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Electron microprobe analyses of chlorine in hornblendes and biotites from the charnockitic rocks of Kondapalli, India

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SUMMARY. Chlorine is estimated in nine hornblendes (0·13–1·12 %) and nine biotites (0·19–0·62 %) from the Kondapalli charnockites for the first time, using the electron microprobe. The data obtained suggest that these Kondapalli minerals are unexpectedly and unusually rich in Cl, which is well equilibrated in the five available coexisting hornblende–biotite pairs.

HORNBLENDES and biotites are not common minerals of the charnockites from Kondapalli (16° 37′ N. 80° 32½′ E.; Krishna district, Andhra Pradesh), India, but they become major minerals when the host rocks occur as bands, dykes, or lenses, or when the host rocks occur in close proximity to the granitic gneisses and pegmatites. Though it is inferred that hornblendes and biotites of the charnockitic rocks occurring in different parts of the world may contain considerable amounts of fluorine, no attempt has hitherto been made either to detect the presence of chlorine or to estimate its amount in these minerals. This note records the estimation of chlorine, for the first time, in these minerals from the Kondapalli charnockites using the electron microprobe X-ray analyser.

The analyses were performed on an instrument in the Department of Mineralogy and Petrology, University of Cambridge. A detailed account of its design, operation, and of the general procedure adopted is given by Reed (1964) and Long (1967). In the instrument used, the electron beam is incident normally on the surface of the specimen and the angle of take-off of the X-rays is 40° to the surface. All measurements were made with a beam-accelerating voltage of 15 kV, and rock salt (NaCl) was used as a standard; the measurements are the result of at least six determinations, each taking 20 sec. The measurements have been corrected for the effects of absorption and atomic number; an absorption correction factor of 1·107 and an atomic number correction factor of 1·05 were obtained for the determination of chlorine in the biotite 220 (from a basic charnockite lens) taking into consideration its chemical analysis. A scrutiny of the chemical analysis of the hornblende 220 indicated that there is no need to change these factors for chlorine estimation in it. The same correction factors were utilized in estimating chlorine in all other minerals in the present study. As individual corrections for these minerals of differing compositions (though of the same series or group) were not made, it is not unlikely that a slight error may be introduced in these estimations; this error, however, is considered to be insignificant. Corrections for the fluorescence effect have not been made.

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The data thus obtained for nine hornblendes and nine biotites from the charnockites of Kondapalli are recorded in table I; the hornblende 431 and biotite 359 were also chemically analysed for chlorine and the values obtained are in very good agreement with those obtained by the electron microprobe.

TABLE I. *Chlorine in the Kondapalli hornblendes (H) and biotites (B)*

Rock type and number	Chlorine %	
	H	B
Ultrabasic charnockites		
J22 (96247*)	0·13	—
431 (96250)	0·46†	0·28
G4 (96248)	0·24	0·19
D14 (96242)	0·43	—
Basic charnockites		
A7 (96253)	0·75	0·53
28 (96256)	1·12	n.d.
P45 (96259)	—	0·32
220 (96252)	0·68	0·43
G17 (96258)	0·91	n.d.
A18 (96251)	0·66	0·32
Acid or intermediate charnockites		
382 (96273)	—	0·22
359 (96287)	—	0·28‡
S1 (96280)	—	0·62

* The five-digit numbers of specimens correspond to those catalogued in the Harker collection at the Department of Mineralogy and Petrology, Cambridge.

— indicates the mineral is absent. n.d. = not determined.

† Chemical analysis gave 0·49 %. ‡ Chemical analysis gave 0·27 %.

The content of chlorine varies from 0·13 to 1·12 % in the Kondapalli hornblendes. The hornblendes from basic charnockites, as a group, contain greater amounts of Cl than those from the ultrabasic charnockites. The available literature indicates that the few amphibole analyses in which Cl has been reported generally belong to the pargasite–ferrohastingsite group (see also Deer, Howie, and Zussman, 1963). Hornblendes from different rock types, for example, of the Adirondack Mountains contain varying amounts of chlorine. Thus, the chlorine content varies from only 0·01–0·05 % in seven hornblendes from the amphibolites of the Colton area, though two secondary hornblendes contain 0·12 and 0·17 % Cl (Engel and Engel, 1962); three hornblendes from the metamorphosed basic rocks contain 0·03, 0·04, and 0·63 % Cl (Buddington, 1952), while seven hornblendes from the granitic rocks contain Cl ranging from 0·26–0·77 % (Buddington and Leonard, 1953). Referring to the latter values, Buddington and Leonard stated: 'There are but few analyses of hornblendes in the literature that give the per cent of chlorine. If this is to be taken to indicate that chlorine is minor in amount, then the Adirondack hornblendes are exceptionally rich in this element. It is possible, however, that chlorine occurs in significant amounts in some hornblendes in which it has not been determined.' The present study demonstrates that the Kondapalli hornblendes are unusually rich in Cl and indeed richer than the Adirondack hornblendes, though the host rocks of the two areas are not comparable.

The exceptionally high value of 1·12 % Cl is found in the Kondapalli hornblende 28 from a basic charnockite lens. A perusal of the available amphibole analyses shows that such a high Cl value is rather uncommon for metamorphic hornblendes, though higher values are reported for amphiboles from skarns.

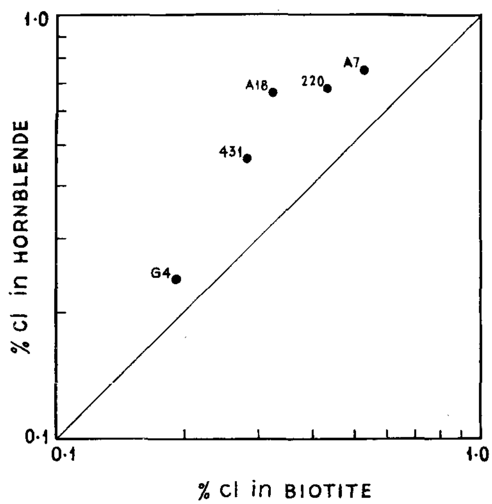

FIG. 1. Graphical log-log plot indicating the distribution of Cl in coexisting hornblende–biotite pairs from the Kondapalli charnockites.

The chlorine content in the charnockite biotites of Kondapalli ranges from 0·19–0·62 %. Chlorine occurs in greater amounts in biotites from the basic charnockites than in those from ultrabasic charnockites; this is similar to what has been observed earlier for the hornblendes. The available data do not permit comment on the occurrence of chlorine in the biotites from acid charnockites relative to other types of rocks. But it should be mentioned that there is a tendency for Cl to be concentrated in greater amounts in biotites whose host rocks (A7 and S1) are in close proximity to the adjacent granite gneisses.

The scarcity of chlorine determinations in biotite has been noted and the need for its determination stressed by earlier workers (Kuroda and Sandell, 1953; Correns, 1956; Lee, 1958). An examination of the existing literature discloses that the amount of Cl in the Kondapalli biotites is unexpectedly very high. Kuroda and Sandell (1953) inferred that as much as 0·2 % Cl is not uncommon in biotites, but the present study reveals that more than 0·2 % Cl is most common in the Kondapalli biotites.

Chlorine analyses for hornblende–biotite pairs from five Kondapalli charnockites were obtained during the present study and it is observed that Cl as a rule is greater in hornblende than in the coexisting biotite (table I). The distribution of chlorine in coexisting hornblende and biotite is graphically represented on a log-log plot (fig. 1) and equilibrium distributions are reflected in clusters of points elongated parallel to the 45° line on such a plot. It is concluded that there is a close approach to equilibrium with respect to Cl in these minerals of the Kondapalli charnockites.

As none of the hornblendes and biotites in charnockites occurring in different parts of India and other countries have been analysed for chlorine, there are no data to compare with the results for the Kondapalli minerals. The present communication, however, shows the importance of testing for the presence of chlorine in future studies of hornblendes and biotites from similar rock types at other localities. The writer is of the opinion that the concentrations of chlorine in these minerals is primarily a reflection of regional or environmental characteristics peculiar to a terrain.

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