NOTES ON PETROGRAPHY AND ROCK-FORMING MINERALOGY (5) REVERSE-ZONED GARNET IN SANBAGAWA PELITIC SCHISTS IN CENTRAL SHIKOKU, JAPAN

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INTRODUCTION

Zoned garnets are common in the Sanbagawa schists. They mostly show normal zoning, in which the MnO content decreases from the core to the rim. However, zoned garnets, which have minimum MnO content near the rim, do also occur, though not very commonly. Detailed description of this type of garnets, or reverse-zoned garnets, will be given below, along with the discussion on their genesis.

PETROGRAPHY

The reverse-zoned garnets are found in two pelitic schists collected from the outcrops near the biotite isograd of Higashino (1975) in the Asemi valley of the Shiragayama area in central Shikoku. Their mineral assemblages are graphite+phengite+chlorite+garnet+epidote+albite+quartz. The garnets are porphyroblasts, measuring 0.40 mm (No. 92) and 0.32 mm (No. 89) across at maximum and dispersed in the thin sections, in which the grain size of quartz is $0.31 \times 0.31 \text{ mm}^2$ (No. 92) and $0.13 \times 0.29 \text{ mm}^2$ (No. 89) in average. Albite forms porphyroblasts, measuring $1.6 \times 1.3 \text{ mm}^2$ (No. 92) and $1.6 \times 1.4 \text{ mm}^2$ (No. 89)

in average. The garnets in both specimens are euhedral, as shown in Fig. 1. The major differences of two samples lie in the TiO_2 -minerals. In specimen No. 92, ilmenite-rutile composite grain surrounded by sphene is common, but in the other, No. 89, incipient replacement of ilmenite by rutile is recognized, and the composite grains are not surrounded by sphene.

Fig. 1 Typical euhedral reverse-zoned garnet in Sample No. 92

Typical zoning patterns of the garnets are shown in Fig. 2. Garnets in both samples have distinct minimum of the MnO content near the rim, as seen in the figure. Fig. 2 also shows that, although the garnets in specimen No. 89 shows a simple reverse zoning near the rim, a garnet in sample No.

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92 shows an oscillatory zoning near the rim. Garnets which do not have distinct minimum of the MnO content near the rim also occur in these samples. Even in the same single garnet grain, the minimum of the MnO content appear along some radial traverses, but not along others. The zoning pattern for the FeO content is the opposite to that for the MnO content (Fig. 2). The profiles for Ca and Mg are similar to the general profiles observed in the normally zoned garnet of the present area. The rim of the

garnets in these samples has significantly different chemical compositions at various parts of one grain as well as among the grains in one thin section. The compositional profiles of garnets shown in Fig. 2 is an example of such heterogeneous zoning. Table 1 shows the representative values of the MnO and FeO contents and MnO/FeO ratios of three garnets from each of these samples.

The MnO/FeO wt. ratios of the rim of normally zoned garnets in equilibrium with other major silicate minerals during progressive metamorphism of the present area decrease gradually with increasing of metamorphic temperature as shown in Fig. 3, in which MnO/FeO wt. ratios for the reverse-zoned garnets in both samples also are plotted. The ratio near the biotite isograd is about 0.08–0.09. It is seen in the figure that the ratio at the rim (a part with maximum of the MnO content near the rim for No. 92) of reverse-zoned garnets is closer to trend observed for the rim of normally zoned garnets than that at the part with minimum of the MnO content. Mn-Fe partition coefficient between euhedral coarse-grained ilmenite and the rim of normally zoned garnet is 1.5 ± 0.5 in the present area (Itaya and Banno, in prep.). Ilmenite in these two samples often occurs forming the composite grains with rutile or

Fig. 2 Typical zoning pattern of reverse-zoned garnets

Table 1 Representative values of MnO and FeO contents, and MnO/FeO wt. ratios of the reverse-zoned garnet and ilmenite

Sample No.	grain	garnet						ilmenite	
		a		b		c		a	b
		rim	min.Mn	rim	min.Mn	rim	min.Mn		
89	MnO	1.84	1.07	1.44	1.01	2.61	1.09	5.91	5.61
	FeO	27.74	31.86	29.21	30.25	29.66	29.69	38.27	38.44
	MnO/FeO	0.066	0.034	0.049	0.033	0.088	0.037	0.154	0.146
92	MnO	2.50	0.83	1.95	1.09	1.56	0.72		
	FeO	30.07	31.53	30.01	32.27	30.06	31.92		
	MnO/FeO	0.083	0.026	0.065	0.034	0.052	0.023

Fig. 3 MnO/FeO wt. ratios of the rim of normally, abnormally and reverse-zoned garnets plotted on a line parallel to the Asemi valley

sphene, or both, in specimen No. 89, however, ilmenite which is rarely replaced by rutile and sphene also occur. Between this type of ilmenite and the Mn-richest rim of the reverse-zoned garnets, $(\text{MnO}/\text{FeO})^{\text{il}}/(\text{MnO}/\text{FeO})^{\text{ga}}$ ratio is 1.8, the value similar to the partition coefficient for Mn-Fe between ilmenite and garnet examined by Itaya and Banno. As the chemical compositions of the rim of the reverse-zoned garnets vary in one grain as well as among the grains in one thin section, the rim may have not been in chemical equilibrium with other major silicate minerals. From the facts mentioned above, however, the Mn-richest rim of the reverse-zoned garnets in sample No. 89 is considered to have the chemical composition similar to that of the garnet in chemical equilibrium with other major silicates during the Sanbagawa metamorphism.

DISCUSSION

De Béthune et al. (1975) confirmed that, when chlorite replaced garnet, the excess Mn ion diffuses in the garnet. However, as most of the reverse-zoned garnets of the present area are euhedral (Fig. 1), the chloritization-resorption process of de Béthune et al. cannot directly be applied to their genesis. Ilmenite of the present area is manganoan, and often is replaced by

rutile or sphene, or both, and most of ilmenite in specimen No. 92 are replaced by sphene and rutile. If excess Mn liberated by decomposition of ilmenite diffuse toward the core of the garnet, the garnet will show reverse zoning in which MnO content simply decreases toward the core from the rim. However, the garnet in sample No. 92 shows oscillatory zoning in regard to MnO near the rim (Fig. 2). Thus, the material exchange induced by the decomposition of ilmenite can hardly be a major factor. The genesis of reverse-zoned garnet in surface equilibrium process proposed by Banno and Chii (1976) requires the temperature decrease and limited diffusion in associated layer-silicate, and hence can not directly applied to this case, too. Thus, no probable mechanism of the formation of reverse-zoned garnets described here can be proposed, but it still is important to recognize that not all of the garnets in the Sanbagawa pelitic schists is simply normally zoned as hitherto considered (cf. Banno and Kurata, 1972; Higashino, 1975).

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四国中央部三波川泥質片岩中の逆累帯ザクロ石

板谷 徹丸

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