

A CHLORINE-RICH BIOTITE FROM KONDAPALLI, ANDHRA PRADESH, INDIA

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ABSTRACT

A pegmatite biotite of the charnockitic region of Kondapalli, India, has a chlorine content of 1.96 percent, the highest for any biotite analyzed to date. A chemical analysis for major and trace elements of the biotite is presented.

INTRODUCTION

Charnockites form the major rock unit of the ranges near Kondapalli in Krishna district of Andhra Pradesh (India). They, together with a small amount of associated khondalites (quartz-feldspar-biotite-garnet-sillimanite gneiss), form a basement complex. A large number of pegmatite veins occur in the area cutting the khondalites and charnockites. A specimen from a grey pegmatite was studied in detail with particular attention to the chemistry of the constituent biotite. The significance of the K/Ar age (500–525 m.y.) of this pegmatite biotite in elucidating the geochronological sequence of the Precambrian of Peninsular India has been noted by Grasty and Leelanandam (1965).

GEOLOGIC SETTING

Nakkal Banda is a small, flat-topped hillock extending eastwards from the main Kondapalli ranges. Rocks on the northern, eastern and southern slopes of the hillock are well exposed due to extensive quarrying. The eastern face of the Nakkal Banda quarry extends for about 600 feet in the north-south direction with a maximum height of 50 feet. A variety of rock types are seen in this quarry. Acid and intermediate charnockites are predominant; khondalites and leptynites (nonfoliate quartz-feldspar-garnet rocks, with little or no biotite and sillimanite; see also Krishnan (1951)) are less abundant; there are minor amounts of granitic gneisses and migmatites; cross-cutting basic charnockite dykes and bands are present at some places. There are a few grey and pink pegmatite veins, aplite veins and bluish-grey opalescent quartz veins. Contorted mylonite bands and rare plagioclase-magnetite rocks are also present.

During the last ten years, the Nakkal Banda quarry has been intensively developed and the eastern working face has been advanced into the hillock about 25 feet. The pegmatite vein, from which the specimen 318 (deposited in the Harker Collection—catalogue number 96299—

Department of Mineralogy and Petrology, Cambridge) was collected and studied, has unfortunately been completely removed.

MINERALOGY OF THE PEGMATITE

The pegmatite is an extremely coarse-grained rock with quartz, plagioclase, biotite and potassium feldspar as essential minerals, garnet and ore as subordinate minerals, and with trace amounts of zircon and secondary calcite. Plagioclase (An_{35}) occurs in large grains, shows feeble undulose extinction and, rarely, reversed zoning; it possesses a "transitional" structural state, as judged from its $\Gamma(0.529)$ and $B(0.896)$ values (Smith and Gay, 1958). The potassium feldspar (Or_{77}) is orthoclase; the separation of $130\text{--}130$ and $131\text{--}131$ peaks on the X-ray diffractometer trace is zero, corresponding to zero triclinicity. Garnet ($a = 11.534 \pm 0.002 \text{ \AA}$) forms rims around opaque minerals or occurs as individual grains with inclusions of opaques and biotite. More detailed information on mineralogy of the host is given by Leelanandam (1966).

Biotite exhibits extremely strong pleochroism, bent cleavage and wavy extinction. It has the following properties:

Density 3.14

$\beta = \gamma = 1.661 \pm 0.002$

$2V_{\alpha} = 7 \pm 2$

Pleochroism $X =$ light brownish-yellow

$Y = Z =$ deep brownish-black.

CHEMISTRY OF THE BIOTITE AND GENERAL DISCUSSION

The biotite was separated and purified by using the isodynamic separator and centrifuging in heavy liquids. The purity of the analyzed sample was greater than 99.5 percent. Standard wet-chemical techniques were followed for the analysis of the mineral; Ti and Mn were determined colorimetrically and the alkalis by flame photometry. Total iron was determined by titration with standard ceric sulphate, and ferrous iron was determined against standard permanganate solution. Total water was determined by the Penfield method and fluorine by the method of Willard and Winter (1933); for details of these methods see Leelanandam (1969a). Chlorine was estimated using NaCl as the standard by electron microprobe X-ray analysis; the necessary corrections for absorption and atomic number have been made (Leelanandam, 1969b). Microprobe analysis of Cl was made on four grains, each grain being checked at several regions (Fig. 1); a total of twenty determinations were made, and the values are remarkably consistent ($1.96 \pm 0.03\%$). In this context,

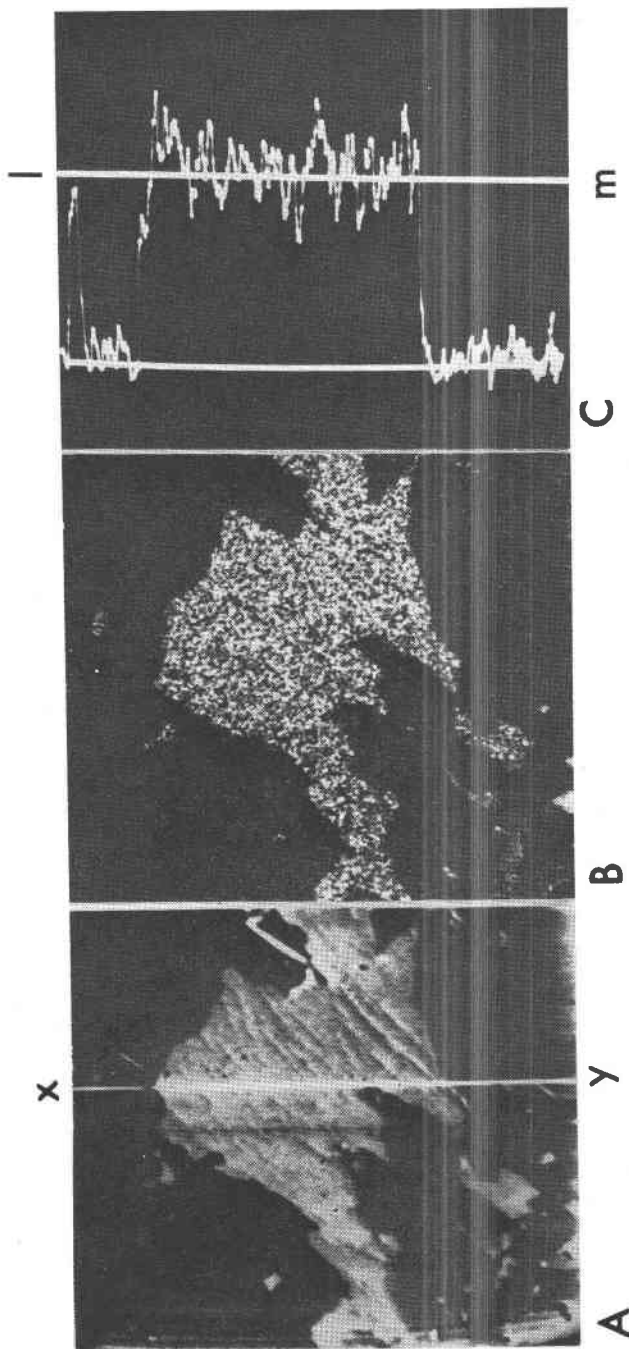


FIG. 1. Electron microprobe studies of biotite

- A. Back scattered electron scan picture the distance; *x-y* represents 0.5 mm.
- B. Chlorine $K\alpha$ X-ray scanning picture of field shown in A; white areas are rich in chlorine.
- C. Chlorine $K\alpha$ line scan along *x-y* shown in A. Base line (towards left) is zero intensity. Marker line (*l-m*) represents $\sim 2\%$ Cl (1/30th of 60.67% Cl in NaCl standard), and the zero for NaCl is shifted to compensate the background.

TABLE 1. ANALYSIS OF THE PEGMATITE BIOTITE (318) FROM KONDAPALLI^a

Weight percent		Numbers of ions on the basis of 24 (O, OH, F, Cl)		Trace elements ^b (in ppm)			
SiO ₂	35.29	Si	5.494	}	8.000	Ga	60
TiO ₂	4.79	Al	2.506			Cr	10
Al ₂ O ₃	14.78	Al	0.206	}	5.920	Li	100
Fe ₂ O ₃	2.00	Ti	0.561			Ni	125
FeO	19.25	Fe ³⁺	0.234	}	5.920	Co	80
MnO	0.05	Fe ²⁺	2.506			V	140
MgO	10.37	Mn	0.007	}	5.920	Zr	70
CaO	0.00	Mg	2.406			Sc	32
Na ₂ O	0.12			}	1.905	Ba	1250
K ₂ O	9.41	Ca	—			Rb	2500
H ₂ O(+)	1.77	Na	0.036			Cu	125
H ₂ O(-)	0.06	K	1.869				
F	1.71	OH	1.838	}	3.197		
Cl	1.96	F	0.842				
		Cl	0.517				
	101.56						
Less O=F+Cl	1.15						
Total	100.41						

^a Analysis by C. Leelanandam^b Spectrographic determination by R. Allen

it is of interest to note that the Cl values obtained by microprobe analysis of the Kondapalli hornblende 431 (0.46%) and biotite 359 (0.28%) are in very good agreement with those obtained by chemical analysis (0.49% and 0.27% respectively) (see Leelanandam, 1969b, Table 1).

Chemical analysis, structural formula and trace element data of the biotite are presented in Table 1. The biotite contains no Ca, low Mn and combined water, high Ti, F and Cl, and more Ni than Co—features which are all common to the nine analyzed biotites from charnockites of Kondapalli (Leelanandam, 1965). Compared to the trace element contents of the charnockite biotites, the pegmatite biotite contains high Ga and low V and Cr. The remarkably high chlorine content of this pegmatite biotite is the most noteworthy of the chemical features. The amount of chlorine is the highest for any biotite analyzed to date (see Deer, Howie and Zussman, 1962, Tables 12 & 13). The highest chlorine

content previously reported for the mineral is 1.11 percent in biotite from a biotite-garnet-schist from Idaho (Lee, 1958). Lee pointed out that "the presence of chlorine is especially to be suspected when careful analysis of a mica gives a low total for the oxides and fluorine, and calculations show the deficiency to be in the (OH) group". Eleven biotites from the charnockites and associated granulites of Kondapalli contain chlorine ranging from 0.14–0.62 percent (Leelanandam, 1965).

The high chlorine content of the pegmatite biotite has no effect on optical properties. The refractive index, $\gamma = 1.661$, is about the same as what would be expected from its content of FeO, Fe₂O₃ and TiO₂ (see Heinrich, 1946, Fig. 10).

The high concentration of chlorine in the Kondapalli biotites is probably a reflection of environmental characteristics. No exact correlation can be made between Cl contents of the biotites and SiO₂ contents (or Fe²⁺/Mg ratios) of the host rocks (Leelanandam, 1965). However, Cl tends to occur in greater amounts in iron-rich biotites (Leelanandam, 1969a) and the pegmatite biotite is the most iron-rich of all the analyzed Kondapalli biotites. Chlorine is geochemically lithophilic and highly mobile in character (Johns and Huang, 1967). It is not known whether or not any chlorine was expelled from the Kondapalli rocks during metamorphism. The mineralogy of the pegmatite suggests that virtually all the chlorine present in the rock is effectively locked up in the constituent biotite.

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