Illustrated Introduction to Eclogite in Japan

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Abstract Eight collections of various photographs of Japanese eclogite are illustrated with brief descriptions. This paper intends to introduce significant hand specimens and thin sections of eclogite from the Tonaru, Seba, Western Iratsu, Eastern Iratsu, Higashi-akaishi, Gazo and Kotsu masses in the Sambagawa metamorphic belt, and the Yunotani eclogite in the Renge metamorphic belt in Japan. This is a vivid sampling of current field-research for eclogite in Japan.

Key words: Sambagawa belt, Renge belt, eclogite, high-pressure matamorphism, SW Japan.

INTRODUCTION

Oceanic crust is constantly being consumed or subducted at convergent plate margins. One of the consequences of this subduction is the formation of eclogite. Eclogite is a very dense rock formed at high pressures by metamorphism of basaltic and gabbroic rocks. Because of its high density large amounts of the eclogite formed are expected never to return to the earth's surface. Locally, however, eclogite and associated high-pressure rocks are found in metamorphic belts formed in convergent margins and as xenoliths in kimberlitic volcanic rocks. Research on these unusual rocks can be used to study the large-scale material flow that brings them back to the earth's surface, to place constraints on recycling of material in the earth, and to characterize the state of subduction zones at depth.

The Japanese archipelago has been a site of active subduction since the Paleozoic and eclogite has been found in several areas in southwest Japan. Despite their formation in similar tectonic settings the eclogite in these areas shows considerable variation. This guide brings together the main types of eclogite facies rocks including both mafic and other types, that have been discovered in this area and to present their principal features in hand specimen and thin section. It is the first time for photographs of many of these rocks to be presented and the first time that this type of illustrated guide to eclogite in Japan has been produced.

ECLOGITE-BEARING METAMORPHIC BELTS IN SOUTHWESTERN JAPAN

The geology of southwestern Japan is characterized by a series of accretionary complexes that formed since Early Paleozoic (e.g. Isozaki, 1996). The geologic structure is characterized by subhorizontal nappes, where the older nappes usually occupy upper structural positions. These nappes were gently folded in Cretaceous time to form a synform-antiform structure. Several stages of exhumation of high-*P*/*T* metamorphic rocks can be recognized (Table 1), ca. 450−400Ma (Kitomyo-Fuko), 330−280Ma (Renge), 220−170Ma (Suo), 90−60Ma (Sambagawa). Eclogite occurs in the Cretaceous Sambagawa and Carboniferous Renge metamorphic belts (Fig. 1).

Sambagawa metamorphic belt

The Sambagawa belt, located on the southern side of Median Tectonic Line (M.T.L. in Fig. 1), is one of the best documented subduction-zone metamorphic complexes in the world (e.g. Banno and Sakai, 1989; Hara et al., 1990; Takasu et al., 1994; Wallis, 1998). The dominant rock types of the Sambagawa belt are intergradational pelitic and mafic schists with small amounts of quartz schist. Metamorphism of the Sambagawa belt is classified by Miyashiro (1973) as an intermediate high-pressure facies series and is generally non-eclogitic. However, several eclogite localities have also been

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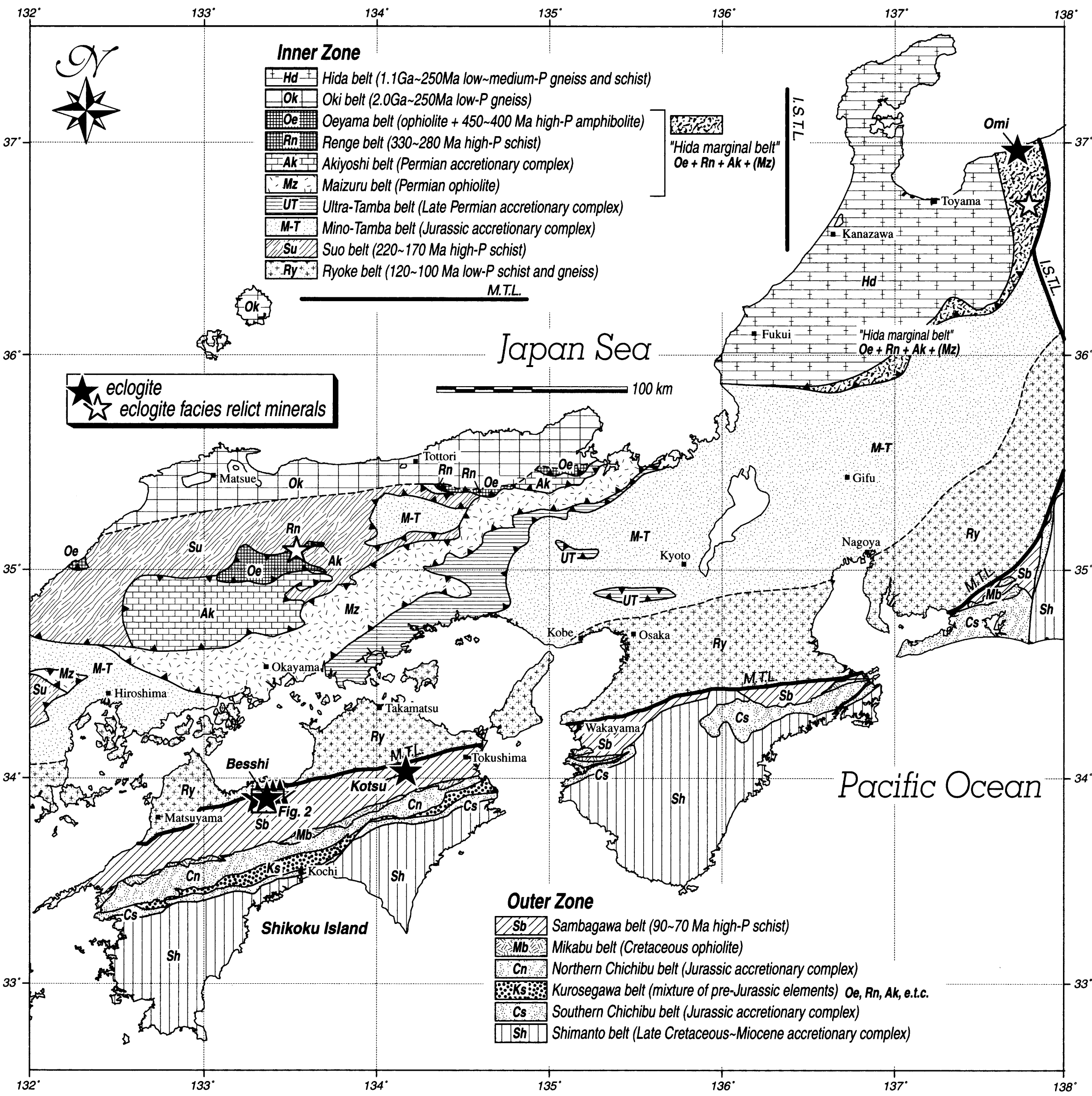

Fig. 1. Geotectonic subdivision of southwest Japan (after Isozaki and Itaya, 1990; Tsujimori and Itaya, 1999). Note that timing of accretion is generally getting younger oceanward.

Table 1. List of high-P/T metamorphic belts in southwestern Japan and their cooling ages. An overview of geochronologic data of the high-P/T metamorphic belt in southwestern Japan can be found in a number of review papers (e.g. Isozaki and Itaya, 1990; Isozaki, 1996; Maruyama et al., 1996; Nakajima, 1997).

metamorphic belt	*approx. age*	*method*	*lithology*	*representative reference*
Kitomyo-Fuko				
Kitomyo	*445~402 Ma*	*K-Ar, Ms*	*pelitic schist*	*Maruyama and Ueda (1974)*
Fuko Pass	*443~403 Ma*	*K-Ar, Hbl*	*amphibolite*	*Tsujimori et al. (2000)*
Renge	*330~280 Ma*	*K-Ar, Ms*	*pelitic schist, basic schist*	*Nishimura (1990)*
(older 'Sangun')				*Nishimura (1998)*
				Tsujimori and Itaya (1999)
Suo	*220~170 Ma*	*K-Ar, Ms*	*pelitic schist, basic schist*	*Nishimura (1990)*
(younger 'Sangun')				*Nishimura (1998)*
Sambagawa	*90~70 Ma*	*K-Ar, Ms*	*pelitic schist, basic schist*	*Itaya and Takasugi (1988)*
				Itaya and Fujino (1999)
		Ar-Ar, Ms	*pelitic schist*	*Takasu and Dallmeyer (1990)*

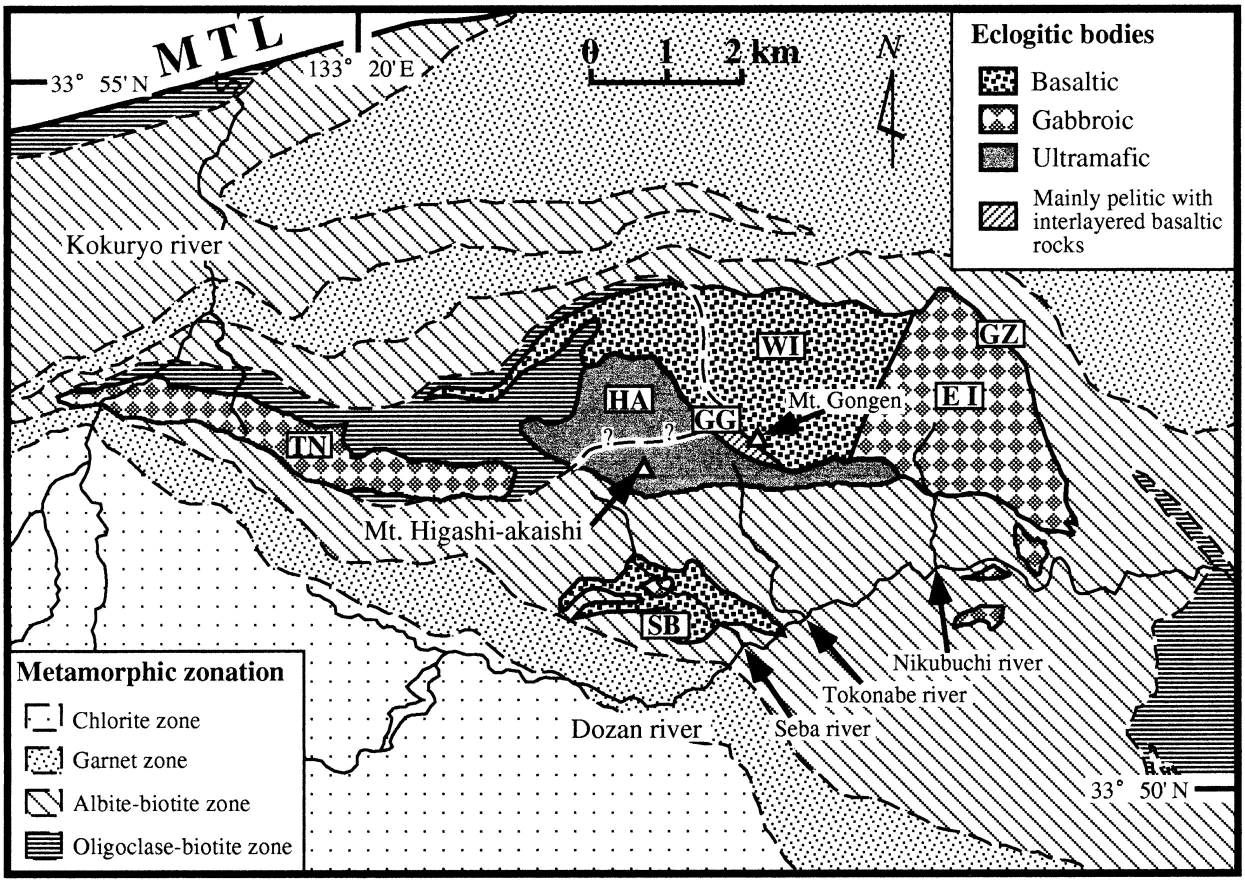

Fig. 2. Geological map of Besshi district showing localities of eclogitic bodies introduced in this paper (based on Takasu,1989; Higashino, 1990; Enami, 1996 and Naohara and Aoya, 1997). Eclogitic bodies: GG = Gongen mass; TN = Tonaru mass; SB = Seba area; WI = Western Iratsu mass; EI = Eastern Iratsu mass; HA = Higashi-akaishi mass; GZ = Gazo mass. MTL = Median Tectonic Line. The boundary of Gongen mass is presented based on the definition by Enami (1996). The four metamorphic zones of the Sambagawa belt based on the appearance of key metamorphic minerals in metapelite (Higashino, 1990) are also presented. In order of increasing grade these are: the chlorite, garnet, albite-biotite and oligoclase-biotite zones. Note that the oligoclase isograd cross cuts the Western Iratsu mass (Enami, 1982).

reported, mainly from the Besshi district of central Shikoku (Fig. 1). In this contribution, we introduce seven eclogite localities in the Sambagawa belt, six of them from the Besshi district (Tonaru, Seba, Western Iratsu, Eastern Iratsu, Higashi-akaishi and Gazo; Fig. 2) and one from the Kotsu district. A detailed review of the Sambagawa belt is provided in the companion publication to this (Wallis et al., 2000) and we will not make further descriptions here. One more eclogite locality in Besshi district (Gongen; GG in Fig. 2) is introduced in Enami (2000) as a pictorial in this issue.

Renge (Renghe) metamorphic belt

Late Paleozoic high-*P*/*T* schists of various metamorphic grades are sporadically distributed in the Inner Zone of southwestern Japan. Many localities occur as tectonic blocks in serpentinite melange. Many other outcrops of high-*P*/*T* schists are considered to be constituents of a Carboniferous (330−280Ma) regional high-*P*/*T* metamorphic belt called the ‘Renge metamorphic belt’ (e.g. Nishimura, 1998; Tsujimori and Itaya, 1999). Most of the metamorphism of the Renge belt took place in the greenschist/blueschist transitional facies to epidote-amphibolite facies. However, lawsonite blueschist to epidote blueschist facies metamorphism and associated glaucophane-bearing eclogite is also locally found (Tsujimori and Itaya, 1999; Tsujimori et al., 2000a; 2000b). In the Renge belt, relict eclogite facies mineral assemblage are found in blocks in serpentinite melange (Komatsu and Yamazaki, 1981; Nakamizu et al., 1989; Tsujimori, 1998; Tsujimori and Itaya, 1999). The latest find in the Omi area of the northeastern Hida mountains is part of the regional schist and contains up to 40 modal % garnet + omphacite (Tsujimori et al., 2000a; 2000b). Further studies of the Renge belt eclogite will be important in deciding the eastern extension of the Dabie-Sulu ultrahigh pressure metamorphic belt in central China.

REPRESENTATIVE ECLOGITE LOCALITIES IN SOUTHWESTERN JAPAN*

Tonaru eclogite, Sambagawa metamorphic belt

Tonaru eclogitic mass, located in the western part of the Besshi district (TN in Fig. 2), was derived from a gabbroic protolith (Takasu, 1989). The outcrop size of this mass is fairly large and has dimensions of 6.5 × 1km (Fig. 2). However, although garnet amphibolite with sodic plagioclase + hornblende ± sodic augite symplectite is relatively common, the characteristic eclogitic assemblage garnet + omphacite is very rare in the Tonaru mass. The photographs we present in Plate 1 are examples of thus rare and precious eclogite.

With the exception of studies reviewing the geology of the Besshi district (e.g. Takasu,1989; Kunugiza et al. 1986), Moriyama (1990) is probably the only published paper dealing with the Tonaru eclogite. Okamoto (1998) discusses the deformation history of rocks around the Tonaru mass.

Plate 1 *(photographs are provided by Y. Miyagi)*

(a) Hand specimen of eclogite from the Tonaru mass.

(b) Photomicrographs of eclogite from the Tonaru mass. The assemblage garnet + omphacite is well preserved in the thin section. The dark green parts are symplectite consisting of calcic amphibole, sodic plagioclase and aegirine augite. Open nicol.

(c) The same view as (b). Crossed nicols.

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*Note: arranged in geographical order from west to east.

Plate 1

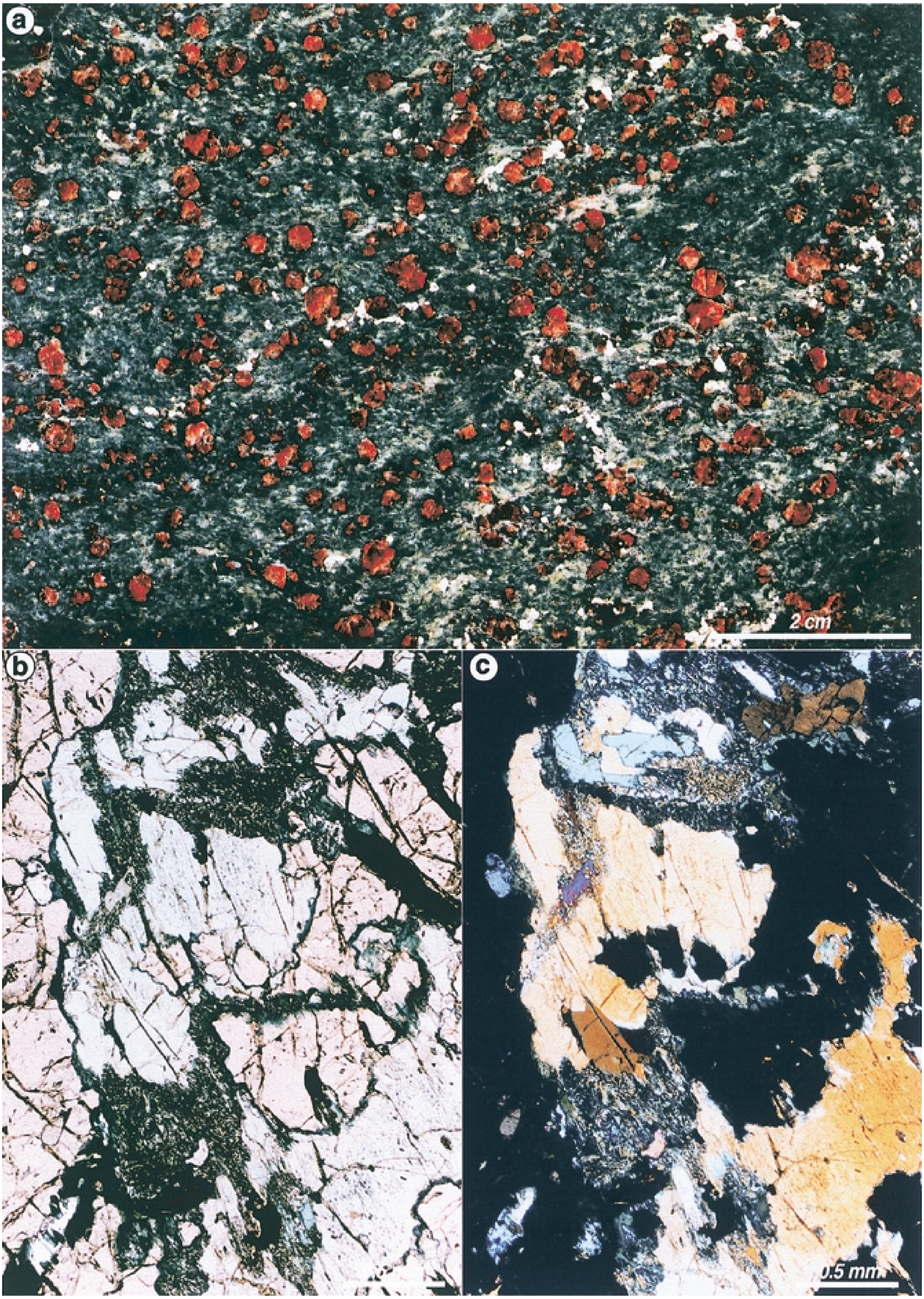
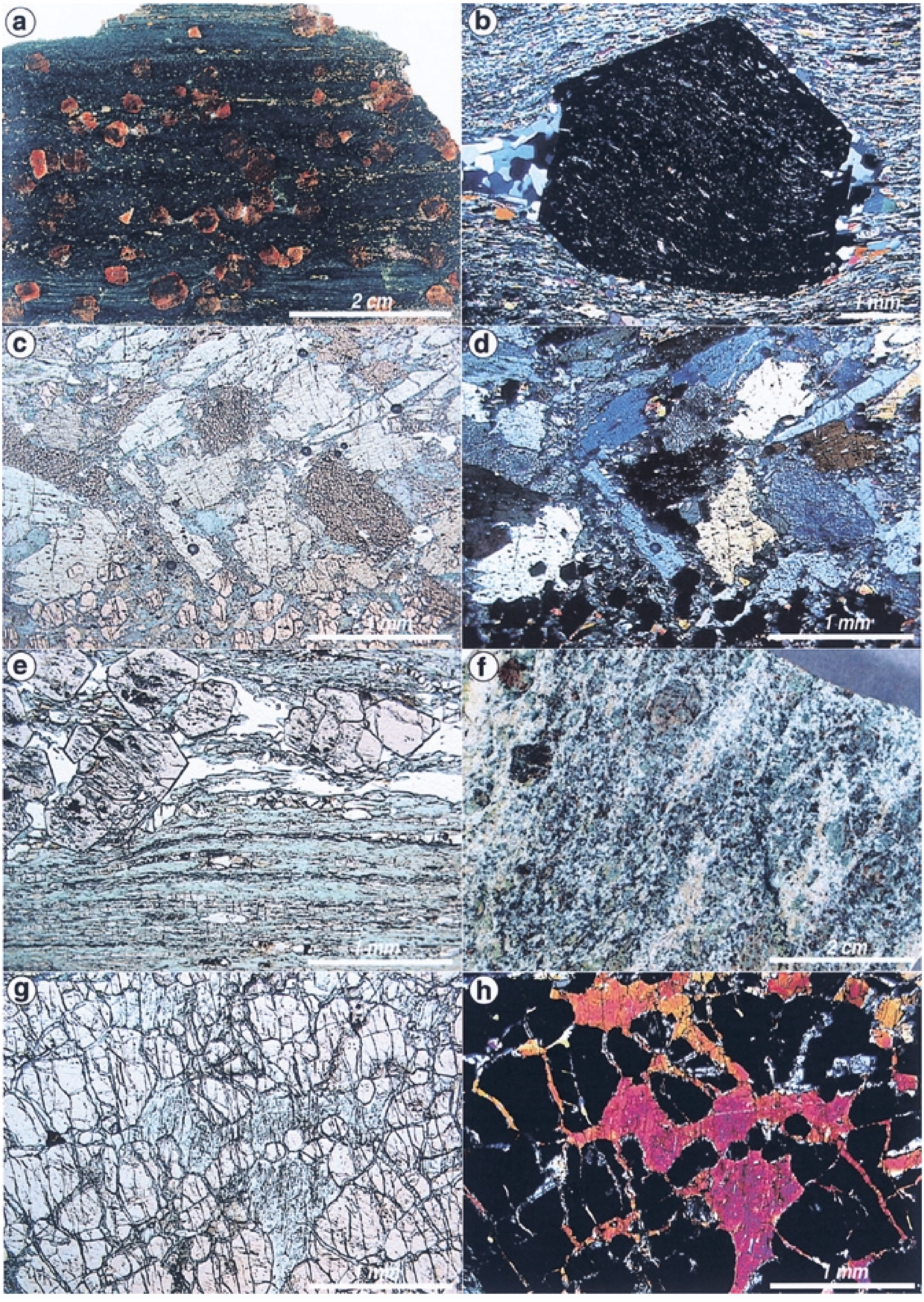


Plate 2



Seba eclogite, Sambagawa metamorphic belt

The Seba area (SB in Fig. 2) contains two eclogite-bearing lithologies: the Seba basic schist and the Seba metagabbro (Fig. 2). This area is well known for an challenging idea proposed by Takasu (1984; 1986) that tectonic emplacement of the Seba metagabbro caused solid-state contact metamorphism resulting in formation of eclogite in the surrounding Seba basic schist. In contrast to this idea, Aoya and Wallis (1999) consider that all eclogites in the Seba area formed by the Sambagawa regional metamorphism. The existence of the two contrasting opinions can be attributed mainly to presence of a very wide variety of eclogitic textures in the Seba area. Whatever its ultimate causes, this textural variation of eclogite is a fruitful source for discussion and research. We are sorry that we can present only a part of them in Plate 2.

Studies focusing on the Seba area other than those mentioned above include Dallmeyer and Takasu (1991), Nomizo (1992), Naohara and Aoya (1997), Aoya (1998), Wallis and Aoya (2000) and Aoya (2001).

Plate 2 *(photographs are provided by M. Aoya)*

Seba basic schist, *(a)~(e)*

(a) Hand specimen of schistose (lineated type) eclogite. Matrix-forming minerals, including omphacite, are fine grained and show strong grain-shape preferred orientation defining a mineral lineation (see also (e)). Omphacite-rich layers have a light greenish coloration while barroisite rich layers are dark greenish. Garnet is porphyroblastic and relatively coarse-grained (see also (b)).

(b) Porphyroblastic garnet in a thin section of schistose eclogite. Inclusion trails within the garnet show a sigmoidal curvature and are continuous with the surrounding schistosity in the outermost rim of the garnet. The pressure shadows outside of the garnet consist of quartz. Crossed nicols.

(c) Photomicrograph of eclogitic basic schist with randomly oriented omphacite. Porphyroblastic omphacite is randomly oriented and crosscuts the dominant schistosity mainly composed of barroisitic amphibole, epidote, phengite and rutile. The garnet-rich layer in the lower part of the photograph lies parallel to the dominant schistosity. Open nicol.

(d) The same view as (d). Crossed nicols.

(e) Photomicrograph of schistose eclogite with omphacite grains strongly aligned within the dominant schistosity. Together with the grain shape of omphacite, the arrangement of epidote, rutile and dolomitic carbonate also defines the schistosity. Quartz around garnet forms highly elongate lenses subparallel to the schistosity. Open nicol.

Seba metagabbro, (f)~(h)

(f) Hand specimen of eclogitic sample with small-scale gabbroic layering. Assemblage of garnet + omphacite (light greenish) together with barroisitic amphibole (black-coloured) is observed within mafic layers. White-coloured layers are mainly composed of zoisite.

(g) Photomicrograph of garnet + omphacite aggregate in a thin section of eclogite. Cracks in garnet are filled by a single grain of omphacite (the thin section is a little thick). Open nicol.

(h) The same view as (g). Crossed nicols.

Western Iratsu eclogite, Sambagawa metamorphic belt

Among the eclogitic bodies introduced in this paper, the Western Iratsu mass (WI in Fig. 2) may be the most challenging for field investigation. In addition to its location deep in the mountains, the large area occupied by the Western Iratsu mass and the surrounding rocks includes a wide variety of lithologies (e.g. Minakawa and Momoi, 1982; Enami and Tokonami, 1984; Enami, 1996). Plate 3 presents photographs of eclogitic samples taken from this "tough" area.

The dominantly basaltic origin of the Western Iratsu mass and the prograde nature of the eclogitic metamorphism are discussed in Takasu and Kohsaka (1987) and Toriumi and Kohsaka (1995).

Plate 3 *(photographs are provided by Y. Kugimiya)*

(a) Eclogite from the Western Iratsu mass. The hand specimen consists of an omphacite-rich part (green) and a barroisite-rich part (black) with scattered quartz and white mica (white). The wine-red crystals scattered in the specimen are porphyroblastic garnet (< 1 cm).

(b) Microstructure of the Western Iratsu eclogite. Omphacite occurs as porphyroblasts up to 3 mm in diameter and are locally replaced by hornblende + sodic plagioclase symplectite. Open nicol.

(c) The same view as (b). Crossed nicols.

Plate 3

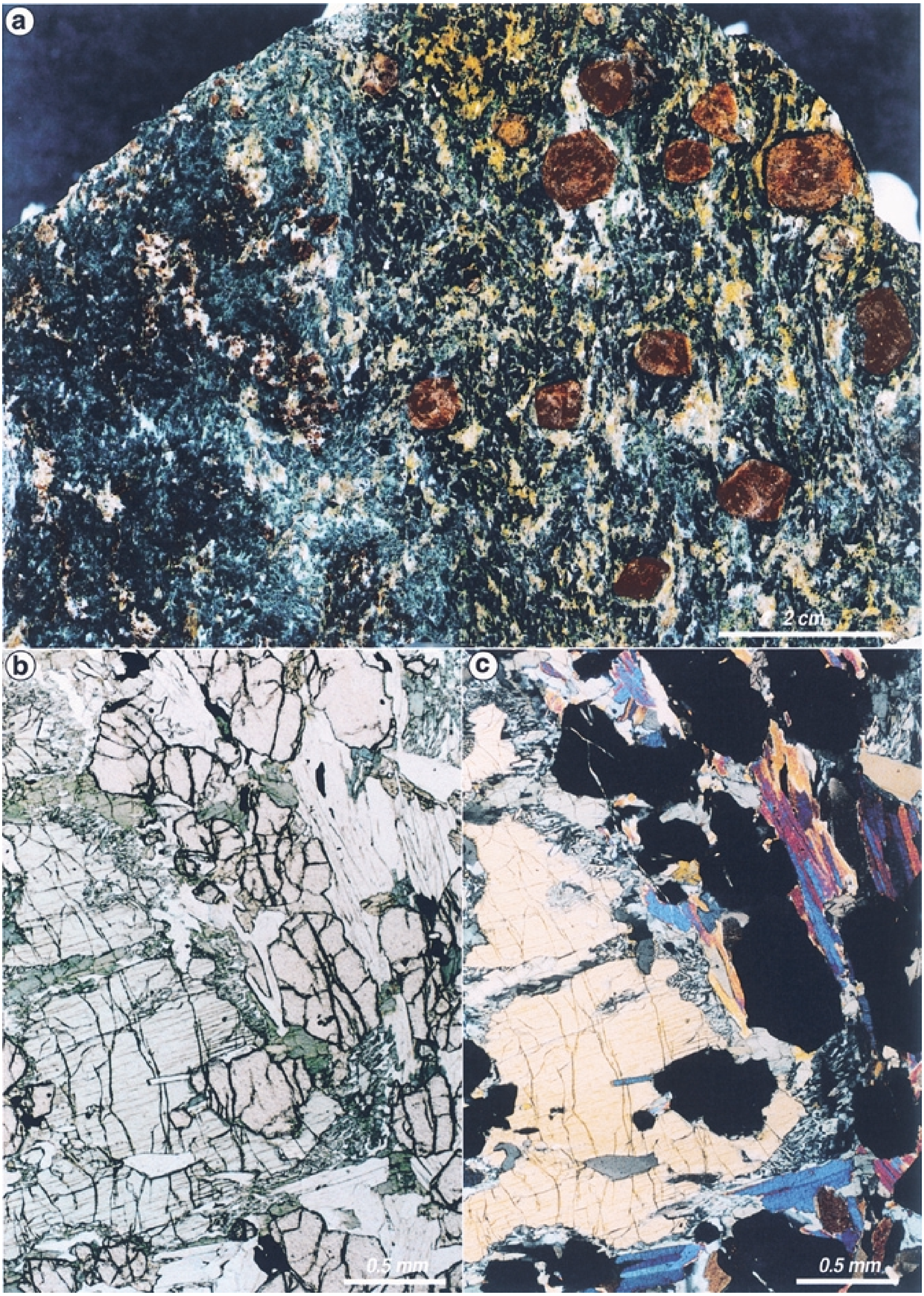
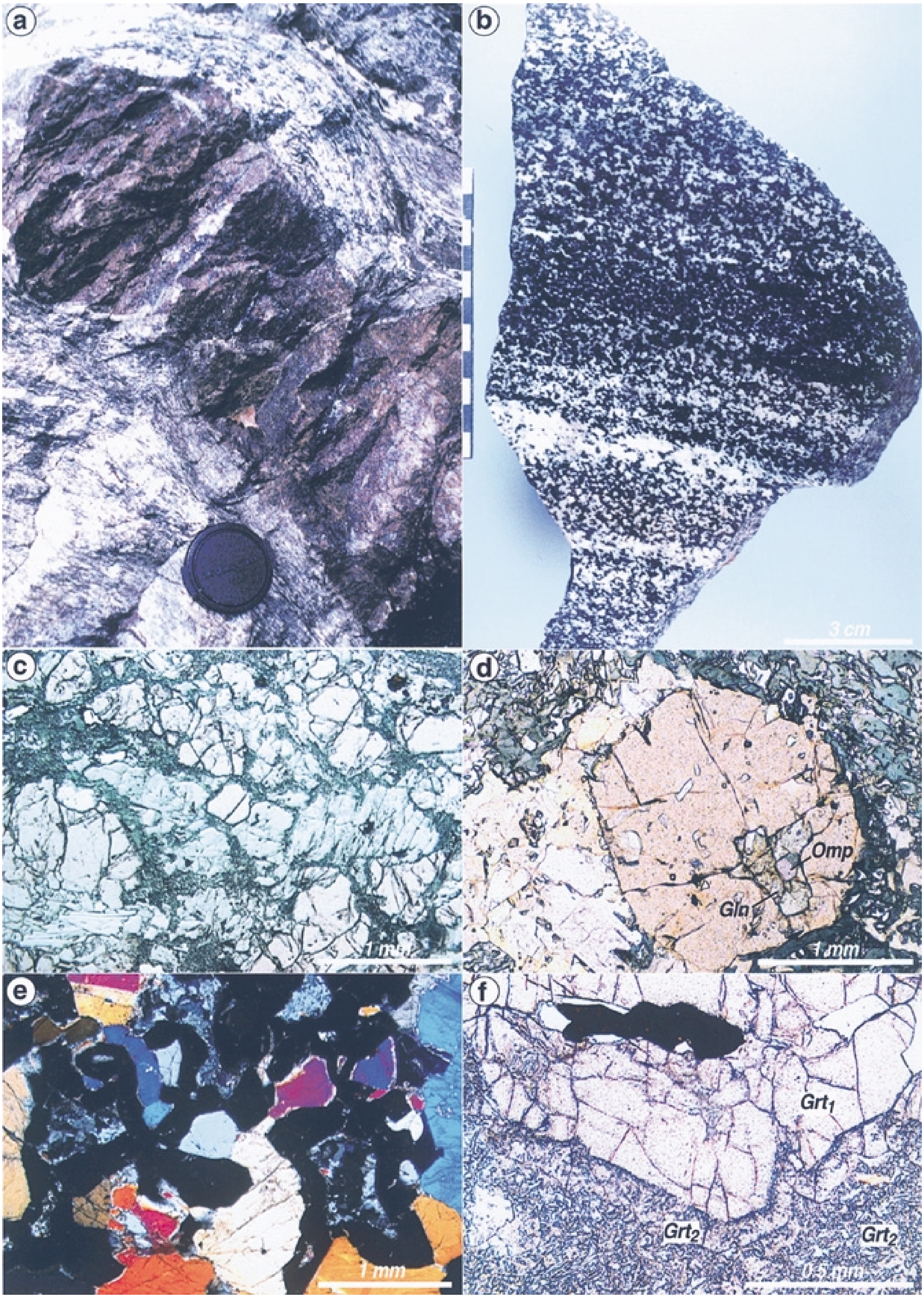


Plate 4



Eastern Iratsu eclogite, Sambagawa metamorphic belt

Eastern Iratsu (EI in Fig. 2) is the only eclogitic mass in the Besshi district where the occurrence of granulite is also reported (e.g. Goto and Banno, 1990). In addition, it is proposed that the metamorphic history after the granulite facies metamorphism includes two eclogite stages interposed by a distinct blueschist facies metamorphism (Takasu, 1989; Toriumi and Kohsaka, 1995). Rocks of the Eastern Iratsu mass (Plate 4), for which such a complex metamorphic history is proposed, remind us both of the significance and enjoyment of metamorphic petrology, in particular the analysis and interpretation of microstructures. These rocks still pose challenging problems for us to solve.

Enami et al. (1979) and Enami (1980) also focus on the Eastern Iratsu mass, but studying different rock types, and propose a simpler metamorphic history than that mentioned above.

Plate 4 *(photographs are provided by C. Tanaka)*

(a) Outcrop of eclogite in the Eastern Iratsu mass along Nikubuchi river (Fig. 2). A lens of the eclogite block mainly composed of garnet and omphacite is centrally located and is surrounded by epidote amphibolite, which makes up nearly all of the Eastern Iratsu mass. In the Eastern Iratsu mass, well-preserved eclogite commonly occurs as a lens or a layer.

(b) Rock sample from the Eastern Iratsu mass. The surface of the sample is normal to the gabbroic layering. The transition from the granulite to eclogite can be observed. The layering is composed of mafic and felsic parts, both of which suffered weak overprinting in the epidote amphibolite facies metamorphism. The mafic layer well preserves granulite facies mineral assemblage. In contrast in the felsic layer, the transitional reaction from granulite to eclogite is well developed.

(c) Photomicrograph of eclogite from the Eastern Iratsu mass. The pale pinkish mineral is garnet, and the pale greenish mineral is omphacite. The rim part of omphacite is usually replaced by symplectite composed of albite and barrosite. A small amount of phengite is also present. Open nicol.

(d) Photomicrograph of garnet in well-preserved eclogite. Glaucophane (*Gln*) and omphacite (*Omp*) are included in the garnet grain. The matrix has suffered weak retrogression in the epidote amphibolite facies metamorphism. The coexistence of glaucophane and omphacite can be observed. Note that this section has been made slightly thick in order to emphasize the color of the minerals. Open nicol.

(e) Photomicrograph of granoblastic eclogite in the Eastern Iratsu mass. This sample is included in the felsic layer in the transitional zone (see also (b)). The characteristic texture is the coronitic garnet that formed around the plagioclase domain. The plagioclase is decomposed into aggregates of zoisite and quartz. Clinopyroxene is omphacite. Crossed nicols.

(f) Photomicrograph of overgrowth of garnet (Grt_2) that probably formed during epidote amphibolite facies metamorphism. The eclogitic garnet (Grt_1) shows a weak pinkish color and includes large-sized inclusions. The garnet overgrowth usually contains a large amount of microinclusions in innermost part. The texture of garnet in the eastern Iratsu mass is very complicated. Open nicol.

Higashi-akaishi garnet clinopyroxenite, Sambagawa metamorphic belt

Higashi-akaishi peridotite mass (HA in Fig. 2), which mainly consists of dunite and other ultramafic rocks, contains the highest peak of the Higashi-akaishi mountain range (Mt. Higashi-akaishi; Fig. 2). Although rocks including garnet + clinopyroxene occur in the Higashi-akaishi mass, the correct petrographic name of the rock is garnet clinopyroxenite rather than eclogite because of the diopsidic composition of clinopyroxene. However, the mineral chemistry indicates that this garnet clinopyroxenite underwent eclogite facies metamorphism (Kunugiza et al., 1986). Garnet clinopyroxenite is striking in the field both for its beautiful color and thought provoking structures (Plate 5a, b, c, e). Magmatic crystallization processes at a high-pressure conditions is proposed for the origin of the mineral assemblage and the modal variation (Mori and Banno, 1973; Kunugiza et al., 1986). The Higashi-akaishi peridotite mass may represent the hanging wall of the former Sambagawa subduction zone and is, therefore, of great significance in tectonic reconstruction of the region.

Other than those mentioned above, the following studies discuss the thermal and deformational history of the Higashi-akaishi mass: Bamba (1953); Yoshino (1961; 1964; 1978) and Toriumi (1978).

Plate 5 *(photographs are provided by T. Mizukami)*

(a) Boudinaged layer of garnet clinopyroxenite in serpentinized dunite. Garnet (pinkish) is concentrated at the center of the layer and surrounded by greenish clinopyroxene. The boundary between garnet clinopyroxenite and dunite is very sharp and is parallel to the foliation of the dunite. The area of light color at the lower left of the slab was not polished.

(b) Layered structure in garnet websterite. Monomineralic thin layers of garnet or orthopyroxene (brown) identify the foliation of the sample. Clinopyroxene is dark green in this sample.

(c) Folded layer of garnet clinopyroxenite. Pinkish garnet-rich layer has been isoclinally folded. Small amount of green clinopyroxene is associated with garnet. The host dunite has been highly serpentinized.

(d) Homogeneous dunite. Olivine (grayish green) occupies most of the volume. Minor amount of chromian spinel (black) and chromian diopside (green) are also observed as common minerals in the dunite. A weak foliation recognized by alignment of spinel and olivine dips steeply toward the right of the photograph.

(e) Close-up photograph of garnet clinopyroxenite. This slab section is part of garnet clinopyroxenite showing diffuse layering. Clinopyroxene is concentrated in the center of the section (dark greenish part) and garnet at both sides. Clinopyroxene shows two colors: interstitial clinopyroxene is light green in the garnet-rich part and dark green in the monominelaric part. Open nicol.

(f) Photomicrograph of garnet clinopyroxenite. Granular anhedral grains of clinopyroxene form a granoblastic texture. Garnet has a subhedral shape. Many cracks in garnet show a parallel arrangement within the thin section. Clinopyroxene near garnet tends to be smaller, probably due to recrystallization during deformation. Some grains of clinopyroxene contain orthopyroxene lamellae. Open nicol. (Some air bubbles were inadequately included in the thin section during preparation)

(g) The same view as (f). Crossed nicols.

Plate 5

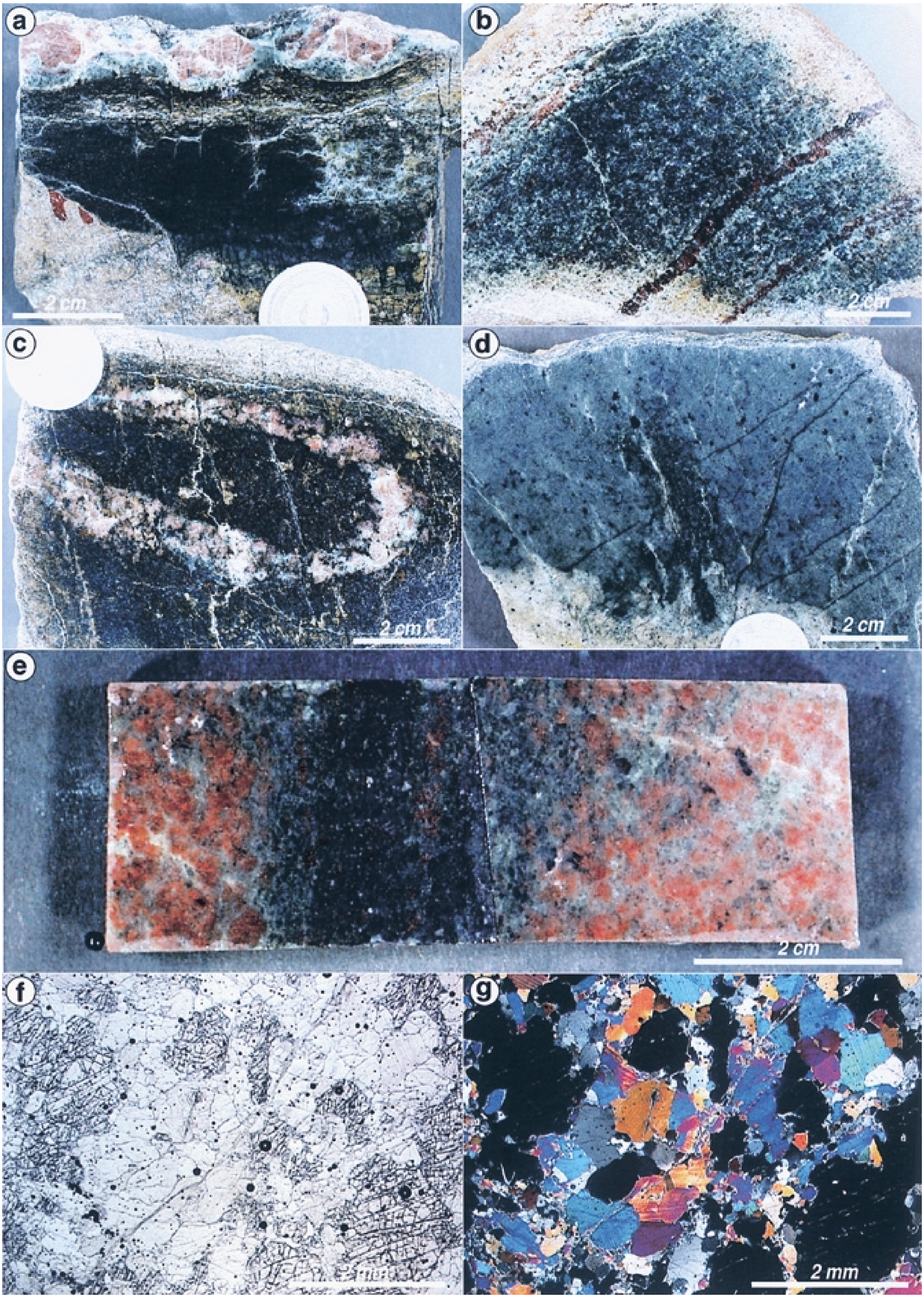
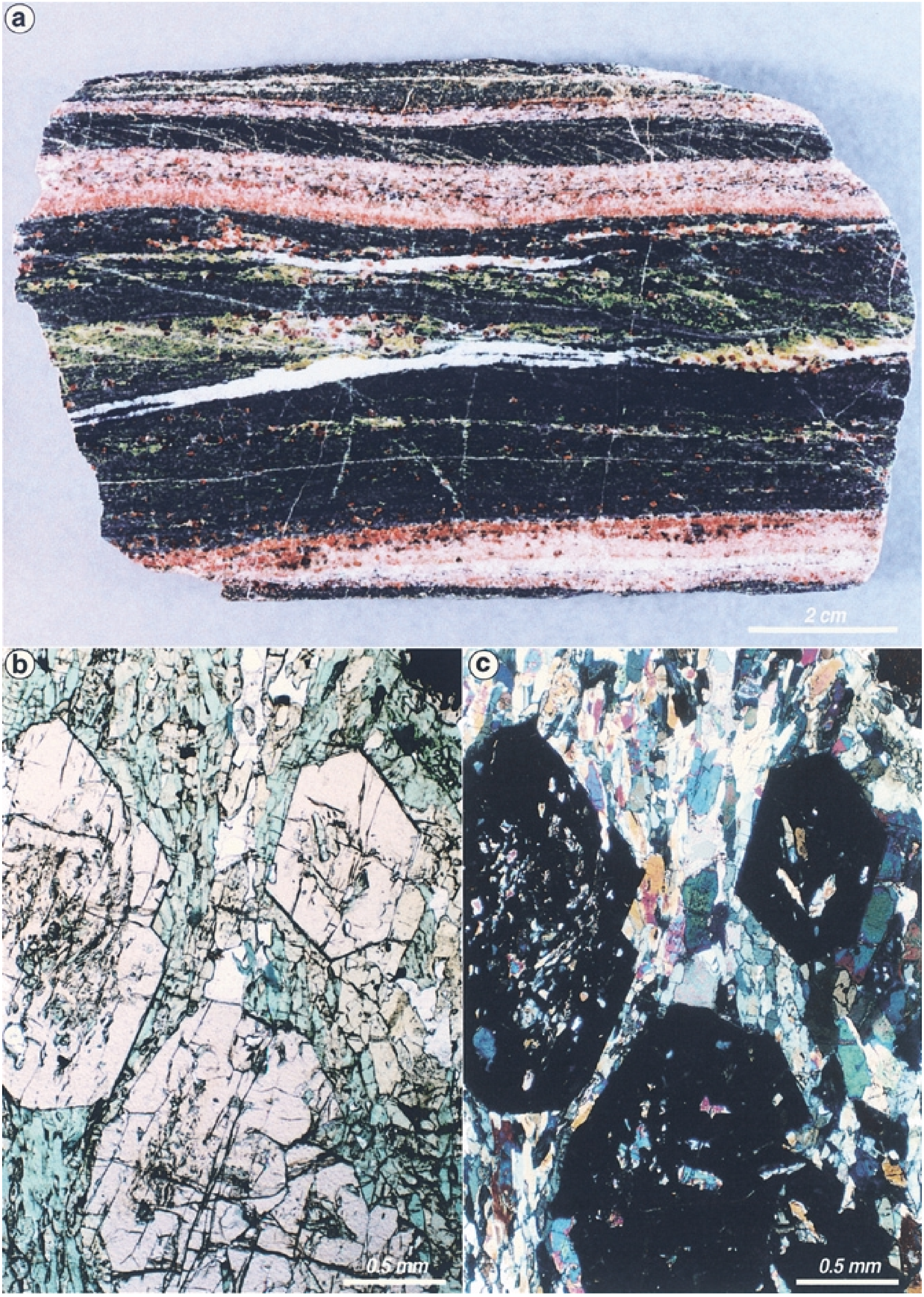


Plate 6



Gazo eclogite, Sambagawa metamorphic belt

Gazo mass (GZ in Fig. 2) is a newly discovered eclogite locality located near the northeastern margin of the Eastern Iratsu mass (Fig. 2). Despite detailed previous field studies by many workers, the Gazo eclogite remained undiscovered until the discovery and description by Sakurai and Takasu (1999). This finding suggests that there may be many other eclogite localities still hidden in the Besshi district. Plate 6 presents photographs of the new eclogite from the Gazo mass.

Plate 6 *(photographs are provided by T. Sakurai)*

(a) Hand specimen of eclogite from the Gazo mass.

(b) Microscopic structure of the Gazo eclogite. Garnet occurs as porphyroblasts up to 2 mm in diameter. Open nicol.

(c) The same view as (b). Crossed nicols.

Kotsu eclogite, Sambagawa metamorphic belt

Eclogite in Kotsu area is generally schistose and this is defined by omphacite, amphibole, epidote and mica minerals. Locally, eclogite is associated with carbonate and quartz-rich layers. These features are very similar to those of schistose eclogite from the Seba basic schist in the Besshi district (Plate 7a, b, e). However, eclogite in the Kotsu area has two striking characteristics that distinguish it from other eclogites in the Sanbagawa belt. The first is its locality. Other eclogites in the Sambagawa belt are concentrated in the Besshi district and the Kotsu eclogite is the only one found outside this area about 80 km to the east (Fig.1). The second distinguishing characteristic is composition of the amphibole coexisting with omphacite. In the Besshi district, amphibole coexisting with omphacite has a barroisitic composition, whereas in the Kotsu area it is mostly glaucophanic (note that the first eclogite reported from the Kotsu area by Takasu and Kaji (1985) is barrosite eclogite). Wallis and Aoya (2000) attractively propose that this difference in compositions may reflect different styles of *P-T* paths experienced by the two distant localities.

Plate 7 *(photographs are provided by M. Matsumoto)*

(a) Typical sample of blueschist eclogite in the Kotsu area. Dark blue and green layers are composed mainly of glaucophane and omphacite, respectively. Red globular minerals are garnet crystals.

(b) Eclogite sample from the Kotsu area composed mainly of coarse garnet and fine omphacite. White-colored part is composed of white mica, carbonate and zoisite.

(c) Photomicrograph of Kotsu eclogite showing its schistose occurrence. Omphacite (greenish), glaucophane (violet), epidote (pale brownish) and white mica minerals define the schistosity. Open nicol.

(d) Photomicrograph of porphyroblastic garnet in Kotsu eclogite. The garnet crystal at upper right includes an omphacite crystal. Open nicol.

(e) Photomicrograph showing pre- to syn-deformational coexistence of omphacite + glaucophane. Omphacite and glaucophane filling the strain shadow of the garnet at upper right are in direct contact without a reaction zone between them. Open nicol.

(f) Photomicrograph of garnet with a zoning in coloration and internal microstructure (at lower right). The garnet grain includes omphacite in its outer part. Open nicol.

(g) Photomicrograph of garnet-rich part in a fine-grained quartz-rich eclogite. Open nicol.

(h) Photomicrograph of eclogite with coarse-grained omphacite. Some eclogites from the Kotsu area show massive occurrence of omphacite like this. Crossed nicols.

Plate 7

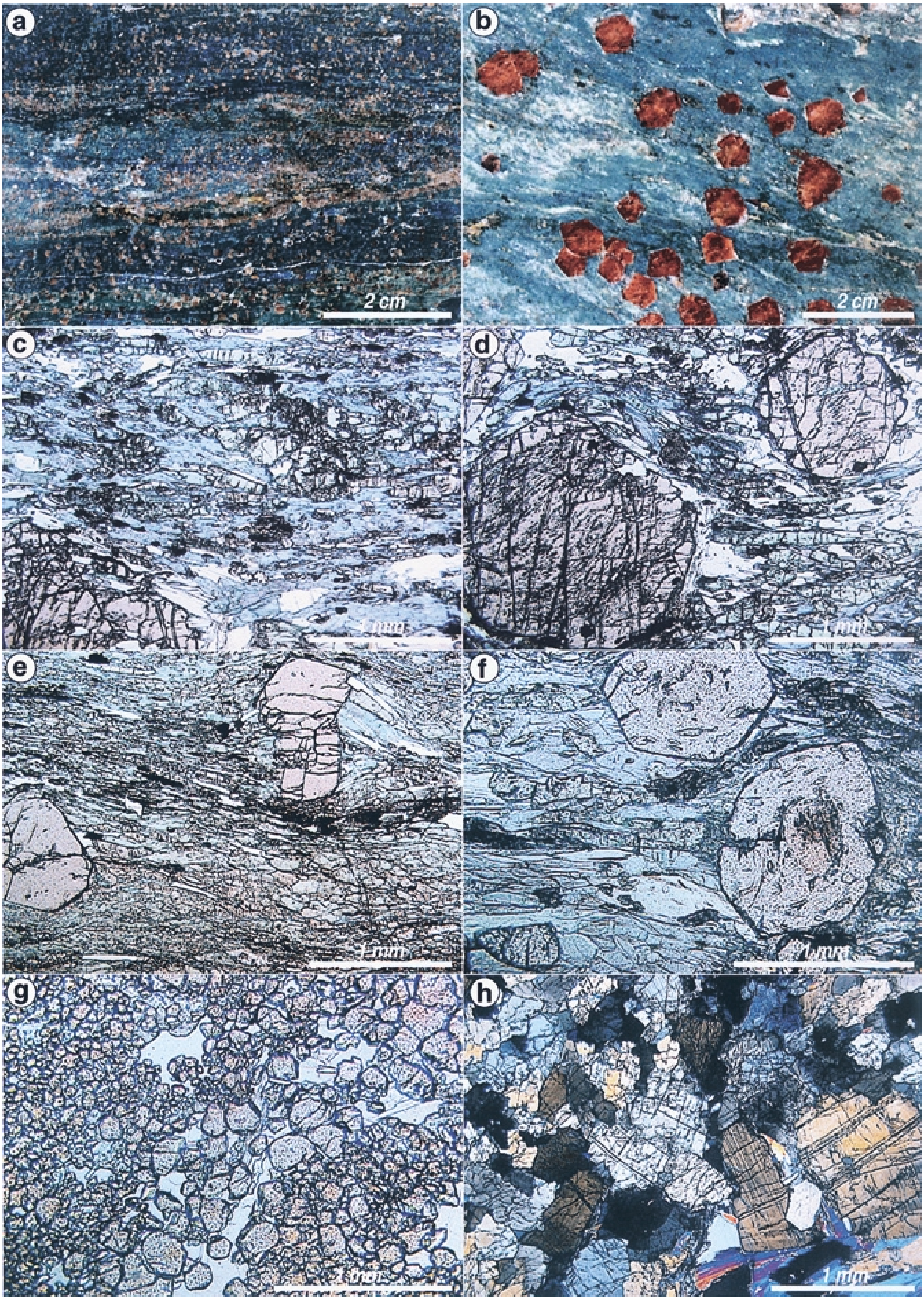
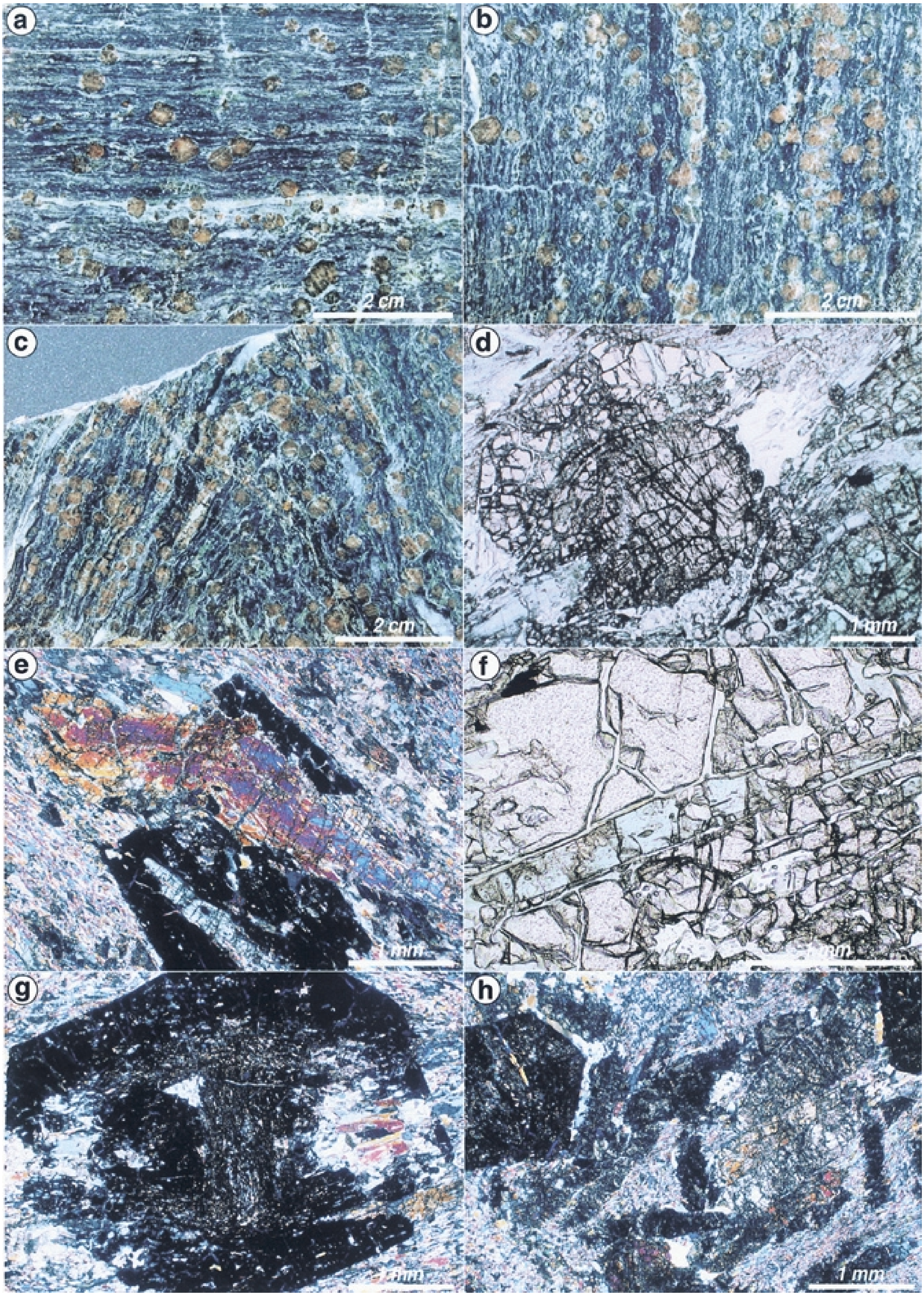


Plate 8



Yunotani eclogites, Renge metamorphic belt

The Yunotani eclogite of the Renge metamorphic belt was first described as a mafic layer (1.2 m wide) intercalated with pelitic schist (garnet-paragonite-phengite schist) formed in a boulder with a diameter of about 4 m from the Yunotani valley in the Omi area (Tsujimori et al., 2000a; 2000b). In this eclogite, the eclogite facies mineral assemblage garnet + omphacite + glaucophane + epidote + rutile + quartz is slightly replaced by secondary chlorite, titanite, albite, calcite and rarely actinolite. The minerals define a penetrative schistosity. Epidote blueschist facies mineral inclusions glaucophane + epidote + titanite + quartz + albite are locally preserved in porphyroblastic garnet where they define a schistosity at high angle to the surrounding matrix. The petrographic features show progressive transition from the epidote blueschist facies to the eclogite facies with a little retrogression. This eclogite provides the first evidence for the *P-T* path leading to the development of eclogite in the Late Paleozoic Renge metamorphic belt.

Plate 8 *(photographs are provided by T. Tsujimori)*

(a) A hand specimen of the Yunotani eclogite. Note that the compositional banding and preferred orientation of glaucophane and omphacite define a penetrative schistosity. Eudhedral porphyroblasts of garnet are scattered in a fine-grained matrix.

(b) A hand specimen of the Yunotani eclogite. Note that garnet-rich layers are arranged parallel to a penetrative schistosity.

(c) A hand specimen of the Yunotani eclogite, showing tight folding.

(d) Photomicrograph of porphyroblastic garnet coexisting with both green-colored omphacite and pale-blue glaucophane. Some epidote is also present. The modal volume of garnet + omphacite reaches 40 %. Open nicol.

(e) Photomicrograph of prismatic omphacite partially contained within a porphyroblast of garnet. Crossed nicols.

(f) Photomicrograph of prismatic omphacite included within porphyroblastic garnet. The omphacite contains rounded-shaped glaucophane (slightly lower relief) as inclusions. Open nicol.

(g) Photomicrograph of porphyroblastic garnet. Note that two different inclusion trails can be identified. The inclusion trail in the rim is parallel to a schistosity in the matrix, and it consists of eclogite facies minerals, such as omphacite and rutile. The core lacks inclusions of omphacite and rutile and has an internal fabric at high angle to the surrounding foliation. Crossed nicols.

(h) Photomicrograph of omphacite showing only a weak alignment. The omphacite grown in a fine-grained matrix consisting of glaucophane and epidote. Crossed nicols.

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* in Japanese with English abstract.

** in Japanese

＜地　名＞

Besshi ……別子
Fuko ……普甲
Gazo ……峨蔵
Gongen ……権現
Higashi-akaishi ……東赤石
Iratsu ……五良津
Eastern Iratsu ……東五良津
Western Iratsu ……西五良津
Kitomyo ……木頭名
Kotsu ……高越
Nikubuchi ……肉淵
Omi ……青海
Renge (Renghe) ……蓮華
Sambagawa (Sanbagawa) ……三波川
Seba ……瀬場
Suo ……周防
Tonaru ……東平
Yunotani ……湯ノ谷