NOTES AND NEWS

THE CHEMICAL COMPOSITION OF GARNET ASSOCIATED WITH CORDIERITE

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An analysis of euhedral wine-red crystals of a garnet which occurs north of Great Slave Lake, indicates a close chemical control over mineral associations. The garnet occurs as crystals and crystal aggregates with a maximum diameter of 4 inches, in an injection and assimilation gneiss. The associated minerals are cordierite (of gem quality (1)), sillimanite, green spinel, graphite, biotite, quartz, microcline, andesine, and tourmaline.

TABLE 1. ANALYSIS OF GARNET FROM GREAT SLAVE LAKE, N.W.T., CANADA*

SiO_2	37.53		
Al_2O_3	22.42		
Fe_2O_3	0.74		
FeO	32.53	Molecular Composition	
MgO	5.74	Almandite	74.0
CaO	0.16	Pyrope	24.0
H_2O+	0.10	Grossularite	0.5
H_2O-	0.00	Spessartite	1.5
TiO_2	0.03		
MnO	0.66		
	99.91		

* Analysis by the writer in the rock analysis laboratory at the University of Minnesota, under the supervision of Dr. R. B. Ellestad.

Wright (2) has indicated that almandite is the dominant molecule in garnets from biotite schists. Where the three minerals garnet, biotite, and cordierite are associated (a not unusual case) the range in composition of the garnets entering into such an association is limited. These garnets range from 71–78% almandite, from 15–25% pyrope, an average (closely approached by 4 out of the 5 examples) of 2% spessartite, and less than 5% grossularite. (Table 2).

Figure 1 indicates that all garnets within this range of composition are associated with biotite and cordierite, and conversely, that all garnets associated with biotite and cordierite are of this composition.

Within the limited range indicated in Fig. 1 we have the three minerals, garnet, cordierite, and biotite in stable association. These minerals belong

TABLE 2. GARNET FROM CORDIERITE—BIOTITE SCHISTS AND GNEISSES*

	1	2	3	4	5
Almandite	78.3	74.6	71.4	73.4	74.0
Pyrope	14.7	20.3	25.2	17.1	24.0
Spessartite	2.2	2.3	1.6	4.9	1.5
Grossularite	3.8	2.8	1.8	4.6	0.5
Andradite	1.0				

1. Cordierite hornfels, *Centralb. Mineral.*, 356 **(1924).**
2. Cordierite schist, *Neues Jahrb. Mineral., Beil. Band* **34,** 136 (1912).
3. Idem 2.
4. Graphite cordierite schist, *Neues Jahrb. Mineral., Referate* 2, 39 **(1922).**
5. Garnet—cordierite—sillimanite—biotite gneiss, Great Slave Lake (this paper).

* The data for Table 2 and Figure 1 were obtained from Wright's paper, (2) pp. 439, 440, 447; with the addition only of the analysis in Table 1.

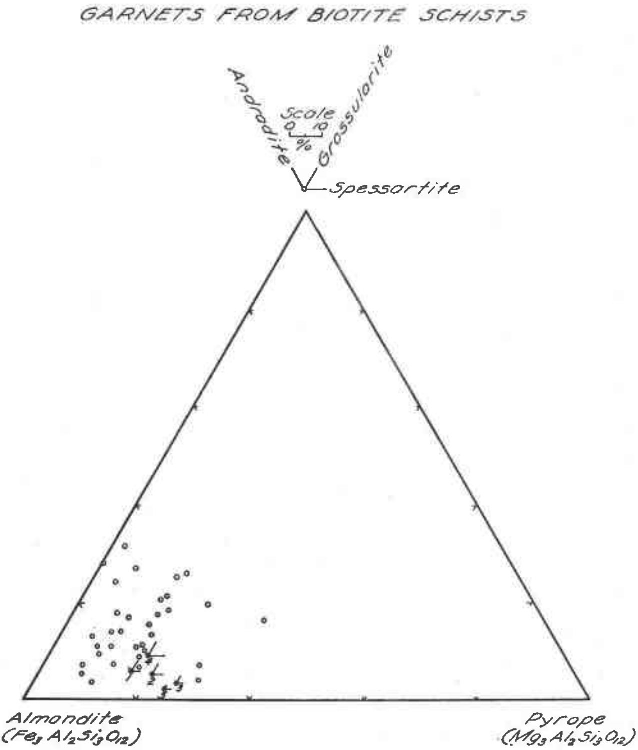

FIG. 1. The limited range in composition of garnets associated with cordierite (Nos. 1–5).

to the ferro-magnesian group in which the Fe-Mg ratio constitutes the chief chemical variable.

For one particular composition of garnet (Number 5, Table 2) the composition of the associated minerals is as follows:

TABLE 3

Garnet	24.0% $Mg_3Al_2Si_3O_{12}$	74.0% $Fe_3Al_2Si_3O_{12}$†
Biotite	39.9% $KMg_3Al\ Si_3O_{10}(OH)_2$	60.1% $KFe_3Al\ Si_3O_{10}(OH_2)$*
Cordierite (3)	61.0% $Mg_2Al_4Si_5O_{18}$	39.0% $Fe_2Al_4Si_5O_{18}$†

* Optical analysis (4).
† Chemical analysis.

An examination of Fig. 1 and Table 3, reveals a logical explanation for the limited range in garnet composition over which garnet, cordierite and biotite are associated. An increase in the vertical component in Fig. 1, (brought about, for example, by an increase in the amount of calcium available in the original sediment) would be marked by the appearance of a grossularite garnet. Cordierite, however, can not accommodate calcium in its structure, and would not be stable in a calcium-rich sediment. For this reason, garnets associated with cordierite are predominantly a mixture of almandite and pyrope.

Cordierite is far more stable in magnesia-rich than in iron-rich schists. It tends to incorporate into its structure a higher percentage of the available magnesium than the associated minerals, as indicated in Table 3. Of the 14 complete cordierite analyses available in the literature, 12 of them have less than 44% of the $Fe_2Al_4Si_5O_{18}$ molecule. A slight increase in the ratio of iron to magnesium, say enough to produce an almandite garnet with less than 12% pyrope, would tend to force the amount of the iron molecule in the cordierite past the stable range. Therefore, garnets associated with cordierite must be moderately magnesia-rich.

As a result of this study a three fold suggestion may be advanced:

(a) Garnet, biotite, and cordierite are associated in thermally metamorphosed sediments only when the composition of the garnet lies within a small range.

(b) If, by chemical or optical methods (5, 6), a garnet is determined to lie within this range, there is a strong possibility that cordierite is associated with the garnet. This is important since the diagnostic mineral cordierite is difficult to recognize in thin section or in the field, and must be specifically searched for.

(c) The association of garnet and cordierite gives us a clue as to the composition of the original sediment. It must have been low in calcium, rich in iron and magnesium (7).

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