島根大学地球資源環境学研究報告　22, 167～172 ページ（2003 年 12 月）
Geoscience Rept. Shimane Univ., 22, p.167～172（2003）

Article

Zoned amphibole in an eclogite from the Hida Marginal belt in the Hakuba district, Nagano Prefecture, Japan

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Abstract

A cobble-sized clast of eclogite was recently found in gravels in the bed of the Matsukawa River at Wadano in Hakuba village, Nagano Prefecture. The cobble was probably derived from an area in the Hida Marginal belt, which consists of high-pressure type schists and closely associated serpentinites, and also includes blocks of garnet glaucophane schist and garnet-epidote-glaucophane schist.

The eclogite cobble consists mainly of garnet, omphacite, epidote and amphibole, along with small amounts of quartz, albite, chlorite, phengite, apatite, rutile, titanite and pumpellyite. Amphibole occurs as abundant subhedral prismatic crystals showing distinct zoning, with bluish cores and greenish rims. The cores of such amphiboles often have resorption texture, and are overgrown by green amphibole at their rims. The boundaries between the cores and rims are sharp and abrupt. The cores of the prismatic amphibole are chemically classified as glaucophane, whereas the rims are divided into two parts; inner rims consisting of barroisite, and outer rims of actinolite.

The eclogite described in this paper shows a typical clockwise P-T path of metamorphism, which is composed of a prograde path from the glaucophane schist facies to form eclogite, and a retrograde path from eclogite through the epidote amphibolite to the greenschist facies.

Key word: eclogite, glaucophane, barroisite, actinolite, chemical zoning, metamorphic P-T path

Introduction

The Hida Marginal belt (Renge belt, Nishimura, 1998; Fig. 1) comprises a Paleozoic complex containing high-P/T metamorphic rocks and serpentinites, and is unconformably overlain by the Upper Jurassic Kuruma Group. Eclogite and eclogitic rock have been found as clasts in gravels derived from the Hida Marginal belt (Figs. 2 and 3), i.e. at Yunoirizawa in the Hakuba district (Komatsu and Yamazaki, 1981; Nakamizu et al., 1989) and at Yunotani in the Omi district (Tsujimori et al., 2000a, b). Takasu et al. (2003) recently found another eclogite cobble, probably derived from the serpentinite body exposed in the Hakuba district.

The eclogite cobble consists mainly of garnet, omphacite, epidote and amphibole. According to its petrographic characteristics, the eclogite formed from a glaucophane schist facies-assemblage, and subsequently retrograded into the greenschist facies, probably through the epidote amphibolite facies. The amphibole in the eclogite shows a distinct zonal structure, with bluish cores and bluish-green and greenish rims.

In this paper we describe the texture and chemistry of the distinctly zoned amphibole in the eclogite, and discuss the metamorphic P-T path of the specimen.

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Locality and geologic background of the eclogite sample

A cobble-sized clast of the eclogite was found in the bed of the Matsukawa River at Wadano in Hakuba village, Nagano Prefecture (Takasu et al., 2003; Fig. 3). The site of the eclogite discovery is located in the lower course of the Yunoirizawa stream where Komatsu and Yamazaki (1981) first discovered an eclogite block within the Hida Marginal Belt. The eclogite cobble was probably derived from the areas of fine-grained and coarse-grained schists (Nakamizu et al., 1989; Nakano et al., 2002) that are closely associated with the Happo-one serpentinite body in the Hida Marginal belt. The fine-grained schists consist mainly of pelitic and basic schists of the pumpellyite-actinolite facies. The coarse -grained schists consist of garnet-muscovite schists, epidote-glaucophane schists, barroisite schists and garnet amphibolite. Small blocks of garnet-glaucophane schists and garnet-epidote-glaucophane schists also occur within the serpentinite body itself (Nakamizu et al., 1989).

Petrographic description of eclogite and zoned amphibole

The eclogite consists mainly of garnet, omphacite, epidote, and amphibole with small amounts of quartz, albite, chlorite, phengite, apatite, rutile, titanite and pumpellyite (Fig. 4). Garnet occurs as subhedral porphyroblasts up to 6 mm in diameter. Amphibole and epidote show a preferred orientation defining a stretching lineation. Garnet is partly replaced by chlorite along cracks, and the cracks are filled by albite veins. Omphacite is

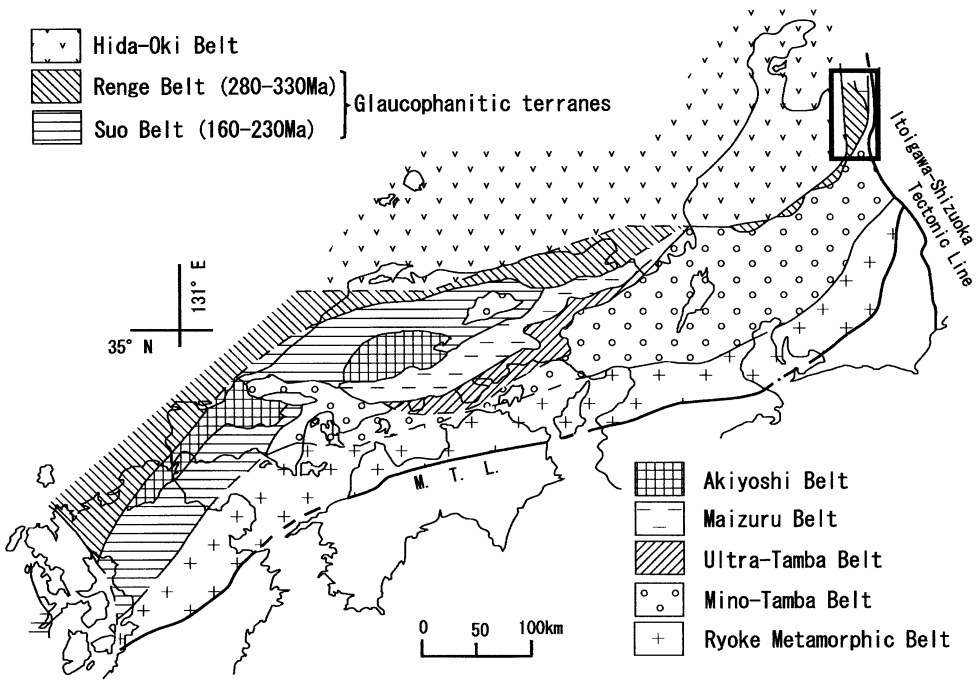

Fig. 1. Geotectonic division of the Inner Zone of southwest Japan (Nishimura, 1998). The eastern end of the Renge belt (the area of the rectangle) is shown in Fig. 2. M.T.L.: Median Tectonic Line.

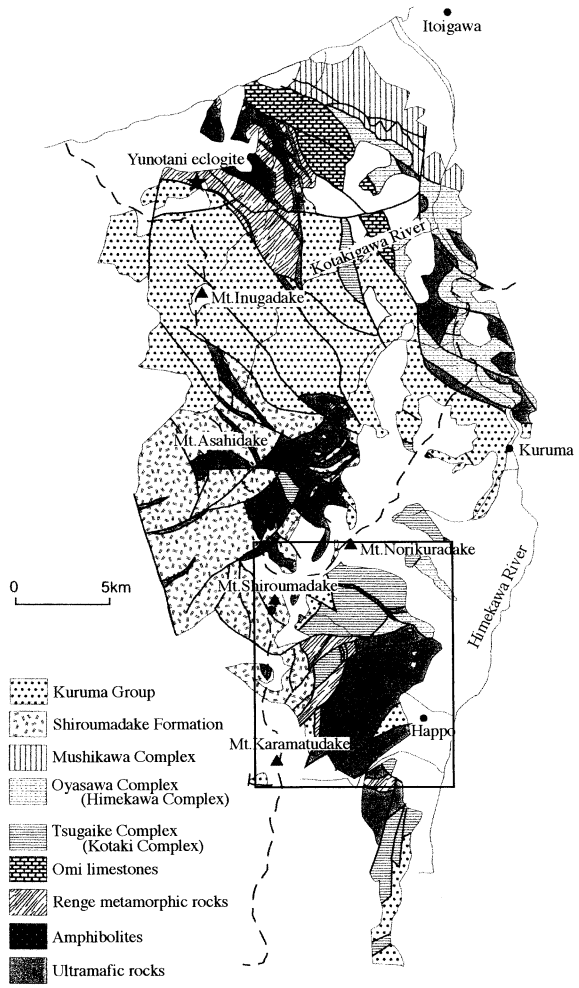

Fig. 2. Geologic map of the easternmost area of the Renge belt (Nakano et al., 2002)

Table 1. Representative chemical compositions of the zoned prismatic amphibole in the eclogite.

No.	1	2	3	4	5	6
Analytical	4	36	38	39	43	44
SiO_2	56.80	57.28	50.93	50.47	53.68	53.51
TiO_2	0.17	0.00	0.09	0.10	0.03	0.00
Al_2O_3	10.34	11.45	8.28	7.78	2.02	2.25
Fe_2O_3	2.41	1.95	3.00	3.51	2.12	2.43
FeO	10.04	9.63	11.67	11.12	13.66	13.62
MnO	0.11	0.04	0.16	0.24	0.39	0.42
MgO	9.71	9.53	11.86	12.35	13.74	13.47
CaO	1.78	1.07	8.90	9.33	11.65	11.43
Na_2O	6.54	6.95	2.73	2.86	0.90	1.01
K_2O	0.07	0.05	0.76	0.29	0.10	0.13
Cr_2O_3	0.00	0.03	0.01	0.03	0.04	0.03
Total	97.97	97.98	98.39	98.08	98.33	98.30
Cation numbers per 23 oxygens						
Si	7.865	7.877	7.310	7.269	7.762	7.745
Ti	0.018	0.000	0.009	0.011	0.003	0.000
Al	1.687	1.856	1.400	1.320	0.345	0.384
Fe^{3+}	0.251	0.201	0.324	0.381	0.231	0.265
Fe^{2+}	1.162	1.107	1.401	1.339	1.652	1.648
Mn	0.013	0.005	0.019	0.029	0.047	0.051
Mg	2.004	1.954	2.538	2.652	2.961	2.907
Ca	0.263	0.158	1.368	1.439	1.804	1.772
Na	1.755	1.853	0.760	0.800	0.253	0.284
K	0.013	0.009	0.138	0.053	0.018	0.024
Cr	0.000	0.003	0.001	0.003	0.005	0.003
Total	15.031	15.023	15.268	15.296	15.081	15.083

The ferric iron contents in the amphiboles were calculated using the method (13 eCNK) of Leake et al. (1997).

1, 2: bluish core of prismatic amphibole (glaucophane); 3, 4: intermediate amphibole (barroisite); 5, 6: greenish rim (actinolite).

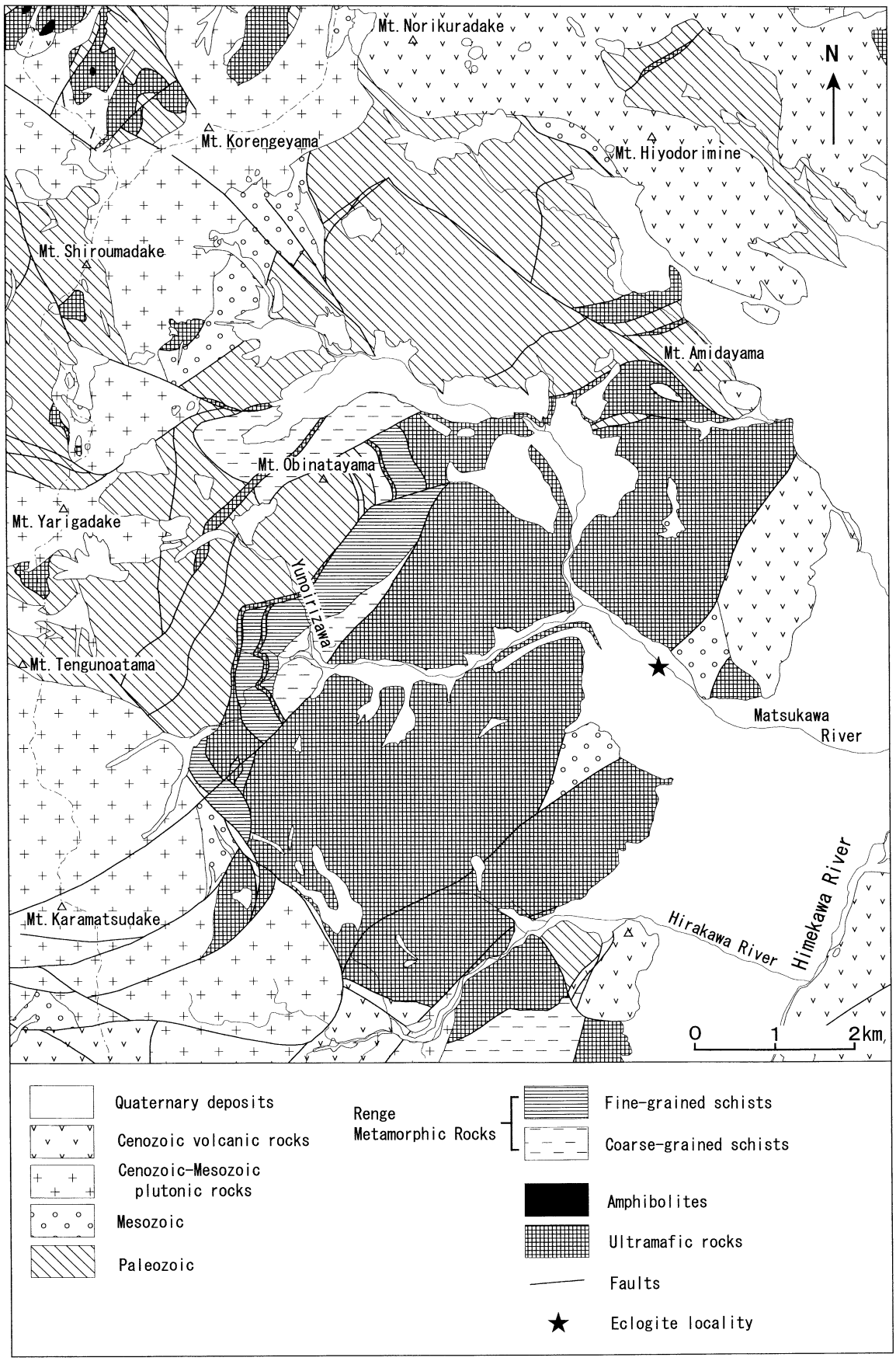

Fig. 3. Geologic map of the Hakuba district (Nakano et al., 2002). Eclogite was first discovered at Yunoirizawa by Komatsu and Yamazaki (1981). The eclogite described in this study was collected at the locality shown by the star.

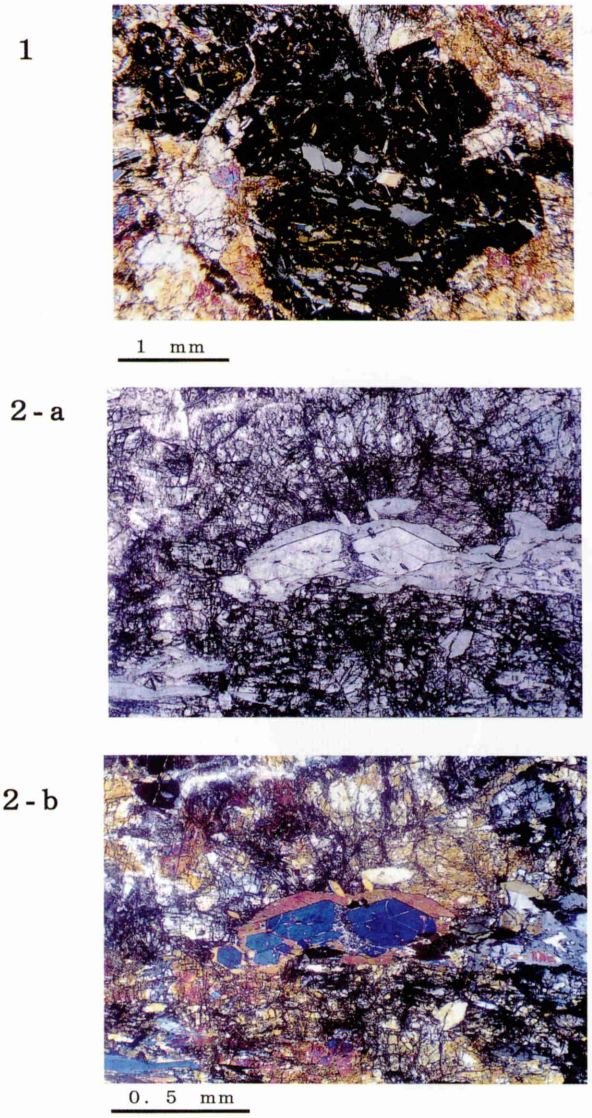

Fig. 4. Photomicrographs of the eclogite and its constituent minerals. 1.: Texture of the eclogite. 2.: zoned prismatic amphibole with bluish core (glaucophane) and greenish rim (barroisite and actinolite). 2-a: one nicol, 2-b: crossed nicols.

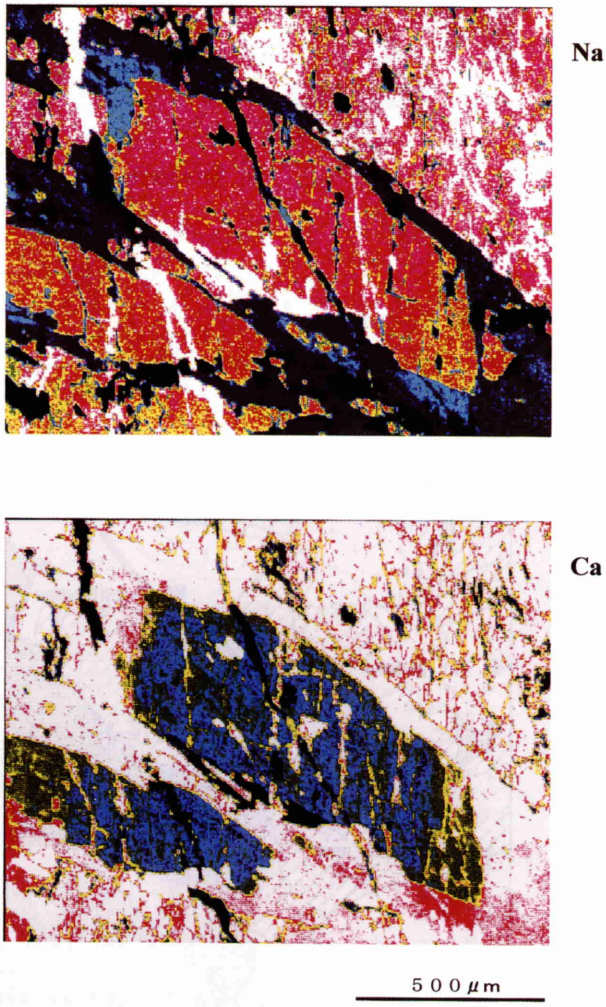

Fig. 5. Elemental color map photos (Na and Ca) of zoned prismatic amphibole in the eclogite. Barroisite (blue areas in the Na map) partly overgrows the glaucophane, and glaucophane and barroisite are fully rimmed by actinolite (black areas).

sometimes rimmed by albite and amphibole symplectite. A later stage albite vein up to 0.2 mm wide cross-cuts the preferred orientation of epidote and amphibole in the matrix.

Amphibole also occurs as abundant subhedral prismatic crystals which show distinct zoning, with blue cores and green rims. The boundaries between the cores and rims are sharp and abrupt. The cores sometimes show euhedral shapes, but in many cases cores exhibit resorption textures and are overgrown by green amphibole at their rims (Fig. 4).

Chemical composition of distinctly zoned amphibole in the eclogite

Chemical compositions of zoned prismatic amphiboles were determined by EPMA (JEOL JXA-8800M). The analyses were performed at an accelerating voltage of 15 kV, specimen current of 2×10^{-8} A, and using a probe diameter of 3-5 μm, following the correction method of Bence and Albee (1968). Elemental color maps were captured using 15 kV accelerating voltage, 7×10^{-8} A specimen current, 70 msec dwell time, and pixel size of 2 μm × 4 μm. Representative chemical compositions of the zoned prismatic amphibole are given in Table 1.

Subhedral prismatic amphiboles are optically zoned, with bluish cores and greenish rims. Examination of elemental color maps show that the cores are rich in Na and poor in Ca, whereas the rims are poor in Na and rich in Ca (Fig. 5). Boundaries between the cores and the rims show abrupt change in chemical composition. Zones of intermediate composition occur between the cores and the rims (Fig. 5). This intermediate amphibole partly overgrows the cores, but is in turn completely mantled by the rim.

The cores and the rims of the prismatic amphiboles are chemically classified as glaucophane and actinolite (Leake et al., 1997), respectively. The intermediate amphibole is classified as barroisite.

The chemical composition of the core of the prismatic amphibole shows high Na_B ranging from 1.73 to 1.90, and low Ca ranging from 0.10 to 0.28. Si and Mg/(Mg + Fe^{2+}) are 7.80-8.03 and 0.58-0.86, respectively. The intermediate amphibole, barroisite, has Na_B ranging from 0.51 to 0.63 and Ca ranging from 1.37 to 1.49. Si and Mg/(Mg + Fe^{2+}) are 7.22-7.32 and 0.64-0.68. K in barroisite ranges from 0.05 to 0.14, and it is slightly higher than K in glaucophane (0.00-0.01). The chemical composition of the rim of the amphibole, actinolite, shows low Na_B ranging from 0.19 to 0.37. Si and Mg/(Mg + Fe^{2+}) in actinolite are 7.56-7.76 and 0.58-0.68, respectively.

Metamorphic history of the eclogite deduced from the zoning of the amphibole

The mineral assemblage of the eclogite consists of omphacite, garnet, glaucophane, epidote, phengite, rutile and quartz, suggesting peak eclogite facies metamorphic conditions. According to the minerals included in porphyroblastic garnet, the eclogite crystallized through the glaucophane schist facies by a prograde metamorphism.

The glaucophane forming the cores of the zoned prismatic amphiboles was stable during prograde metamorphism from the glaucophane schist facies to the eclogite facies. The amphibole which first overgrows the resolved cores is chemically classified as barroisite. The core glaucophane and barroisite overgrowths are then totally rimmed by actinolite. Omphacite, a principal constituent of the eclogite stage, is partly replaced by symplectite consisting of albite and green amphibole. This amphibole is chemically classified as actinolite, and is similar in composition to the rims of the prismatic amphiboles. Therefore, the peak eclogite assemblage is retrograded into the greenschist facies via the epidote amphibolite facies.

The eclogite found in the Hakuba district shows a typical clockwise P-T path, comprising a prograde eclogite metamorphism from the glaucophane schist facies, and a retrograde metamorphism from the eclogite facies, through the epidote amphibolite facies, to the greenschist facies.

Acknowledgements

Our thanks to Drs. S. Iizumi, B. Roser and the members of the Geoscience Seminar of Shimane University for their variable suggestions and discussion on the chemistry of the zoned amphibole in this eclogite. This work was partly supported by a Grant-in Aid for Scientific Research from the Japan Society for the Promotion of Science (No. 11440150).

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(Received: Nov. 25, 2003, Accepted: Dec. 12, 2003)

（要　旨）

高須　晃・櫻井　剛・柏原由芙子・南出幸代，2003，長野県白馬村の飛騨外縁帯より発見されたエクロジャイト礫中の角閃石の累帯構造，島根大学地球資源環境学研究報告，22，167-172

長野県白馬村和田野の松川河床より大礫サイズのエクロジャイト礫が発見された．この礫は松川上流の飛騨外縁帯の高圧変成岩と蛇紋岩体の分布する地域に由来すると考えられる．

エクロジャイトはざくろ石，オンファス輝石，緑れん石および角閃石を主要構成鉱物とし，その他に石英，曹長石，緑泥石，フェンジャイト，りん灰石，ルチル，チタン石およびパンペリー石からなる．エクロジャイト中の角閃石は半自形の柱状結晶で，核部が青色，縁部が緑色の顕著な累帯構造を示す．角閃石の核部は融食の組織を示し，縁部の緑色角閃石が取り囲む．核部と縁部の境界は明瞭であり，漸移することなく急激に化学組成が変化する．

柱状角閃石の核部の組成は藍閃石であり，縁部は内側と外側に分かれ，内側はバロワ閃石であり，外側はアクチノ閃石である．

このエクロジャイトの変成作用は典型的な時計回りのP–T経路を示す．すなわち，累進変成期は藍閃石片岩相からエクロジャイトへの変成作用を受け，後退変成期はエクロジャイトから緑れん石角閃岩相を経て緑色片岩相に至ったと考えられる．