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Grandidierite from Cuvier Island, New Zealand

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SUMMARY. Grandidierite has been found in hornfelses around a diorite stock on Cuvier Island. Physical properties and electron microprobe analyses are given for two Cuvier Island and two Madagascan grandidierites. The Cuvier Island grandidierite has crystallized under conditions of the K-feldspar–cordierite hornfels facies at temperatures of approximately 600 °C. and pressures (P_{load}) of less than 300 bars.

THE magnesium aluminium borosilicate, grandidierite, has been previously recorded with certainty only from Madagascar (Lacroix, 1902) although possible occurrences have been noted in Hungary (Hlawatsch, 1918) and Natal (de Villiers, 1940).

During the course of a study of the petrology of the thermal aureole around a small diorite stock on Cuvier Island (36° 26′ S., 175° 46′ E.), New Zealand, a blue pleochroic mineral, later identified as grandidierite, was recorded at two localities (Black, 1967).

Occurrence. Grandidierite occurs at Blanket Bay in a hypersthene–cordierite–biotite–spessartine–andesine–pyrrhotine hornfels and in a hypersthene–biotite–andesine–orthoclase–quartz–rutile–magnetite hornfels at Landing Bay. Both localities are within 10 m of the contact with the pluton. Hydrothermal sprays of tourmaline occur in both hornfelses and in the Landing Bay locality the grandidierite hornfelses are cut by tourmaline-bearing pegmatites. However, grandidierite has not been found in the pegmatitic phases of the plutonics, nor in the intensely tourmalinized country rocks on the outer margins of the aureole and on textural evidence grandidierite appears to have crystallized in equilibrium with mineral associations typical of the K-feldspar–cordierite hornfels facies. The only other boron mineral recorded on Cuvier Island is axinite, which occurs in calcareous hornfelses (Black, 1967).

Description. The Cuvier grandidierite occurs as small subhedral crystals less than 0·1 mm in diameter and constituting less than 1 modal % of the hornfels. Because of the sparse occurrence of the grandidierite and the small size of the original hornfels specimens it was not possible to separate sufficient material for a conventional wet-chemical analysis. Mineral grains were hand picked from crushed rock samples and analysed with an Applied Research Laboratories E.M.X. electron microprobe using natural analysed tourmaline as a standard. The data were corrected for background, atomic number differences, and absorption. Since there is little chemical data available for grandidierite, two specimens of Madagascan grandidierite from the collections of the U.S. National Museum were also analysed using the same techniques and standards.

Analyses and physical data for the four grandidierite specimens are presented in table I. The analyses are similar to the analysis of grandidierite from Sakatelo, Madagascar, given by McKie (1965), but all are richer in boron than the original analysis for grandidierite listed by Lacroix (1922).

All the grandidierites examined showed moderate to strong dispersion ($r > v$), optical orientation $a \parallel \alpha$, $b \parallel \gamma$, $c \parallel \beta$, a good cleavage parallel to (100) and a poor cleavage parallel to (010). The magnesium-rich grandidierite from Vohliboly is weakly

TABLE I. *Chemical composition of grandidierite and contents of a quarter of the unit-cell calculated to* O = 9

	1	2	3	4		1	2	3	4
SiO_2	20·4	19·8	20·1	20·3	Si	1·03	0·99	1·00	0·99
TiO_2	0·05				Al	2·92	2·95	2·99	3·01
Al_2O_3	49·2	50·6	50·9	52·3	Fe^{2+}	0·28	0·19	0·21	0·04
FeO*	6·7	4·7	5·0	1·1	Mn	0·01			
MnO	0·3	0·05	0·1		Mg	0·79	0·88	0·87	1·02
MgO	10·5	12·0	11·6	14·0	Ca	0·01	0·02		0·01
CaO	0·2	0·3		0·1	B^{3+}	0·97	0·97	0·96	0·93
B_2O_3	11·2	11·3	11·2	10·9					
Total	98·55	98·75	98·9	98·7					

1. Blanket Bay, Cuvier Island (10181)† α 1·593, β 1·628, γ 1·633, $2V\alpha$ 25°, D 2·980 (±0·005).

2. Landing Bay, Cuvier Island (10194)† α 1·590, β 1·624, γ 1·628, $2V\alpha$ 28°, D 2·975 (±0·005).

3. Ampamatoa, Madagascar (U.S.N.M. 114135). α 1·590, β 1·626, γ 1·629, $2V\alpha$ 30°, D 2·973 (±0·005).

4. Vohiboly, Madagascar (U.S.N.M. 121887). α 1·587, β 1·618, γ 1·622, $2V\alpha$ 32°, D 2·930 (±0·005).

* Total iron calculated as FeO.

† Specimen numbers refer to the collections of the Department of Geology, Auckland University.

pleochroic with α pale blue, β colourless, γ very pale blue. The three relatively iron-rich specimens are more strongly pleochroic with α blue, β colourless, γ blue-green. The data listed in table I show that substitution of Fe for Mg is accompanied by an increase in density and refractive indices as well as by the appearance of green colours into the pleochroic scheme.

Zero, first, and second layer *a*- and *c*-axis Weissenberg photographs were taken of the Landing Bay, Cuvier Island, grandidierite. Inspection of the photographs showed symmetry consistent with the space group *Pbnm* reported by Stephenson and Moore (1968). Unit-cell dimensions obtained from the single crystal photographs were: *a* 10·36, *b* 10·94, *c* 5·75 Å (estimated errors ±0·02 Å).

Paragenesis. None of the previous records of grandidierite have yielded clear evidence of its paragenesis.

McKie (1965) suggested that grandidierite could have crystallized from a boron-

enriched contaminated magma. However, the Cuvier grandidierite is clearly not a magmatic mineral and it has apparently crystallized under the same physical conditions as the associated hornfelses.

It is uncertain whether or not the occurrence of grandidierite is related to boron metasomatism. Boron metasomatism has occurred on Cuvier Island as is evidenced by intense localized tourmalinization of country rocks but the tourmalinization is related to a late hydrothermal phase of the plutonism and did not take place at the same time as the crystallization of the high-temperature hornfelses. Grandidierite is not abundant and it could have crystallized from boron-rich aluminous sediments prior to the boron metasomatism.

Stratigraphic evidence (Black, 1967) indicates that the pluton and hornfelses crystallized less than 1 km from the surface, i.e. at load pressures of less than 300 bars, and the association of grandidierite with assemblages of the K-feldspar–cordierite hornfelses indicates temperatures of crystallization of at least 600 °C.

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