Contribution to the mineralogy of Norway, No. 58

NORWEGIAN CHROMIAN UGRANDITE-GARNETS

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Chromian garnets from the Røros district and from the Oslo Region have been analysed chemically and were found to contain 61 and 44 % of the uvarovite molecule respectively. A new occurrence of chromian grossular is described from inclusions of the monzodiorite rocks in the Velfjorden area, Nordland.

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Chromian garnets of the pyralspite solid-solution series occur in rocks which crystallized at high pressure. Such garnets have been described from peridotite in the Møre district (Hysingjord 1967, Carswell 1968). Uvarovite has been found only in two localities in Norway (Neumann 1959). The uvarovite from Rødtjern mine in the ultramafic rocks of Feragen of the Røros district has been known for a relatively long time, and good samples were found in the collections at both Mineralogisk-geologisk museum at Universitetet i Oslo and at Geologisk institutt at Universitetet i Trondheim. The uvarovite from Rødtjern has previously been analysed (Aars-Andersen 1907) and was then found to have a very high chromium content. Uvarovite from this locality has also been reported by Falck-Muus sen. (1957).

The uvarovite from Kalkovnen, Grua in the Oslo Region, has not yet been described. The only sample known from this locality occurs in the collections of Mineralogisk-geologisk museum in Oslo.

A. The uvarovite from Rødtjern mine occurs together with pink Cr-chlorite (kämmererite) and traces of pyrite as secondary minerals in the chromite ores from the mine. The uvarovite is very clear emerald green.

B. The sample from Grua is from the contact zone of nordmarkite. The rock is light-coloured and felsic with the mineral association: quartz + albite + prehnite ± uvarovite ± pyrrhotite. The uvarovite occurs as an irregular mass of ill-defined grains which is green also in thin section. Only a few grains are good enough for chemical analysis by electron micro-probe. Even the best grains are somewhat inhomogeneous. The sample from this locality has previously been studied only by X-ray diffraction. Goldschmidt (1911) described many garnets from the Oslo region, and among these were also

greencoloured varieties of grossular and andradite. A check for chromium of dark green andradites from the Grua and Kjenner areas in the Oslo Region was negative.

C. During the summers of 1972 and 1973 green garnets were found by the author at several places within inclusions in the monzodioritic rocks near Svartvatnet in the Velfjorden area, Nordland (location map, Fig. 1, and Myrland 1972). These inclusions are mostly calc-silicate rocks with a metamorphic fabric, in some places the rock is felsic with the mineralogical association: diopside + Cr-grossular ± pyrrhotite ± pyrite. The pyrrhotite has pentlandite inclusions. In other places quartz is a dominant mineral often assembled in clusters, 1–3 cm in size, giving the rock a conglomeratic appearance. In this rock type the Cr-grossular is concentrated in thin layers.

The garnet from these localities is not so typically emerald green as that from Rødtjern mine. In thin section the garnet is clear light green and seems to be fairly homogeneous. Some of the garnet grains show inclusions of a brown semi-opaque material which may probably represent the chromian spinel picotite or chromite.

One of the samples from Velfjorden was crushed, and the garnet was separated by means of heavy liquids and magnetic separator. The refractive index was measured as n = 1.785 (± 0.002, Na-light), and X-ray diffraction analysis gave a typical grossular pattern with each line displaced only very little to higher d-values. According to data published by Knorring (1951) the refractive index indicates a chromian-grossular somewhat lower in chromium than the uvarovite from Luikonlahti, Finland.

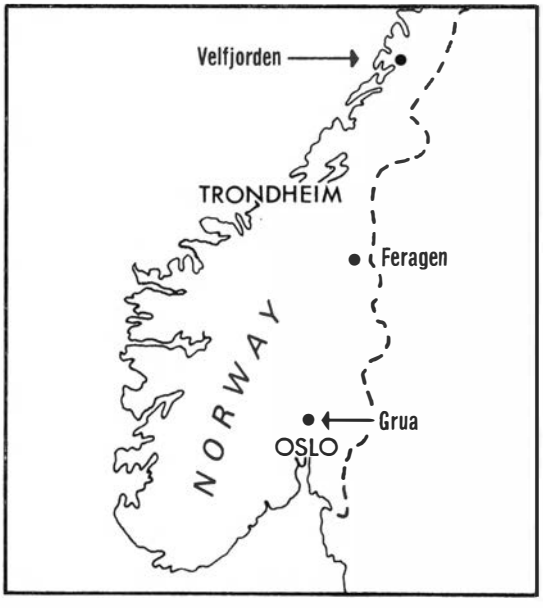

Fig. 1. Localities of chromian ugrandite-garnets in Norway.

Table 1. Chemical composition of Norwegian Cr-ugrandite garnets and of one diopside from Velfjorden. Analyst: T. Prestvik. Analytical method: Electron micro-probe analysis.

	Chromian grossular Velfjorden	Uvarovite Kalkovnen, Grua	Uvarovite I Rødtjern mine Røros	Uvarovite II Rødtjern mine Røros	Diopside Velfjorden
SiO_2	37.55	36.77	36.03	36.08	49.16
TiO_2					1.08
Al_2O_3	15.58	8.36	5.31	5.70	7.38
Cr_2O_3	9.01	13.72	17.83	17.48	0.87
Fe_2O_3*	2.67	5.85	2.36	2.66	
FeO**					1.47
MnO	0.52	0.22	0.06	0.06	0.23
MgO	0.54	0.27	0.31	0.33	14.53
CaO	34.51	34.56	35.60	35.30	24.65
Total	100.38	99.75	97.50	97.61	99.37

Atomic proportions to 12 oxygen atoms for the garnets and to 6 oxygen atoms for diopside.

Si	2.91	3.00	2.97	3.00	3.03		3.01		Si	1.81	2.00
Al^{IV}	0.09		0.03						Al^{IV}	0.19	
Al^{VI}	1.39		0.76		0.52		0.56		Al^{VI}	0.13	
Cr	0.55	2.10	0.87	1.99	1.17	1.91	1.15	1.88	Ti	0.03	
Fe	0.16		0.36		0.22		0.17		Cr	0.03	
Mn	0.03		0.01						Fe	0.04	1.99
Mg	0.06	2.94	0.03	3.02	0.04	3.22	0.04	3.19	Mg	0.79	
Ca	2.85		2.98		3.18		3.15		Ca	0.97	
	End member percentages									
Grossular	66		38		27		30		Mg	44	
Uvarovite	26		44		61		61		Fe	2	
Andradite	8		18		12		9		Ca	54	

* Total Fe as Fe_2O_3.
** Total Fe as FeO.

As Norwegian uvarovites have not earlier been analysed thoroughly (the analysis of Aars-Andersen is probably not correct), polished thin sections of uvarovites from Rødtjern mine and from Grua and chromian-grossular from Velfjorden were prepared for micro-probe analysis. The uvarovite from Rødtjern mine had many impurities rich in Fe which made an accurate analysis difficult. In the sample from Grua the uvarovite was very inhomogeneous, but regular zonation has not been observed. The analysis presented represents the highest chromium content found.

The chromian-grossular from Velfjorden, however, was very homogeneous, and several point analyses gave approximately the same values. From this locality, diopside was also analysed. The data from the micro-probe analysis is presented in Table 1.

According to Deer, Howie & Zussman (1962) it seems likely that uvarovite/grossular and uvarovite/andradite form continuous solid-solution series and that the gap in composition between analyses presented (their Tables 16 and 19, pp. 95 and 102 respectively) is due to lack of data. They also recognized that the analyses of available uvarovites showed only small amounts of the andradite molecule. The gem garnet demantoid is almost a pure andradite, having a green colour due to both Fe^{III} and traces of chromium (Anderson 1959). The analytical data presented in this paper comprise compositional ranges that enable one to complete the data of Deer, Howie & Zussman (op. cit.). In addition, the uvarovite from Kalkovnen, Grua, especially, indicates that Cr-ugrandites, as expected, may show extensive solid-solution also between the uvarovite and andradite end members. It should be noted that total iron has been calculated as Fe_2O_3 for all the garnets, and of course, this is not exactly correct.

Discussion

According to Deer, Howie & Zussman (op. cit.) uvarovite is usually associated with serpentinites containing chromite, or with metamorphosed limestones and skarn ore-bodies where the uvarovite was formed secondary from chromite in associated serpentinites.

A. The uvarovite from Rødtjern mine fits well into that scheme; both uvarovite and the pink Cr-chlorite (kämmererite) are clearly secondary, and the source of Cr is obviously the aluminous chromite of the ore.

B. The occurrence of uvarovite at Kalkovnen, Grua, resembles those described from Finland (Knorring 1951), but the source for Cr is not so obvious in our case. The actual locality is situated in the contact aureole around the nordmarkite plutonic rocks of this area, and a number of mineralizations of mostly sulphides and skarn minerals are known from this area (Goldschmidt 1911). But chromium-rich minerals genetically related to the plutonic rocks of the

Oslo Region has not (as far as known to the author) been reported, and possibly should not be expected. Another possible source for the Cr is the monzodioritic (Oslo-essexite) volcanic neck of Ballangrudkollen (Barth 1944) some 5 km to the west of Kalkovnen. Chemical analysis of this rock (Finstad 1972) shows a Cr_2O_3 content of 0.05 per cent which was the highest Cr_2O_3 value found among 8 different occurrences of Oslo-essexite from the Oslo Region. The intrusion of Oslo-essexite into the Cambro-Silurian sediments of this area preceded the intrusion of the nordmarkite. The chromium was eventually introduced before the sediments were contact-metamorphosed. This is consistent with the texture of the rock, which does not indicate a postmetamorphic development of the uvarovite.

As no typically chromite-bearing rocks are known from the area, the source of Cr to form the uvarovite may be the premetamorphic sediment itself. The age of the host rock is late Ordovician (stage 5, Goldschmidt 1911). Later geochemical investigations (Bjørlykke pers. comm.) of Cambro-Silurian sediments of the Oslo Region show a considerable chromium content (1000 ppm) in calcareous schists of Upper Ordovician age. This Cr-content should be more than high enough to account for the formation of uvarovite in the Ca-Al-silicate hornfels.

C. The mode of occurrence of Cr-grossular from Velfjorden resembles that of the uvarovite of Kalkovnen, Grua. The rocks have a metamorphic texture, and the minerals probably represent equilibrium crystallization conditions indicating that the Cr-content of the rock is premetamorphic.

These localities are situated some 2 kilometers SW of the chromite-bearing ultramafite body to the east of Heggefjorden (Myrland 1972, map). A small ultramafic rock-body is located some 3 km west of the Cr-grossular localities. A plausible explanation for the chromium mineralization at the present localities is that the chromium was derived from one of the two ultramafic rocks mentioned, or from a yet unexposed ultramafite.

The occurrence of Cr-rich diopside (Table 1) from one calc-silicate inclusion may also be of petrological interest. Chromium-rich silicate minerals are usually associated either with ultramafic rocks or mafic rocks with high pressure mineral assemblages. The possible presence of picotite remnants within the chromium-grossular (see p. 178) and the chemical content (high Al_2O_3 and Cr_2O_3) of the main mineral diopside may indicate that the felsic rock once crystallized at high-pressure conditions (Aoki & Shiba 1973). It should be noted, however, that high Al_2O_3-content of diopside does not imply a high-pressure formation (Hytønen & Schairer 1961). The rock is now free from plagioclase, but one may suggest that the premetamorphic mineral assemblage included the latter mineral also.

There is no evidence that the ultramafic rocks of the area contain Al-spinel or pyrope-rich pyralspite garnets which indicate high-pressure assemblages resembling those of peridotitic nodules of mafic rocks.

As there is no conclusive evidence that the calc-silicate inclusion of the

monzodiorite once crystallized at high pressure, the chromian minerals (grossular and diopside) could be easily formed from Cr-enriched marls which were later metamorphosed. The chromium should be derived from ultramafic rocks of the area.

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