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Study of minerals from the pegmatites of the Nellore mica-belt, Andhra Pradesh, India
Part I. Microcline perthites

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SUMMARY. The obliquity values of microcline perthites are nearer to maximum microcline type, indicating that they have less than 10 % Ab in their lattices, apart from exsolved albite. The perthites are classified based on form as stringlet, string, film, vein, and replacement types. It is concluded that stringlet and string perthites are formed by exsolution along contraction cracks, followed by film as a result of decrease in rate of cooling and increase in water vapour content of the pegmatites, whereas vein and replacement perthites are formed last, by replacement when the pegmatites crystallized in a closed system. Based on the chemical composition of microcline perthites, a temperature of 600 °C is arrived at for unmixing of feldspar to give rise to microcline perthite.

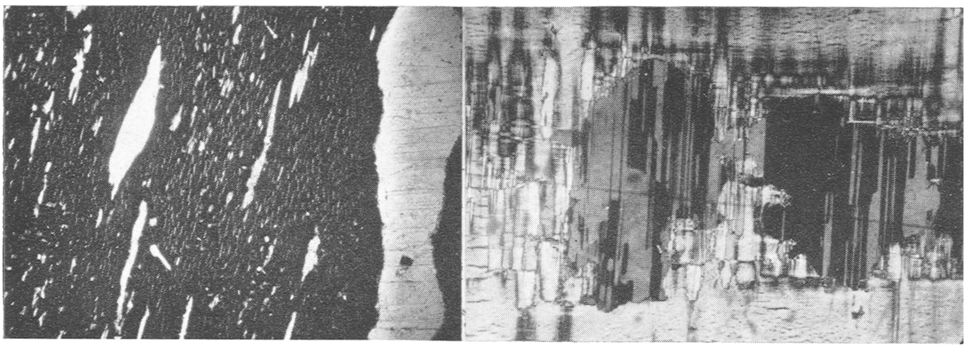
THIS work is a part of the studies on pegmatites of the Nellore mica-belt (14° to 15° N., 79° 40′ to 79° 45′ E.) carried out at the Geology Department, Andhra University, Waltair. The pegmatites were emplaced in the Precambrian Schistose Series: quartzite, quartz-schist, quartz–mica-schist, mica-schist, biotite-schist, muscovite–biotite-schist, chlorite-schist, hornblende-schist, etc. In the Nellore mica-belt, zoned pegmatites with or without quartz cores, and non-zoned simple or complex pegmatites are observed. But in all the pegmatites border and wall zones are observed. Based on the dates of minerals (samarskite, allanite, cyrtolite, biotite, and muscovite) from the pegmatites, an age of 1490–2100 Myr is assigned to the Nellore pegmatites (Aswathanarayana, 1964; Vinagradov and Tugarinov, 1964).

In the pegmatites quartz, microcline perthite, and soda plagioclase are the abundant minerals, muscovite and biotite are less abundant. Garnet, beryl, and tourmaline are the minor minerals. Samarskite, cyrtolite, sipylite, apatite, and zircon are rarely observed in the pegmatites. Jayaraman (1940) studied the chemistry and mineralogy of the feldspars from pegmatites of the Nellore mica-belt.

The pegmatites are mined mainly for muscovite. Microcline perthite, the by-product, is used in the nearby ceramic industry. It may be an essential constituent of all the zones or may form one of the zones of the pegmatites, except at the quartz core. In non-zoned pegmatites, pockets entirely composed of microcline perthite are observed.

Physical and optical properties. Microcline perthite occurs in shades of white, green, or flesh red. Sp. gr. between 2·55 and 2·60. Microcline portion of the microcline perthite has 2 V −82° to −84°, extinction angles from 12° to 15° to (001) and from 2° to 5° to (010). Cross-hatched twinning is observed. The optical angle of the plagioclase forming the perthites varies from −70° to −87°. The perthites are in optical continuity with one another. The film, vein, and replacement perthites commonly show polysynthetic twinning. The composition of the perthites, as obtained from Reinhard charts, ranges from albite to oligoclase.

Description of perthites. The terms stringlet, string, film, vein, and replacement perthites, as defined by Alling (1932), are used in this paper. The string and stringlet perthites constitute a relatively small amount of the total soda plagioclase of the microcline perthite. The strings and stringlets always accompany both veins and film



FIGS. 1 and 2: FIG. 1 (left). Stringlet, string, film, and vein types of perthite in microcline perthite. Crossed nicols, × 34. FIG. 2 (right). Replacement and stringlet types of perthite. Crossed nicols, × 70.

types and are parallel to them. These show an *en echelon* pattern; they are clearly noticeable in the non-cross-hatched area of microcline, and are not observed adjacent to the vein and replacement perthites.

An association among film, vein, and replacement perthites is generally observed. Pinch and swell texture is observed; there is usually an enlargement when the veins join each other. The contact of the film type with the microcline is sinuous, whereas that of the vein and replacement types is serrated. The walls of vein and replacement perthites are of non-matching type. In the vein and replacement types, inclusions of microcline that exhibit complete optical continuity with one another and also with the 'host' microcline are observed. The microcline inclusions are rounded as well as irregular in form. Replacement perthites are noticed in a few sections. These reach a width of 2 mm and a length of 5 mm. The contact of the replacement perthite with the microcline is more serrated than the microcline-vein perthite contact. Intersection between similar and dissimilar perthites is not noticed (figs. 1 and 2).

The microcline perthite has inclusions of quartz, muscovite, and calcite. Even in the inclusions of the same type, optical continuity is observed. Generally quartz grains will be round or elliptical in shape. The inclusions of muscovite generally have rims of quartz and the size of the rim varies in proportion to the size of the muscovite grain. Partial chemical analyses of the microcline perthites are given in table I.

X-ray analysis. The cell dimensions of the microcline perthites (samples 1, 3, 7) are given in table II. The unit-cell dimensions when plotted in the figures of Orville (1967, fig. 3, p. 68; fig. 4, p. 69), indicate that these belong to microcline–low-albite series. The α and γ values were plotted in the α–γ plot of Orville (1967, fig. 12, p. 78) and the points are near the maximum microcline.

TABLE I. *Chemical analyses and percentages of* Or, Ab, *and* An *of microcline perthite*

Sample Nos. 1–7: Anal. V. R. R. M. Babu. Sample Nos. 8–21: Anal. Jayaraman (1940). Sample Nos. 22 and 23: Anal. Leelananda Rao (1949)

No.	K_2O	Na_2O	CaO	Or	Ab	An	Colour
1	15·40	0·94	0·28	90·82	7·82	1·36	Pale green
2	13·80	1·77	0·66	81·33	15·11	3·57	Flesh red
3	14·22	1·92	0·30	82·64	15·98	1·37	Flesh red
4	13·90	1·56	1·24	80·85	13·39	5·74	Light green
5	14·81	1·17	0·55	87·04	9·92	3·04	White
6	14·52	1·43	0·50	85·50	12·03	2·48	Flesh red
7	14·39	1·44	0·62	84·90	12·03	3·06	Green
8	15·49	0·64	0·09	93·90	5·58	0·52	Flesh red
9	13·02	2·50	0·14	77·90	21·96	0·79	Green
10	15·05	1·12	0·05	90·04	9·68	0·28	Green portion of sample 9
11	2·45	9·55	0·60	14·97	81·93	3·10	White portion of sample 9
12	13·10	2·44	0·16	78·05	21·06	0·89	Pearl white
13	11·52	3·51	0·17	69·11	29·95	0·94	Pale green
14	13·99	1·84	0·07	83·81	15·80	0·39	Green portion of sample 13
15	12·23	3·03	0·10	73·43	26·00	0·57	Flesh red
16	14·09	1·70	0·08	85·09	14·45	0·46	Green
17	13·83	1·95	0·10	82·67	16·77	0·56	Pale green
18	13·52	2·12	0·13	81·02	18·24	0·74	Pale green
19	14·36	1·56	0·08	86·14	13·40	0·46	Flesh red
20	13·06	1·12	2·07	79·46	9·69	10·85	Flesh red
21	14·10	1·18	1·64	82·26	9·81	7·94	Greenish to mauve
22	13·05	2·27	0·32	78·79	19·77	1·43	Green
23	12·12	2·92	0·97	72·95	25·06	1·98	Grey

1. L. P. Mine, Tummalatalupur.
2. Radhakrishna Mine, Tummalatalupur.
3. Mine (abandoned), Orupallirachapalem.
4. Mine (abandoned), Orupallirachapalem.
5. Pallimetta Mine, Saidapuram.
6. Bala Durga Gourishankar Mine, Tummalatalupur.
7. Kodandarama Mine, Tummalatalupur.
8. Pallimetta Mine, Saidapuram.
9, 10, 11. L. N. Mine, Chaganam.
12. Thellabodu Mine, Chaganam.
13, 14. L. N. Mine, Chaganam.
15. Pallimetta Mine, Saidapuram.
16, 17. L. N. Mine, Chaganam.
18, 19. Pallimetta Mine, Saidapuram.
20. Kelly Mine, Saidapuram.
21. Srinivasa Mine, Chennur.
22. L. N. Mine, Chaganam.
23. Pallimetta Mine, Saidapuram.

Obliquity. Goldsmith and Laves (1954) suggested the difference in spacing of the peaks (131) and (1$\bar{3}$1) as a measure for obliquity and of the degree of order. The measure of obliquity, Δ, is defined as $\Delta = 12{\cdot}5\,[d(131)-d(1\bar{3}1)]$, so that a microcline with the maximum observed difference $[d(131)-d(1\bar{3}1)]$ has a Δ value approximating to unity. The obliquity values for the analysed microcline perthites are given in table II, with the values obtained from α and γ plot (Orville, 1967, fig. 13, p. 84). The calculated and observed values are almost equal, showing that the obliquity is related to the α and γ. The entry of sodium ions in a potash feldspar lattice would also change the obliquity values (Goldsmith and Laves, 1954; Lakshmi Narayana Rao, 1959); the obliquity values of samples 1 and 3 indicate that these may have less than 10 % Ab in their lattices (Lakshmi Narayana Rao, 1959) apart from the exsolved albite in them.

Temperature of crystallization. The molecular percentage of microcline and albite in the microcline perthites (table I) when plotted in the binary diagram of Barth (1962, fig. 5, p. 336) indicate a range of temperature from 300 to 575 °C. Because the samples

TABLE II. *Unit cell dimensions, d_{131}, $d_{1\bar{3}1}$, and Δ for three microcline perthites*

No.	*a*	*b*	*c*	α	β	γ	*V*
1	8·555 Å	12·98 Å	7·194 Å	90° 58′	115° 42′	87° 26′	715·3 Å^3
3	8·543	13·01	7·185	90° 57′	115° 57′	87° 30′	717·1
7	8·553	12·96	7·194	90° 47′	115° 57′	87° 32′	716·3

			Obliquity (Δ)	
No.	d (131)	d ($1\bar{3}1$)	Calc.*	Obs.
1	3·028 Å	2·956 Å	0·900	0·91
3	3·026	2·955	0·8875	0·875
7	3·026	2·948	0·975	0·950

* See text.

under study contain anorthite, which increases the temperature of crystallization, it is conceived that the unmixing might have started from about 600 °C. This deduction is supported by the experiments of Jahns and Burnham (1960) in which unmixing of sanidine to form perthite is noticed between 650 and 550 °C, further, according to Fersman (1960) and Sheshulin (1963), microcline perthite forms between 600 and 550 °C. So the feldspar probably started to unmix to give rise to microcline perthite at about 600 °C or perhaps lower due to high volatile contents in pegmatites.

Origin. Based on the regular distribution of stringlet and string perthites, it is assumed that these are formed by exsolution along the contraction cracks developed during cooling. This is possible at the time of emplacement of the pegmatites when there may be less water vapour and other volatiles, perhaps due to the permeability of the country rocks—schists. The *en echelon* arrangement observed in these types may be due to a rapid rate of cooling at the time of emplacement of the pegmatite, which would not permit the diffusion of plagioclase in the stringlets and strings to form films. The film perthite under consideration might have formed when the rapidity of cooling decreased and water vapour increased, as the unmixing of alkali feldspars in the presence of water vapour under pressure is rapid. The vein and replacement perthites are considered to have formed by replacement because of the optical continuity of microcline inclusions in these with host microcline, the protrusion of these into microcline, irregular distribution, non-matching walls, and widening of veins at the joining.

The absence of stringlet and string perthites adjacent to the veins and replacement perthites indicates the diffusion of these perthites into the vein and replacement perthites when the temperature of that portion of the microcline was changed due to the replacing soda plagioclase solutions. The presence of border and wall zones in the pegmatites of Nellore mica-belt is considered to be an indication for a closed system of crystallization. The vein and replacement perthites might have formed after the pegmatite started crystallizing in a closed system. This contention is supported by the similarity of chemical composition of soda plagioclase in the vein and replacement perthite to that of plagioclase in the pegmatites. The relative constancy in the composition of the microcline perthites under study might have been controlled primarily by temperature, with limited metasomatism.

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