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Study of minerals from the pegmatites of the Nellore mica-belt, Andhra Pradesh, India
Part III—Biotite

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SUMMARY. The biotites in the pegmatites are Fe^{2+} type. X-ray analyses indicated that they are 1M or 3T polymorphs. In the colour of the biotite iron plays an important role. From the Fe/(Fe+Mg) ratios, the analysed biotites are assumed to have crystallized between 760 and 500 °C.

IN the pegmatites of the Nellore mica-belt, biotite occurs in border, wall, and outer-intermediate zones; it is black in thick sheets, brown in thin flakes, and yellowish-brown in films, and ranges in size from a few millimetres to tens of centimetres across. The specific gravity is from 3·1 to 3·3. It is pseudo-uniaxial, β from 1·620 to 1·635. Inclusions of ruby muscovite occur along the basal cleavage planes in biotite books (fig. 1).

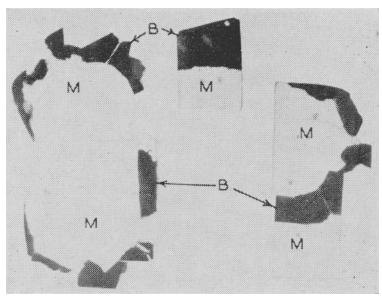

FIG. 1. Biotite–muscovite intergrowths. B, biotite; M, muscovite. $\times\frac{1}{2}$.

Chemical analyses of two biotites, with structural formulae, are given in table I. When the percentages of Mg, $R^{3+}(Al+Fe^{3+}+Ti)$, and $(Fe^{2+}+Mn^{2+})$ of the octahedral layer in the biotites (B1, B2) are plotted in the triangular diagram of Foster (fig. 11, p. 25, 1960), they are in Fe^{2+} biotite field.

The unit cell parameters of the two chemically analysed biotites calculated from powder data are given in table I; the reflections can be indexed equally well on a 1M or 3T cell (Yoder and Eugster, 1954).

According to Hall (1941) the colour of biotite depends on the content of FeO (total), MgO, and TiO_2. When the analysed biotites are plotted on the triangular diagram of Hall (fig. 1, p. 30) a brown colour is indicated, which is the observed colour in flakes. Hayama (1959) considered TiO_2 and the ratio $Fe_2O_3/(Fe_2O_3+FeO)$ the main factors; in his diagram the biotite (B1) falls in the region of yellowish- to greenish-brown, whereas (B2) is in the dark brown to brown region. These plottings indicate that iron plays an important role in the colour of the biotite, in agreement with Fyfe's (1964) conclusion that the colouration of the biotite is mainly caused by electron transfer between Fe^{3+} and Fe^{2+}. But the effect of other elements must also be considered.

Based on the theoretical work of Fersman (1960), the biotite in the area of study, Fe^{2+}-rich type, is assumed to have formed between 700 and 600 °C. According to

Wones (1963), the $Fe^{2+}/(Fe^{2+}+Fe^{3+})$ ratio may serve as an indicator of variations in the oxygen fugacity of the environment in which a biotite crystallizes; this ratio for the two biotites (table II) is near to Ni–NiO (0.10) and Fe_2SiO_4–Fe_3O_4–SiO_2 (0.05) buffer conditions (Wones and Eugster, 1965). The Fe/(Fe+Mg) ratios of the analysed biotites

TABLE I. *Analyses of biotites from Madiga Inam mine, Kalichedu, Nellore*

	B1	B2		Number of ions on the basis of 12 (O, OH, F) B1		B2		Number of ions on the basis of 11 oxygens	B1		B2	
SiO_2	31.66	36.12	Si	2.509	4.000	2.865	4.000		2.396	4.000	2.682	4.000
Al_2O_3	22.55	19.36	Al^{iv}	1.491		1.135			1.604		1.318	
Fe_2O_3	3.42	1.68	Al^{vi}	0.609	3.238	0.673	3.230		0.410	2.921	0.372	2.767
TiO_2	1.44	2.27	Fe^{3+}	0.200		0.103			0.192		0.096	
FeO	20.91	20.80	Ti	0.086		0.136			0.082		0.128	
MgO	8.12	7.85	Fe^{2+}	1.378		1.382			1.232		1.293	
MnO	—	0.17	Mg	0.965		0.927			0.915		0.867	
CaO	0.82	0.75	Mn	—		0.011			—		0.011	
Na_2O	0.44	0.43	Ca	0.067	0.960	0.062	1.068		0.066	0.925	0.058	1.002
K_2O	8.26	9.32	Na	0.057		0.063			0.062		0.059	
H_2O	1.68	0.93	K	0.836		0.945			0.797		0.885	
F	0.50	—	OH	0.884	12.000	0.494	12.000	Valency				
Sum	99.80	99.68	F	0.124		—		Tetrahedral layer	−1.604		−1.318	
			O	10.992		11.506						
a	5.312	5.300						Octahedral layer	+0.610		+0.258	
b	9.225	9.210										
c	10.230	10.160						Interlayer cations	+0.991		+1.060	
β	100° 3′	99° 3′										

TABLE II. *Temperature of crystallization of biotites*

	Analysed biotites		Synthetic biotites*	
	B1	B2	Ni–NiO buffer	Fe_2SiO_4–$SiO_2Fe_3O_4$ buffer
$Fe^{3+}/(Fe^{2+}+Fe^{3+})$	0.1283	0.06717	0.10	0.05
Fe/(Fe+Mg)	0.7968	0.7945	0.765	0.765
d_{060}	1.5375	1.5350	1.5511–1.5518	1.5509–1.5528
Temperature	—	—	700–600 °C	760–500 °C
Pressure	—	—	2070 bars	2070 bars

* Wones, 1963.

plotted in the figure of Wones and Eugster (fig. 4, p. 1244, 1965) indicate a crystallization temperature in the range of 760–500 °C at 2070 bars pressure, depending upon the oxygen fugacity. It may be concluded that the biotite under study crystallized between 760 and 500 °C.

Heinrich (1946), Nockolds (1947), Gower (1957), Engel and Engel (1960), and Foster (1960) studied the variation in composition of biotites in relation to their parent rock type. In the diagram of Engel and Engel (fig. 7, p. 30, 1960), in the diagram of Gower (fig. 5, p. 150, 1957), and in that of Foster (fig. 12, p. 33, 1960), both analysed biotites fall in the granite field.

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