International Association for Gondwana Research

2023 Convention and 20th International Conference on Gondwana to Asia

Field Excursion Guide

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新潟大學 NIIGATA UNIVERSITY

フォッサマグナミュージアム Fossa Magna Museum

Niigata University, Niigata and Fossa Magna Museum, Itoigawa

October 07th to 12th 2023, Niigata.

1. Introduction

The 2-day field excursion will focus on the Paleozoic to recent geology surrounding the Itoigawa UNESCO Global Geopark, which is located about 180 km southwest of Niigata (Fig. 1). Situated exactly in the tectonic gap (called the Itoigawa-Shizuoka Tectonic Line; ISTL) between Northeast and Southwest Japan, the region is famous for understanding the geologic history of Japan, especially the Paleozoic and those relating to back-arc spreading and opening of the Japan Sea. The excursion cover locations representative of geological features of proto-Japan, Paleozoic schist belts, serpentinite mélange, jade, Paleo-guyot, Cenozoic rift faults, Quaternary volcanoes and so on (Fig. 2). A visit to the Fossa Magna Museum, Itoigawa is also included where you can see the wonderful collection of gemstone varieties of ***"Jadeite", the national stone of Japan***. The schist zone is also known for its occurrence of blueschist and eclogite, though such outcrops require mountaineering skills to approach, but the participants may find these rocks as boulders in the stream valleys.

Niigata is generally pleasant in October, with temperatures dropping to around 10ºC in the night, and without much rain. However, the participants are requested to carry windbreakers or raincoats and field shoes, as we have some walking along non-paved paths. With an overnight stay at Itoigawa City, we hope to give you a flavor of geological and cultural heritage of Niigata.

Short description of the localities planned for the excursion along with a schedule are given below. Please note that the localities and schedule given here are still subjected to changes, depending on the weather conditions.

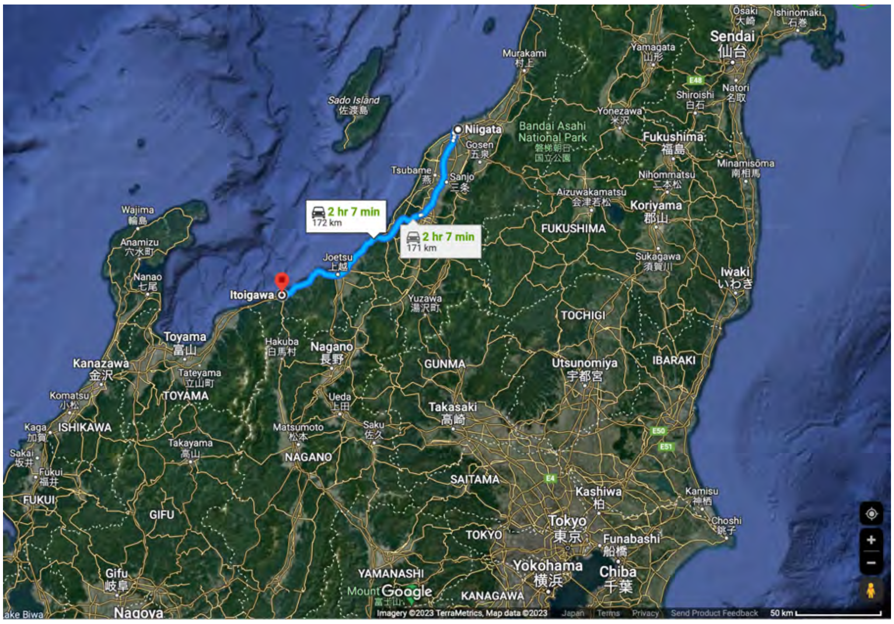

Fig. 1 *Google Earth® map of the Itoigawa region*

2. Schedule

<u>**Day 1:** October 10, 2023</u>

8:30 Departure from Niigata (2.5 hours drive)

11:00 Arrival at Fossa Magna Museum, Itoigawa (geological museum)

12:30-13:30 Lunch at Fossa Magna Museum <u>[Lunch Boxes will be provided]</u>

13:30-16:00 **Stop 1**: Omi River (Hashidate) Jade Gorge

Stop 2: Metamorphic rocks in the Omi river area

Note: The above two localities cannot accommodate the whole group at a single time. We will visit these localities in 2 separate groups and in smaller vehicles.

17:00 Arrival at Hotel Kunitomi Annex

18:00 Excursion Banquet at Kunitomi Annex Hotel

<u>**Day 2:** October 11, 2023</u>

8:30 Departure from Hotel Kunitomi Annex

9:00-10:30 **Stop 3**: Fossa Magna Park (Itoigawa-Shizuoka Tectonic Line)

11:00-12:00 **Stop 4**: Oyashirazu Cliff (garnet dacite, Late Cretaceous)

12:30-14:00 Lunch at Marine Dream Nou <u>[Lunch Boxes will be provided]</u>

14:00-15:30 **Stop 5**: Benten-iwa Rock (volcanic breccia, Early Pleistocene)

16:00 Arrival at Itoigawa Station.

16:15 Departure from Itoigawa Station(2.5 hours drive)

18:30 Arrival at Niigata Station

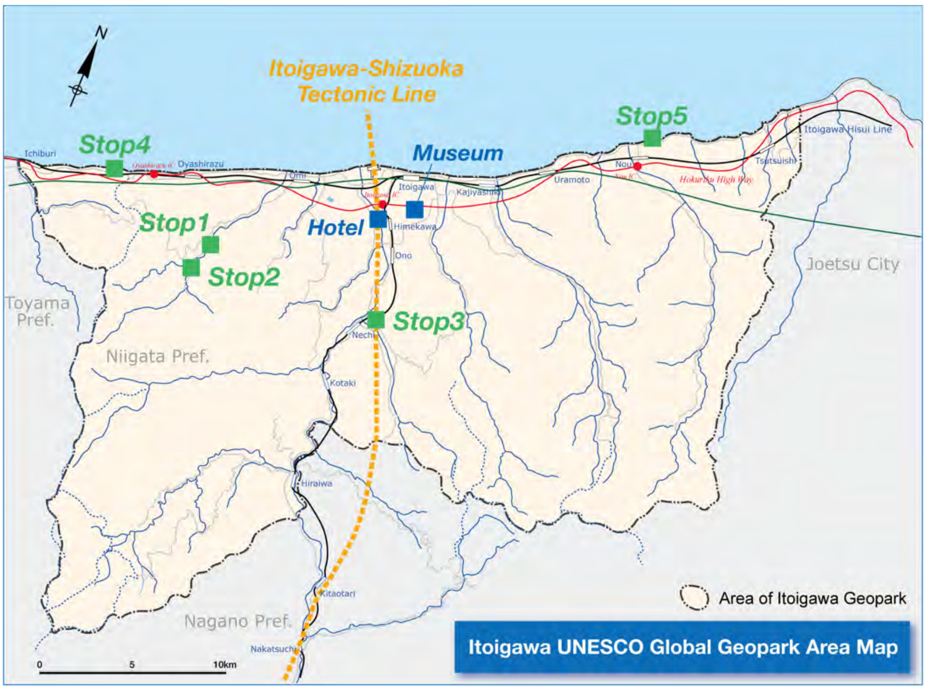

Fig. 2 *Field excursion area map in the Itoigawa UNESCO Global Geopark*

3. Geological Background of the Itoigawa Region

The Paleozoic subduction related accretionary complexes exposed in Japan have formed by the Paleo-Pacific (proto-Pacific) plate subduction beneath the Cathaysia Block margin of the South China craton and tectonic models have predicted an episode of tectonic inversion from passive margin to active margin in the Early Paleozoic (Isozaki, 1996, 2019; Maruyama et al., 1997). In the Early Paleozoic time, the proto-Japan was supposed to have located in the active continental margin of the South China craton (Isozaki, 2019), although some recent studies based on detrital zircon revealed that it may not be true throughout the entire Japanese archipelago (Okawa et al., 2013; Kurihara, 2019). The remnants of early Paleozoic rocks of Japan related to subduction, arc generation and accretion are distributed in narrow belts in southwest Japan (Fig. 3), such as Hida Gaien, Renge, Kurosegawa and South Kitakami belts (Tazawa, 2004, Eihiro et al., 2016, Taira et al., 2016; Isozaki, 2019).

The Renge Belt, a narrow stretch extending more than 300 km, is composed of *HP–LT* type middle Paleozoic metamorphic rocks (Banno, 1958; Kabir and Takasu, 2016; Matsumoto, 1980; Nishimura and Shibata, 1989; Nishimura, 1998, Tsujimori and Itaya, 1999; Tsujimori, et al., 2000). This belt is often associated with serpentine mélange containing blocks of Early Paleozoic rocks, sometimes referred to as "Oeyama equivalents" of ophiolitic origin (e.g., Eihiro et al., 2016), although ocean plate stratigraphy is not observed in the field. In this belt, the metamorphic rocks have Cambrian to Carboniferous ages and some of them have attained blueschist to eclogite facies conditions (Tsujimori, 2002; Yoshida et al., 2020). The Renge Metamorphic Belt is another Paleozoic metamorphic belt, consisting of HP–LT type metamorphic rocks and it shows Paleozoic K–Ar ages (330–280Ma; Nishimura, 1998, Tsujimori and Itaya, 1999). The Renge Belt was previously often included within the Hida Gaien Belt, however in this study we prefer to follow the nomenclature in accordance with recent compilation by Eihiro et al. (2016) and Kojima et al. (2016), as two separate belts because the latter rarely contains metamorphic rocks and serpentinite.

The Omi region in Niigata Prefecture (Fig. 3b) represents a typical area (Fig. 3b), where Paleozoic serpentinite mélange of the Renge Belt is extensively distributed (Matsumoto, 1980; Nakamizu et al., 1989). Kunugiza and Maruyama (2011) suggested that at about 520 million years ago, sedimentation in the fore-arc basin was active and hydrothermal activity in the subduction front formed the c.520 Ma zircons in jadetite rocks. They suggested that arc magmatism and hydrothermal activity operated between 520 and 470 Ma and a sequence of tectonic events was as listed below. (1) c. 520Ma: Oceanic island arc formation by plate subduction, extensive hydrothermal activity and high-pressure–low-temperature metamorphism. (2) c. 450 Ma: Along the subducting oceanic crust, serpentinite and high P–T schist are formed. (3) c. 380 Ma: The metamorphic phase reached the peak eclogite facies conditions. (4) c. 340 Ma: Ridge subduction and squeezing out of serpentinized mantle wedge together with other subducted rock units, forming a serpentinite mélange zone.

Recently, Yoshida et al. (2020) reported a 347+/-4 Ma age for high-pressure metamorphism in the Omi area by precisely dating the zircon rims in a blueschist using an ion probe. Furthermore, the majority of the detrital zircon LA-ICPMS ages obtained from a garnet-phengite schist and garnet-glaucophane schist were in a range of 420–600 Ma, with a prominent peak at around 470 Ma, consistent with the model proposed by Kunugiza and others. In addition, a recent study on amphibolite blocks from the Omi serpentinite mélange have reported U–Pb zircon ages of Ediacaran to Cambrian ages (Ichiyama et al., 2020).

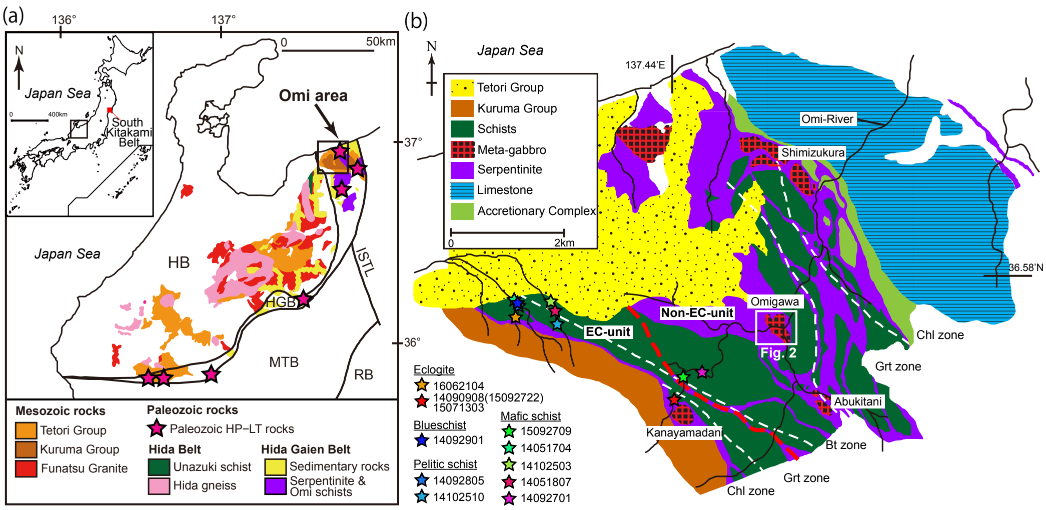

Fig. 3 *Map showing the location of the Itoigawa in a geotectonic setup with local geological features (after Satish-Kumar et al., 2021). (a) Simplified map showing the geological distribution of the Hida Gaien and Renge Belts (after Tsujimori, 2002) in the central Honshu region, SW Japan. These belts form a narrow fault bounded zone of Paleozoic volcano-sedimentary accretionary complex and subduction related HP–LT metamorphic rocks (indicated by stars) situated between the Hida Belt in the west and the Mino–Tamba Belt in the south. The eastern boundary of this belt is the Itoigawa–Shizuoka tectonic line (ISTL). The Omi area is located in the north, adjacent to the Japan Sea coast. HG: Hida Gaien Belt, HB: Hida Belt, MTB: Mino–Tamba Belt, RB: Ryoke Belt. (b) Geological map of the Omi area (after Matsumoto et al., 2011). The Omi schists are divided into chlorite, garnet, and biotite zones based on the mineral paragenesis in metapelites. Red dotted line marks the boundary between EC and non-EC units (after Tsujimori, 2002). Details of samples studied are presented in Yoshida et al. (2021) and Satish-Kumar et al. (2021)*

4. Locality descriptions

Stop 1: The Omi River (Hashidate) Jade Gorge

The main jadeitite localities of Itoigawa in the Renge Metamorphic belt include Omi, Hashidate, Kanayamadani, Kotaki and Yoshio (Kawano, 1939; Chihara, 1958). Varieties of jadeitite found in this region are white, blue, lavender, green, and black (Iwao, 1953; Chihara, 1971; Miyajima, 2017). The formation of jadeite in this region has been attributed to various causes, but recent studies have begun to explore the potential hydrothermal effects on jadeite formation. Morishita (2005) estimated the P/T conditions of the formation of jadeite from primary aqueous fluids as T <350°C and P ~ 0.6 GPa. Morishita et al. (2007) revealed that jadeitites formed as a result of direct precipitation of minerals from aqueous fluids or complete metasomatic modification of the precursor rocks by fluids, after their combined investigations on the morphology, texture, and chemical zoning of mineral grains in jadeitites. The age of formation of the jadeitite was estimated using U–Pb zircon dating to be 497 ± 23 Ma (Tsutsumi et al., 2010) and 519 ± 17 Ma (Kunugiza et al., 2017).

The Omi River (Hashidate) Jade Gorge was discovered by local residents in 1955, and research was conducted by Professor Kazuya Chihara of Niigata University (Chihara, 1958) (Fig. 4). In 1957, it became a national natural monument. At the site, high-pressure metamorphic rocks such as jadeitite, albitite, and schist. ***Note: Collecting rocks containing jadeitite at this location is prohibited.***

With the archaeological viewpoint, the ancient Itoigawa people of the Jomon age used jadeitite as tools as far as 6500 years ago, making it one of the oldest class jadeitite cultures in the world. The jadeitites from Itoigawa were the source of ornaments such as pendants or comma–shaped beads that can be dated to the Jomon age through to the Nara period. These ornaments are widely found in the Japan from Hokkaido to Okinawa Prefecture, and also in the southern part of the Korean Peninsula (Miyajima, 2017).

Fig. 4 *Locality map of Hashidate Jade Gorge*

Stop 2: Metamorphic rocks in the Omi river area

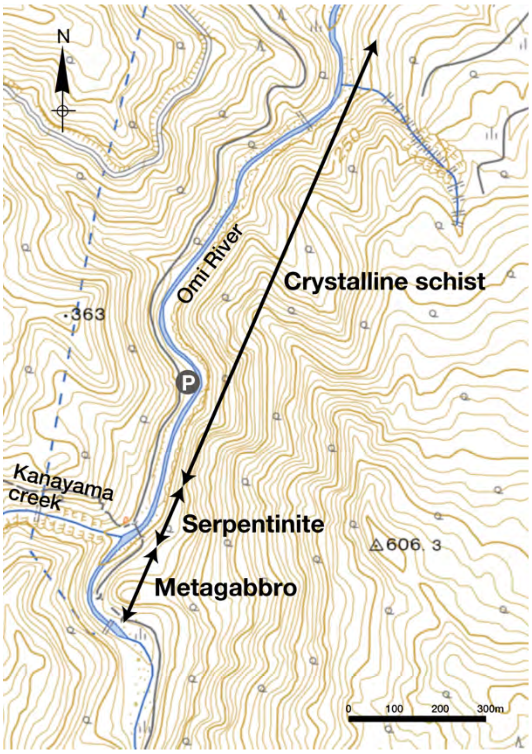

Fig. 5 *Route map of the Omi river*

The metamorphic rocks in the Omi area (Fig. 5), are divided into chlorite zone and biotite zone based on the metapelitic mineral assemblages (Banno, 1958; Matsumoto, 1980). Situated in a regional NW–SE trending antiform, the metamorphic temperature decreases both northeastward and southwestward from the central area, where the highest biotite-grade rocks such as garnet-amphibolite and garnet-biotite schist occur intercalated with serpentinite. Tectonic blocks of garnet-amphibolite, metagabbro, albitite and jadeitite are embedded in serpentinite (Matsumoto et al., 2011). Banno (1958) reported high-pressure schists for the first time and later studies revealed the presence of eclogitic glaucophane schists in the western part of this area (Tsujimori et al., 2000). Takenouchi (2004) conducted a detailed structural analysis of metamorphic rock units along the Omi River and revealed the deformation history of the area. Furthermore, the schist belt in the Omi area was divided into the eclogite unit (EC unit) and the non-eclogite unit (n-EC unit) by Tsujimori (2002). Blueschist to eclogite facies high-pressure rocks in the EC unit occur as layers embedded in garnet-phengite schists. On the other hand, n-EC unit consists of lower pressure and low-medium temperature metamorphic rocks of greenschist to epidote-amphibolite facies conditions. These metamorphic rocks are overlain by Jurassic sedimentary rocks of the Kuruma and Tetori groups with a basal conglomerate which contain clasts of the? Omi schists. Therefore, it is considered that the? Omi schists have already exhumed to the surface by the Jurassic period (Matsumoto et al., 2011). The Kuruma Group comprises Early Jurassic sedimentary rocks (Matsumoto et al., 2011 and references therein). The Tetori Group is composed of Late Jurassic to Early Cretaceous sedimentary rocks mainly of quartz-rich sandstone, conglomerate, mudstone and shelly limestone (Matsumoto et al., 2011). Furthermore, Tsujimori (2004) investigated the chemical characteristics of the zoning in Cr-spinel, and revealed that the origin of the serpentinite of the Omi serpentinite mélange is metamorphosed mantle peridotite of the subduction zone.

The Omigawa amphibolite (metagabbro) body, c. 300 meters long and c. 100 meters wide, is exposed in the banks of the Omi River. In the contact zone of this outcrop a highly deformed serpentinite is observed. Banding structure has a prominent north-south strike, westerly dip (Satish-Kumar et al., 2021).

During the excursion we will visit several typical outcrops of schists, serpentinites and amphibolites. Also, high pressure schists can be observed as boulders.

Stop 3: Fossa Magna Park (Itoigawa-Shizuoka Tectonic Line)

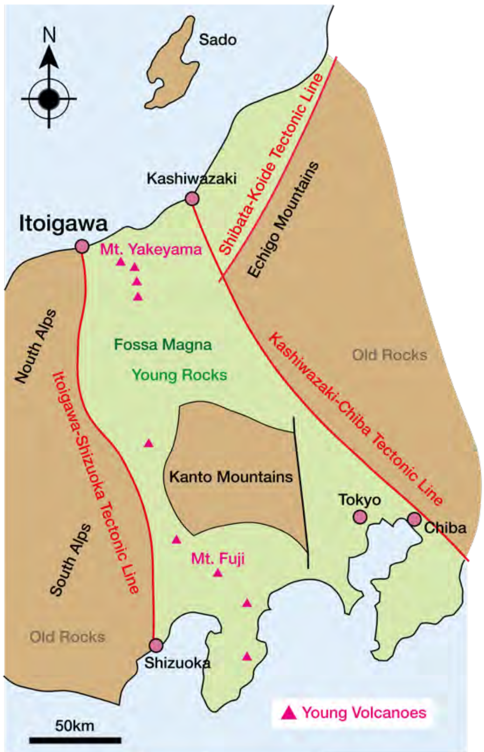

Fig. 6 Overview of the Fossa Magna

The Japanese Archipelago are split down the center between east and west by a large geological trench called the Fossa Magna at about 20Ma (Fig. 6). The rocks, strata and geology inside this Fossa Magna are very different from the rest of Japan. Its western boundary is a massive, 250-km-long fault called the Itoigawa-Shizuoka Tectonic Line, which is regarded as the boundary between the North American and Eurasian plates. At Fossa Magna Park, we can see this massive fault up-close, making it one of the most important sites in Itoigawa UNESCO Global Geopark.

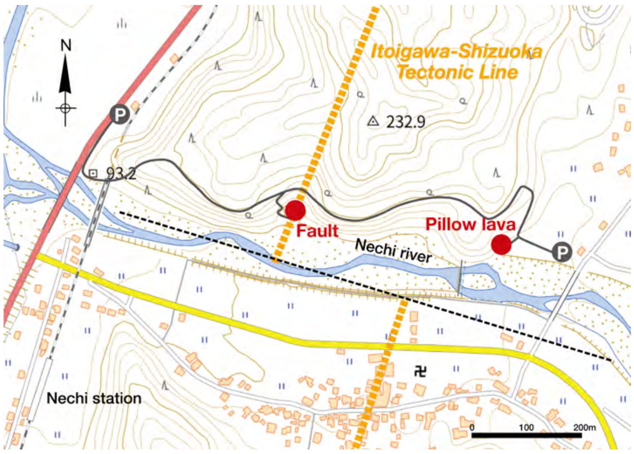

Fig. 7 Route map of the Fossa Magna Park

At Fossa Magna Park, Permian metagabbro and Miocene igneous rocks are observed (Takenouchi and Miyajima, 1996; Fig. 7). The litho-logical boundary between Permian rocks and Miocene rocks corresponds to the Itoigawa-Shizuoka Tectonic Line. Brittle fracture zone consists of fault breccia and fault gouge is widely formed along the lithological boundary. According to the results of structural analysis, this fault records fault activities under several stress fields.

Stop 4: Oyashirazu Cliff (Oyashirazu Formation, Late Cretaceous)

The Oyashirazu Formation consists of basaltic andesite, andesite, and dacite pyroclastic rocks. The Oyashirazu Formation consistently overlies Cretaceous sedimentary rocks and has a maximum thickness of about 1000 m.

In this outcrop, lapilli tuff of dacite with garnet phenocryst, which is weakly welded in some parts, can be observed. Phenocrystic minerals in this dacite consist of garnet, hornblend, biotite and plagioclase. 109-84 Ma has been reported from zircon in this dacite (F.T. and U-Pb; Takeuchi et al., 2017). Garnet bearing biotite-hornblende dacite (109 Ma, U-Pb; Takeuchi et al., 2015) intruding Cretaceous sedimentary rocks was observed about 5 km southwest of this site and is thought to be related to igneous activity of the Oyashirazu Formation.

Although the geochemical characteristics of these volcanic rocks are not known, it is thought that the Oyashirazu Formation and intrusions were formed by the Cretaceous continental arc igneous activity.

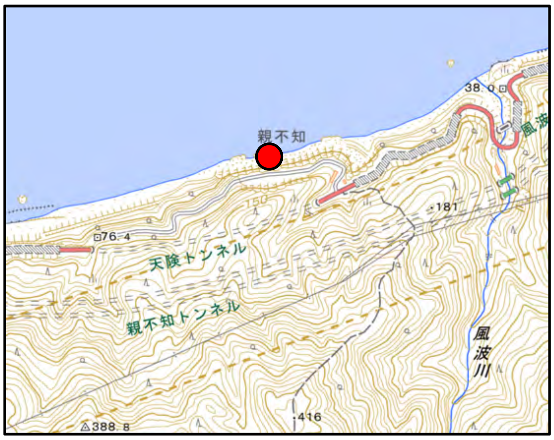

Fig. 8 Locality map of Oyashirazu cliff

Stop 5: Benten-iwa Rock (Eboshiyama Formation, Early Pleistocene)

The small island, called Benten-iwa Rock, is composed of volcanic breccia and tuff breccia of two-pyroxene andesite to basaltic andesite. Benten is one of the Seven Gods of Fortune, and She is the only woman of the seven gods. The Itsukushima Shrine is located on this Benten-iwa, where the goddess of the sea is enshrined.)

Some andesite breccia have the chilled margins in this outcrop, it is thought that the eruption occurred underwater (it may be the shallow seafloor). An age of 1.2Ma reported from andesite breccia of the Eboshiyama Formation (K-Ar; Ooba, 2006).

These andesites are the calc-alkaline andesite of Medium-K series (intermediate potassium), and show typical geochemical characteristics (such as a relatively strong depletion of Nb and Ta) of the Quaternary volcanic rocks in the Northeast Japan arc.

Fig. 9 Locality map of Benten-iwa Rock

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