Mineralogical note on the chrome-chlorite (kämmererite) and chrome-garnet (uvarovite) from the chromite deposits of Kalrangi, Orissa, India

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Summary. The geological set-up, chemical composition, physical and optical properties, and X-ray data of one sample of chrome-chlorite (kämmererite) and of a chrome-garnet (uvarovite) from Kalrangi chromite mines, Orissa, India, are presented here. Chrome-bearing solution contributed in the formation of both the minerals in the hydrothermal stage. It is suggested that the garnet is an intermediary form between uvarovite and pyrope.

CHROME-CHLORITE (kämmererite) and chrome-garnet (uvarovite) occur in the chromite ore-bodies of Kalrangi (85° 46′ E., 21° 01′ N.), at the south-western extremity of the Saruabil–Maruabil chromite belt of Cuttack District, Orissa, India. Both these minerals occur as thin fracture-filling veins (up to 2 mm thickness), in the interstitial spaces of chromite, or along the boundaries of the chromite grains. They are peculiarly confined within the chromite ore-bodies and never extend to the host rocks. Serpentine is found in association with these minerals in some places. In many places both kämmererite and uvarovite are present as thin seams without any impurity. Under the petrological microscope a negligible quantity of fine chromite grains could be detected in such seams, and these could be separated very easily by hand picking after the samples were ground below 200 mesh (B.S.S.). So the minerals analysed were more than 99 % pure.

Chrome-chlorite (*kämmererite*) is pale violet in colour, very soft, and has a greasy feel. It consists of minute flaky crystals with a few larger grains, which often have a fibrous appearance in hand specimen. Under the microscope the kämmererite is pale pinkish in colour, non-pleochroic, and isotropic to very weakly anisotropic. α 1·574±0·002, γ 1·580±0·002, $2V_\alpha$ 0°.

The chemical analysis and the X-ray powder data of the concentrated mineral are presented in table I.

The chemical composition and the optical properties of the kämmererite of Orissa are very similar to those of the micaceous variety described by Varadarajan (1957) from Hassan district, India, and also to the kämmererite cited by Deer, Howie, and Zussman from Deer Park, Wyoming (1963, vol. 3, Table 25, no. 36, p. 145). The X-ray powder data closely resemble those of pennine (Brindley and Robinson, 1951, Table 6).

TABLE I. Chemical and other data for a kämmererite and a uvarovite from Orissa (B. P. Gupta, anal.)

	1	2		1*a*		2*a*	
SiO_2	33·12	32·44	Si	6·17	8·00	5·253	6·00
Al_2O_3	29·69	8·90	Al^{iv}	1·83		0·747	
TiO_2	—	0·07	Al^{vi}	4·72	11·08	1·802	4·784
Fe_2O_3	0·72	1·33	Ti	—		0·009	
Cr_2O_3	3·29	21·96	Fe^{3+}	0·10		0·162	
FeO	0·52	0·54	Cr	0·48		2·811	
MnO	0·02	0·05	Fe^{2+}	0·08		0·073	6·506
NiO	—	0·06	Mn	—		0·007	
CaO	0·62	18·82	Ni	—		0·008	
MgO	20·06	13·02	Ca	0·12		3·266	
Na_2O	0·04	0·06	Mg	5·57		3·132	
K_2O	0·01	0·01	Na	0·01		0·019	
H_2O^+	11·58	0·16	K	—		0·001	
H_2O^-	0·26	2·75	OH	14·41		0·086	
Sum	99·89	100·17					

X-ray powder data for the kämmererite

d	*I*	*d*	*I*	*d*	*I*	*d*	*I*
14·25 Å	6	2·45 Å	7	1·67 Å	vwb	1·30 Å	2b
7·16	9b	2·39	4	1·58	4	1·23	vwb
4·78	8	2·27	3	1·54	8	1·20	wb
4·63	3	2·01	9	1·51	3	1·18	vwb
3·595	10	1·89	3b	1·47	vwb	1·05	vwb
2·86	3	1·84	3	1·40	4b	1·00	wb
2·59	4	1·735	wb	1·32	2b	0·99	vwb
2·54	8						

1. Kämmererite from Kalrangi, Orissa, India.

2. Uvarovite from Kalrangi, Orissa, India; n, 1·835±0·005; a, 11·93±0·005 Å; uvarovite, 62·2, pyrope, 37·8.

1*a*, 2*a*. Analyses 1 and 2, recalculated to atomic ratios on a basis of 36 (O,OH) and of 24 oxygen respectively.

Chromite embedded in chrome-chlorite is fine-grained, unfractured, and subhedral to subrounded in grain shape. Chrome-chlorite and in places also serpentine have crystallized along the grain boundaries of chromite, as well as in the fractures developed in the chromite ore-bodies. Both the minerals have replaced chromite along the margins. This suggests that during serpentinization chromite went into solution to form chrome-chlorite in preference to serpentine within the chromite ore-bodies.

Chrome-garnet (*uvarovite*) is hard and massive in character and does not show any grain boundary even in thin section. The colour is parrot green both in hand specimen and in thin section. It shows complete isotropism where it occurs without any impurity. The mineral is very weakly anisotropic in places, which may be due to the presence of chrome-chlorite or serpentine.

As mentioned earlier garnet was carefully separated from minute chromite grains under the petrographic microscope for chemical and X-ray powder analysis and for determination of refractive index. The results are presented in table I.

The chrome-garnet of Kalrangi, Orissa, has a peculiar chemical composition, which does not agree with any published chemical analysis of uvarovite (Frankel, 1959; Sastri, 1963; Deer, Howie, and Zussman, 1963). To confirm the accuracy of the results, both the chemical and the X-ray powder analyses were repeated, which produced the same results. In calculating the molecular proportion of the end members, only pyrope and uvarovite were formed. No other components could be formed due to the deficiency of silica. Aluminium, chromium, and magnesium remained in excess, and ferric and ferrous iron and also manganese remained unused.

Solid-solution relationships between uvarovite and grossular and between uvarovite and andradite are well established. Natural uvarovite has never been reported as a pure end member; appreciable quantities of grossular and andradite components, with a little pyrope and spessartine are always present in the chemical composition of uvarovite (Frankel, 1959; Deer, Howie, and Zussman, 1963, vol. 1, Table 19). This relationship was also experimentally varified by Isaacs (1965), under dry and hydrothermal condition. But the uvarovite garnet from the chromite deposits of Orissa has no grossular or andradite molecule, on the contrary a large proportion of pyrope molecule (37·8 %) is formed. Gentile and Roy (1960) preferred the following binary joins as both typical and most likely to show the maximum solubility: $Ca_3Cr_2(SiO_4)_3$–$Mn_3Al_2(SiO_4)_3$ and $Ca_3Al_2(SiO_4)_3$–$Mn_3Al_2(SiO_4)_3$. Very recently Němec (1967) described garnets of intermediate composition between the pyralspite and ugrandite series, and suggested an extensive solid solution between the two. The author suggests that the garnet described in this paper is an intermediate form between uvarovite and pyrope.

Chromite grains associated with the chrome-garnet are very small, irregular in shape, highly fractured and corroded at the margins. There is no doubt that uvarovite has replaced chromite along the grain boundaries, as well as along the fractures. It also forms thin fracture-filling veins in the chromite ore-bodies. So it is suggested that the chrome-garnet was formed along with serpentine in the hydrothermal stage, and chrome-bearing solution contributed in the formation of this mineral in places.

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