An X-ray investigation of green mica in khondalite from Auranga-Koel Valley, Palamau, Bihar, India

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Summary. A new variety of chrome mica containing V_2O_3 and TiO_2 has been investigated by X-rays. It is shown that the crystals of this mica are monoclinic with $a = 5{\cdot}25$ Å, $b = 9{\cdot}03$ Å, $c = 20{\cdot}11$ Å, $\beta = 96{\cdot}00'$, space group $C\ 2/c$. Comparison of the intensities of the X-ray powder lines of this new variety of mica with that of pure muscovite may indicate structural changes. The optical properties and chemical composition of the mica are described.

OCCURRENCES of green mica, sometimes also called chrome mica or fuchsite, have been reported in the past by many workers (e.g. Whitmore *et al.*, 1946; Clifford, 1957). The present work describes an X-ray investigation of green mica obtained after separating it from graphite schist obtained from Bhusaria hill nearly two-and-half miles north of Kechki railway station in Palamau, Bihar, India.

The green mica is found in flakes from 1·0 to 1·5 mm in diameter and dispersed in small lenticular pods having widths from 2 to 4 mm and lengths from 5 to 30 mm. According to Verma (1961) 'occurrence of similar mica has not so far been reported from Khondalites or its equivalent Kinzigites. It differs in chemical composition from fuchsite and also contains Cr_2O_3, V_2O_3 and TiO_2'.

The properties of this green mica as reported by Verma and the results of his chemical analysis, following the same scheme as Whitmore *et al.* (1946), are given in table I. These compare favourably with similar values obtained for green mica from other parts of the world, except for the presence of Cr_2O_3, V_2O_3, and TiO_2.

Optical examination. Single crystals of green mica were isolated by detaching the small greenish flakes from the rock sample. They were thin flakes varying in dimensions from 1 to 2 mm, light green in colour, mostly having irregular contours. The flaky face had a lustrous appearance. Subsequent X-ray examination confirmed the flaky face as (001). The other optical properties are given in table I.

X-ray examination. Laue, oscillation, rotation, and Weissenberg

photographs have clearly established the crystals of green mica to be monoclinic, space group $C\ 2/c$ with unit cell dimensions: a 5·25±0·01 Å, b9·03±0·02 Å, c 20·11±0·03 Å, β 96·0°. The X-ray diffraction data are consistent with either the space group $C\ 2/c$ or Cc but a comparison of this unit cell data with those of fuchsite and muscovite makes it extremely probable that the space group is really $C\ 2/c$. These data agree

TABLE I. Chemical analysis (A), atomic ratios to 48 oxygens (A′), and optical properties of the green mica from Auranga-Koel valley (R. Verma, anal.), compared with green mica from Bhandara (B; Chatterji, 1932)

	A	B		A′		
SiO_2	46·48	47·35	Si	12·85	16	α 1·570, colourless
Al_2O_3	27·37	30·99	Al^{iv}	3·15		to greenish
TiO_2	1·33	tr.	Al^{vi}	5·78	8·40	β 1·595, light
Cr_2O_3	0·60	2·74	Ti	0·27		green
Fe_2O_3	—	0·94	Cr	0·13		γ 1·615,
V_2O_3	0·80	0·48	V	0·18		emerald
FeO	5·10	0·64	Fe	1·17		green
MnO	—	tr.	Mg	0·87		
MgO	2·10	1·27	Na	0·58		2Vα 37°
CaO	0·80	1·16	Ca	0·24	4·60	
Na_2O	1·10	1·71	K	3·78		
K_2O	10·70	9·26	OH	6·82	48	
H_2O	3·70	3·98	O	41·18		
Sum	100·08	100·52				

well with the unit-cell dimensions of muscovite and fuchsite reported in the literature (Whitmore *et al.*, 1946).

The spots on the Weissenberg photographs were not very sharp but elongated considerably (5 mm in length). A few weak reflections on a and b axes inconsistent with the space-group condition $h+k = 2n$ are accounted for as due to internal double reflection. The considerable elongation of the spots on the Weissenberg photographs was very similar to that in the Weissenberg photographs reproduced by Whitmore *et al.*, and appears to be a consequence of plastic deformation of the crystals as explained by Buerger (1960).

Powder diffraction data. The green mica was finely pulverized using an agate mortar and filled into a Lindemann glass capillary 0·3 mm in diameter. The powder diffraction data obtained on a 9 cm diameter camera, using nickel-filtered copper radiation, are given in table II.

A comparison of the powder data of this green mica with that of muscovite (A.S.T.M. card 6–0263) suggests structural changes in the green mica. For muscovite the three strongest lines are 3·32 Å (100),

9·95 (95), and 2·57 (54), whereas for the green mica they are 2·58 Å (100), 4·51 (58), and 1·50 (46); there are other variations of intensity in corresponding powder lines of green mica and muscovite. These differences may, however, be due to preferred orientation, or to the different Lorentz polarization factors applicable to Debye-Scherrer cameras and to diffractometers. It has also been observed that for pure two-sheet mica reflections 06*l* with *l* odd are missing whereas we definitely find

TABLE II. X-ray powder data for green mica from Auranga-Koel valley

$d_{obs.}$	I/I_0	$d_{calc.}$	*hkl*	$d_{obs.}$	I/I_0	$d_{calc.}$	*hkl*
9·99 Å	70	10·00 Å	002	1·70 Å	4	1·70 Å	$15\bar{1}$
4·98	11	5·00	004			1·71	241
4·51	58	4·50	$11\bar{1}$	1·64	11	1·64	153
		4·52	111			1·65	312
3·93	23	3·98	112	1·60	4	1·61	228
3·74	23	3·72	023				313
3·52	19	3·52	$11\bar{4}$	1·55	4	1·57	$2.2.\bar{1}0$
3·33	31	3·33	006			1·56	314
3·20	19	3·21	114	1·50	46	1·50	060
3·00	23	2·99	025			1·51	$33\bar{1}$
2·86	10	2·87	115	1·34	4	1·33	0.4.12
2·58	100	2·57	131	1·28	23	1·29	068
		2·59	$20\bar{2}$				$40\bar{4}$
2·27	15	2·47	$13\bar{3}$	1·27	4	1·27	0.4.13
2·39	19	2·38	133	1·24	15	1·25	0.0.16
2·25	15	2·24	041	1·21	4	1·21	$40\bar{8}$
		2·26	134	1·11	8	1·11	408
2·20	15	2·20	042	1·00	3	1·00	0.0.20
		2·22	221	0·98	8	0·98	4.0.12
2.14	31	2·14	043	0·96	4	0·96	0·8.11
2·07	4	2·06	044	0·90	6	0·90	0.10.0
		2·08	223	0·89	8	0·89	4.0.18
1·99	40	2·00	0.0.10	0·87	8	0·87	600

these reflections to be present on the Weissenberg photographs, though very weak.

Unit-cell contents. On the basis of the result of the chemical analysis the chemical formula of the green mica can be written: $(K_{0\cdot94}Na_{0\cdot14}Ca_{0\cdot06})$ $(Al_{1\cdot44}Ti_{0\cdot07}Cr_{0\cdot03}V_{0\cdot04}Fe_{0\cdot29}Mg_{0\cdot22})$ $(Al_{0\cdot79}Si_{3\cdot21})O_{10\cdot29}(OH)_{1\cdot71}$. The assumption of four such units in the unit cell leads, on the basis of the measured unit-cell dimensions for the green mica, to a calculated density of 2·91; the observed density of the crystal (flotation method using bromoform and toluene) was 2·87. The discrepancy of 1·25 % may be partly due to error in the specific gravity and partly to error in the analysis.

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