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Three types of garnets from the metamorphic xenoliths within the Takatsukiyama granitic mass in the Shimanto belt, southwest Japan

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Abstract

The Takatsukiyama granitic mass, intruded into the Cretaceous Shimanto belt, is a typical S-type granitic intrusion of middle Miocene age, and contains several types of xenoliths of regional metamorphic roks such as blastomylonite, blastomylonitic gneiss, gneiss and migmatitic gneiss. These metamorphic rocks often contain garnets, which are classified into three types, i.e., types A, B and C. Type A garnet shows a normal zoning and occurs only in blastomylonite. Type B garnet has no distinct chemical zoning occurring in blastomylonite, blastomylonitic gneiss and gneiss. Type C garnet shows a distinct reverse zoning and it occurs in migmatitic gneiss. Elemental color map (CMP) technique of EPMA well reveals the chemical zoning of the garnets.

Key wards: garnet, chemical zoning, metamorphic xenolith, Shimanto, Takatsukiyama granite

I. Introduction

The Takatsukiyama granitic mass, which was intruded into the Northern zone (Cretaceous) of the Shimanto belt, western Shikoku (Fig. 1), is a typical S-type granitic intrusion of middle Miocene age (Shibata and Nozawa, 1967; Takahashi et al., 1980). Several kinds of igneous and metamorphic xenoliths have been described from this granitic mass (Teraoka et al., 1986; Watanabe and Sato, 1988; Komatsu et al., 1991; Ishikawa and Kagami, 1992). Regional metamorphic xenoliths are classified into four types, i.e., blastomylonitic gneiss, gneiss and migmatitic gneiss (Ishikawa et al., 1992; Ishikawa and Kagami, 1992). We describe the chemical composition and zoning of garnets within these metamorphic xenoliths in this paper.

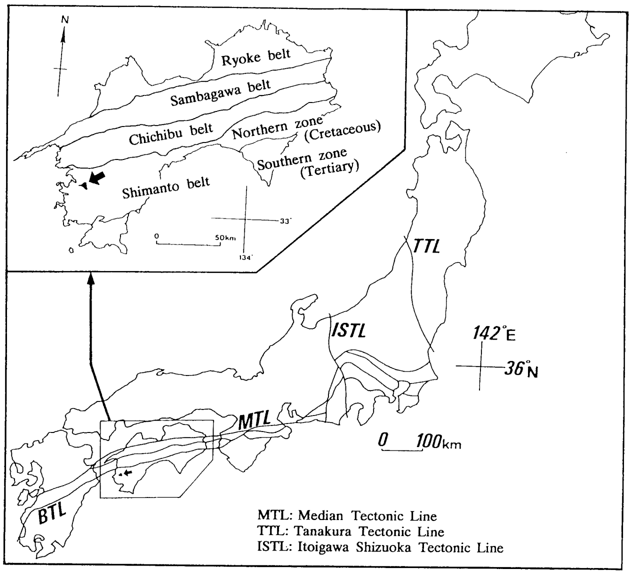

Fig. 1. Location of the Takatsukiyama granitic mass (arrow) in western Shikoku, southwest Japan

II. Variety of garnets in metamorphic xenoliths

Garnets in metamorphic xenoliths are divided into three types, type A, type B and type C based on chemical zoning (Fig.2). Type A shows a remarkable normal zoning with increase in Mg and decrease in Mn from core to rim. It occurs only in blastomylonite (solid and open circles in Fig. 2). Type B usually has no notable chemical zoning and it occurs in blastomylonite, blastomylonitic gneiss and gneiss (open square). Type C shows a distinct reverse zoning with Fe increasing and Mg decreasing from core to rim. This type occurs in migmatitic

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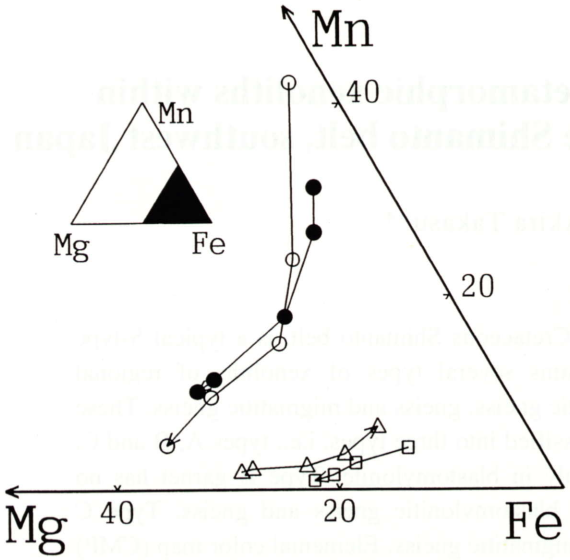

Fig. 2. Chemical composition of the zoned garnets (types A–C) within metamorphic rock xenoliths. Arrow shows a chemical zoning from core to rim. solid and open circles: type A garnets from blastomylonites; open square: type B garnet from gneiss; open triangle: type C garnet from migmatitic gneiss.

gneiss open triangle in Fig. 2).

Chemical zoning of garnets in regional metamorphic xenoliths has been shown using an elemental color mapping (CMP) technique. The color map analyses have been made on a JEOL JXA-8800M electron probe microanalyzer of the Research Center for Coastal Lagoon Environments, Shimane University, under the following analytical conditions: accelerating voltage 15 kV; probe current 4.1-5.8$\times 10^{-8}$A; dwell time 45-55 msec.; no. of pixels 830$\times$830 (Figs. 3, 4-1 and 4-2), 675$\times$675 (Figs. 4-3 and 4-4); pixel size (μm) 2$\times$2 (Fig. 3), 4$\times$4 (Fig. 4-1), 2.5$\times$2.5 (Fig. 4-2), 2.9$\times$2.9 (Figs. 4-3 and 4-4), The relative concentration of each element is represented in terms of color (see color bar).

Figs. 3 and 4-1 show chemical zoning of type A garnets from blastomylonites, with distinct normal zoning where MnO decreases and MgO increases from core to rim (pyrope content varies from 3.1 to 29.3 and from 5.2 to 24.9 mol percent, and spessartine content varies from 33.9 to 4.0 and from

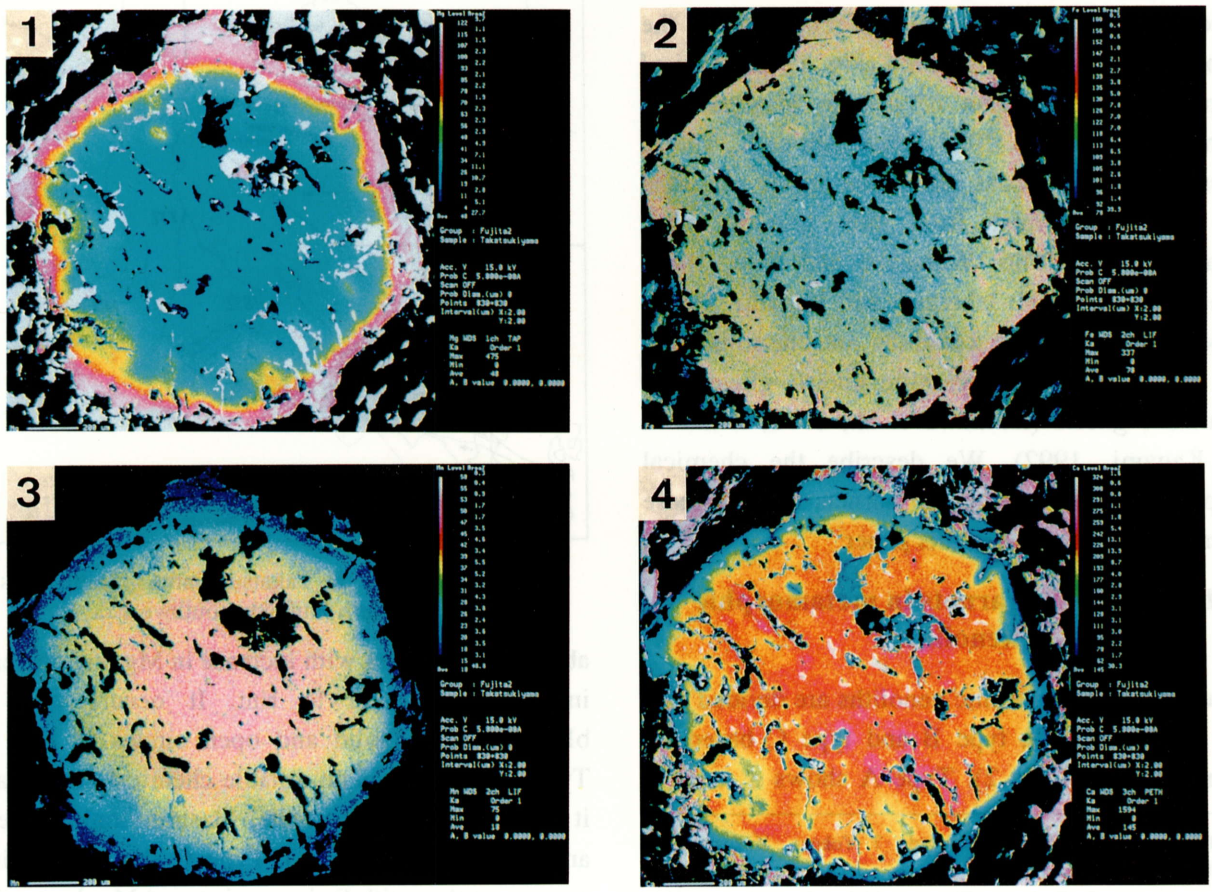

Fig. 3. Color maps of element distribution (CMP) within type A garnet. 1: Mg. Scale bar shows 200μm; 2: Fe; 3: Mn; 4: Ca.

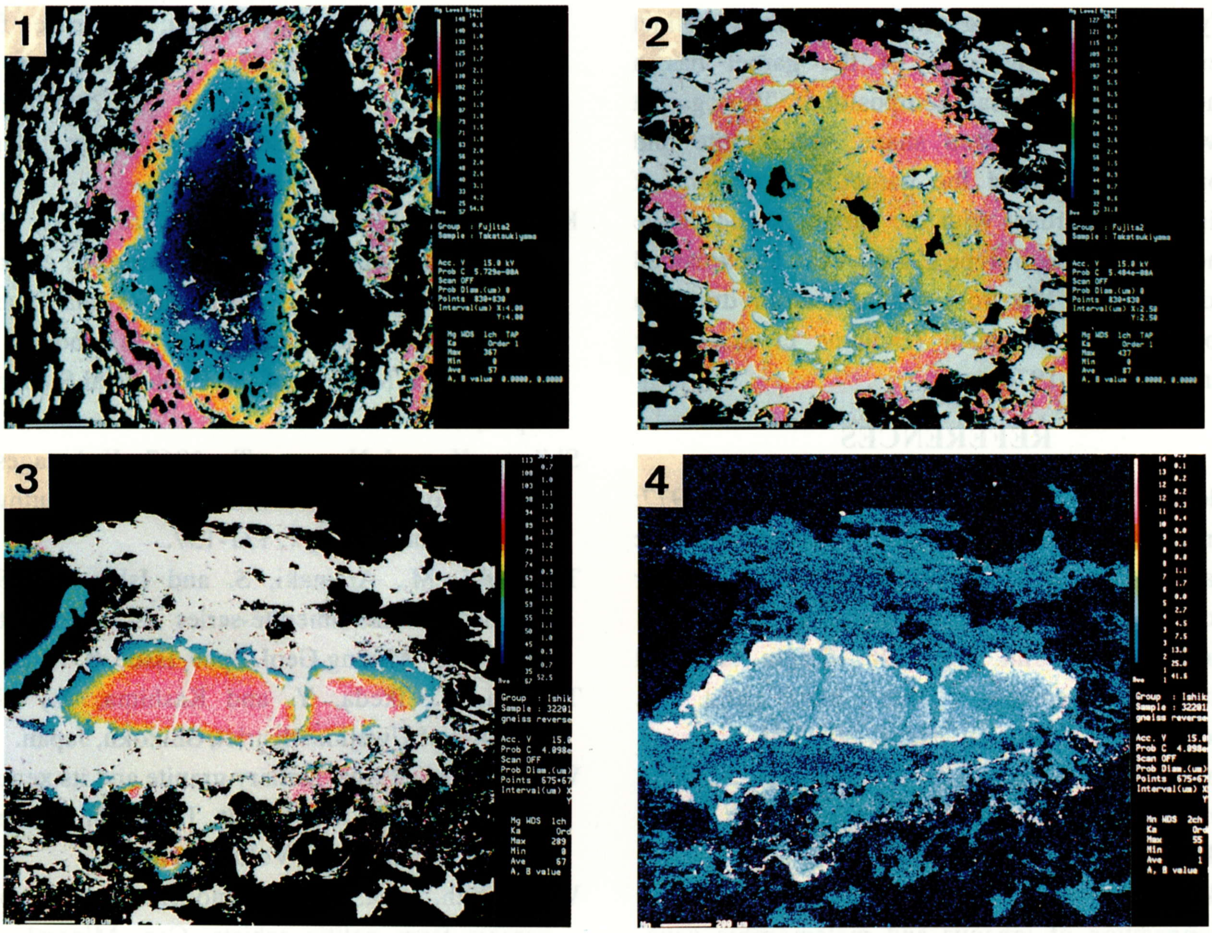

Fig. 4. Color mape of element distribution (CMP) within types A, B and C gaenets. 1: color map of Mg distribution within type A garnet. Scale bar shows 500μm. 2: color map of Mg distribution in type B garnet. Scale bar shows 500μm. 3: color map of Mg distribution in type C garnet. Scale bar shows 200μm. 4: color map of Mn distribution in type C garnet.

24.1 to 9.2 mol percent). Fig. 3 shows a euhedral garnet with chemical zoning concordant with the outline of the garnet. Fig. 4-1 indicates a spindle-shape garnet, and the pattern of chemical zoning is similar to a half of the euhedral garnet of Fig. 3. Fig. 4-2 indicates chemical composition of type B garnet in gneiss. It also shows normal chemical zoning, but is not distinct as compared with Fig. 3 (the core part; Py: 10.4 mol percent, Sp: 3.7 mol percent and the rim part; Py: 19.6 mol percent, Sp: 0.8 mol percent). Figs. 4-3 and 4-4 shows chemical zoning of type C garnet from migmatitic gneiss. It shows a distinct reverse zoning in the rim, with MnO and FeO increasing, and MgO decreasing from interior to rim (Py: from 27.0 to 12.9 mol percent, Sp: from 1.9 to 6.4 mol percent). The zoning pattern of this garnet is concordant with the outline of the garnet.

III. Origin of garnet zoning

Type A garnet in blastomylonite shows distinct normal zoning, and is considered to have formed during prograde metamorphism. As blastomylonite retained a mylonitic texture, this suggests that deformation events occurred before enclosure by granite (Ishikawa et al., 1992). The garnet of Fig. 4-1 first grew euhedrally during prograde metamorphism, and after that this garnet was broken in separate during deformation.

Type B garnets is blastomylonitic gneiss and gneiss also have normal zoning, but a concentric zoning pattern is not clear in compared with type A garnet, probably because of element diffusion and homogenization during high temperature metamorphism (Anderson and Olimpio, 1977; Woodworth, 011977; Yardley, 1977).

Type C garnets in migmatitic gneiss show distinct reverse zoning. The core of the garnet has a homogeneous chemical composition. This garnet shows anhedral resolved shape, and biotite and chlorite occur around the garnet. The pattern of zoning is concordant with the surface shape of the garnet. The zoning of type C garnet can be explained by diffusion of Mn from rim to interior during a retrograde metamorphism (Béthune et al., 1975; Banno and Chii, 1976).

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（要　旨）

石川　玲・高須　晃，1994，四国四万十帯高月山花崗岩体中の変成岩ゼノリスにみられる3種のざくろ石．島根大学地質学研究報告，13，9－12．

高月山花崗岩体は，四国西部の四万十帯（白亜系）に中期中新世に貫入した典型的なSタイプ花崗岩体である．高月山花崗岩体は多数のゼノリスを包有するが，そのうち広域変成岩ゼノリスはブラストマイロナイト，ブラストマイロナイト質片麻岩，片麻岩およびミグマタイト質片麻岩に区分できる．これらの変成岩は多くの場合ざくろ石を含んでいる．ざくろ石は累帯構造の特徴よりA，B，Cの3タイプに区分できる．タイプAは正累帯構造を示し，ブラストマイロナイトのみに出現する．タイプBは顕著な累帯構造を示さないもので，ブラストマイロナイト，ブラストマイロナイト質片麻岩，片麻岩中に産する．タイプCは逆累帯構造を示し，ミグマタイト質片麻岩に出現する．これら3つのタイプの累帯構造をX線マイクロアナライザーの元素カラーマップ（CMP）の手法により観察し，記載した．