresponds to a depth of approximately 7 kilometers (Barker, 1983) is necessary for formation of pseudoleucite in a volatile-rich undersaturated magma. This conclusion is also in agreement with the field observations in that leucite or pseudoleucite occur mainly as phenocrysts in volcanic or hypabyssal rocks but rare or absent in deepseated plutonic environment.

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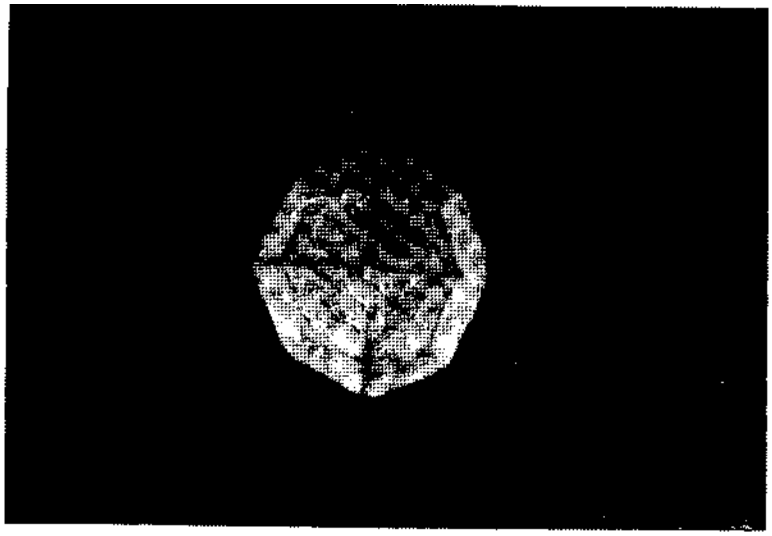
PLATE

PLATE - 1

A - Photograph of Hamitköy pseudoleucite (Lc 75), Mag. 1/2.

B - Photomicrograph of Hamitköy pseudoleucite (Lc 184), displaying mosaic of leucite crystals and pseudographic texture, Mag. X 40, Polarised light.



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