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Chromian amphibole from the chromite ores of Katpal, Dhenkanal District, Orissa, India

CHROMIAN amphibole occurs in the chromite ores of Katpal (21° 1′ N., 85° 43′ E.) at the south-western extremity of the Sukinda Valley chromite belt extending from Cuttack to the Dhenkanal district of Orissa. The mineral occurs as thin fracture-filling veins (up to 0·5 mm thickness), in the interstitial spaces of chromite or along the periphery of the chromite grains. Kämmererite is sometimes found bordering thin lenses of chromite and is itself mantled and replaced by radiating sheaves of chromian amphibole. In many places chromian amphibole is present as thin layers (up to 2·5 mm thickness) with only traces of included chromite, which fill in fissures that have been left open after the formation of the original chromite mosaic. The chromite could be easily separated by hand picking after the sample was ground below 200 mesh (B.S.S.) and the mineral analysed was nearly 100 % pure.

The mineral is characteristically confined within the chromite ore-bodies and is never found in the host rocks (altered dunite). The limited occurrence of chromian amphibole obviously reflects restricted conditions of its development in nature.

The chromian amphibole of Katpal is distinctly green in hand specimen. The crystals are elongated (up to 6 mm long) prismatic, needle-shaped, or even fibrous in nature. Hardness = 4½. The mineral is colourless in thin section and contains minute grains of chromite as inclusions. But in thicker section it is coloured and weakly pleochroic (α colourless, β very pale greenish yellow, γ pale green). Prismatic cleavage is pronounced. The weak pleochroism of this species is presumably due to deficiency in iron.

The optical properties, chemical composition, and X-ray powder data are presented in Tables I and II. The chemical composition and optics of this chromian amphibole are very similar to those of a chromium-rich hornblende (Cr_2O_3 4·68 %) cited by Deer, Howie, and Zussman (1963, **2**, Table 40, No. 2, p. 274) from Turkey. Both the species contain high amount of magnesia, which facilitates the entry of both Cr and Ni. X-ray powder data and cell dimensions (Table II) closely resemble those of normal calciferous hornblende (Ref. P.D.F. Card No. 9–434).

Discussion. Chromite grains associated with the amphibole are irregular in shape, fractured, and corroded at the margins. Chromian amphibole has undoubtedly replaced both chromite and kämmererite along the grain boundaries, cleavages, and fractures (fig. 1*a* and *b*). It also forms thin fracture-filling veins in chromite. So it is suggested that it was formed in the pneumatolitic or hydrothermal stage by replacement of both chromite and kämmererite. Chrome-bearing solutions released from primary chromite contributed to the formation of this mineral under conditions of high oxygen activity. Chromium has entered into the structure of amphibole presumably by substitution of trivalent iron or aluminium. A similar view was expressed

TABLE I. *Chemical composition and optical data of chromian amphibole from Katpal, Orissa (B.P. Gupta, Analyst)*

SiO_2	53·73	Si	7·573	8·04	
Al_2O_3	2·60	Al	0·471		
TiO_2	0·76	Ti	0·078	5·43	
Fe_2O_3	1·96	Fe^{3+}	0·206		
Cr_2O_3	2·52	Cr	0·278		α 1·612±0·002
FeO	1·44	Fe^{2+}	0·167		β 1·617 ,,
MgO	22·06	Mg	4·634		γ 1·630 ,,
NiO	0·64	Ni	0·072		γ−α 0·018
MnO	0·03	Mn	0·003		γ:[001] 21°
CaO	12·25	Ca	1·845	2·05	$2V_\alpha$ 75°
Na_2O	0·74	Na	0·202		
K_2O	0·05	K	0·007		
H_2O^+	1·03	OH^-	0·970	24	
H_2O^-	0·08	O	23·030		
Total	99·89	100	$Mg/(Mg+Fe^{2+}+Fe^{3+}+Mn) = 92·5$		

TABLE II. *X-ray powder data of chromian amphibole from Katpal, Orissa.* *a 9·85, b 18·16, c 5·29* Å, all ±*0·01* Å, *β 105° 30′±15′*

d (Å)	*I*	*d* (Å)	*I*	*d* (Å)	*I*	*d* (Å)	*I*
9·0852	30	3·0419	3B	2·2165	5	1·7468	3
8·3898	65	2·9500	65	2·1694	60	1·7217	2
4·8765	20	2·8199	10	2·0551	20	1·6903	10
4·5370	15	2·7189	100	2·0187	15	1·6556	10
3·8881	40	2·5965	80	1·9702	5	1·6227	15
3·6281	5	2·5422	80	1·9371	3	1·5912	25
3·4005	70	2·4064	2	1·8990	2	1·5614	3
3·2850	70	2·3422	50	1·8715	5	1·5365	1
3·1400	90	2·2892	45	1·8164	5	1·5145	20

114·6 mm diam. camera, filtered Co-radiation.

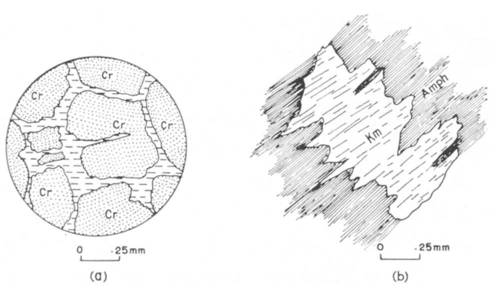

FIG. 1 (*a*). Chromian amphibole (dashed lines) replacing primary chromite (Cr) along periphery and fracture. (*b*) Radiating sheaves of chromian amphibole (Amph) replacing kammererite (Km) along periphery and cleavage planes.

by Borchert (1963) on the formation of chromian amphibole in the chromite deposits of Turkey. Here the amphibole replaces enstatitic rhombic pyroxene, which itself forms the groundmass of disseminated chromite crystals or of nodular chromite aggregates. Borchert emphasized that chromian amphibole was a typical product of the final magmatic stages characterized by the enrichment of the volatile constituents.

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Clinohumite marble from Vemali, Srikakulam district, Andhra Pradesh, India

CLINOHUMITE marble occurs as thin bands intimately associated with diopsidites and quartz–wollastonite–diopside granulite on the top of the hill to the north-east of Vemali (18° 18·7′ N., 83° 25·5′ E.). This hill, a member of the Eastern Ghat hill ranges, is composed mainly of khondalites (garnet–sillimanite schists and gneisses) with subordinate amount of the above-mentioned calc-granulites. In parts of this hill and adjacent ones the khondalite is migmatized by the injection of K-feldspar-forming fluid. This note reports some interesting textures of the clinohumite marble and the mineralogy and chemistry of the clinohumite.

In hand specimen the clinohumite marble is white coarse-grained rock composed of carbonate minerals (mainly calcite, 68·2 % with a subordinate amount of dolomite), clinohumite (26·7 %), grossular (2·2 %), diopside (1·8 %), and accessory tremolite, apatite, and shining flakes of graphite (3×3 mm in diameter). Calcite occurs as coarse crystals (average size 1·0×0·6 cm), within which occur other minerals. Dolomite occurs as rectangular rods, rhombs, and ramifying intergrowths with calcite (cf.