Application Dossier for Nomination to the Global Geoparks Network

A Story of Gifts from Deep Inside the Earth Connecting Land and People Together

Mt. Apoi Geopark

JAPAN

http://www.apoi-geopark.jp/

INDEX

A. Identification of the Area

A-1. Name of the Proposed Geopark

The name of the proposed area is Mt. Apoi Geopark. Mt. Apoi is 810 meters high and located in Hokkaido, which is the northernmost island of the Japanese Archipelago.

The name Mt. Apoi derives from the language of the indigenous Ainu people of Hokkaido; it is a corruption of the term *Ape-o-i-nupuri* (meaning “the mountain where a big fire was made”), which originated in a legend that tells the story of Ainu people making a fire on top of the mountain and praying to a *kamuy* (god) for success in hunting deer (a vital part of the Ainu diet).

The most distinctive feature of Mt. Apoi Geopark is the mountain’s peridotites, which derive from the earth’s mantle. They are visible above ground because part of the upper mantle containing them, which is further beneath the crust, was pushed onto the earth’s surface by a collision of crustal plates. These rocks form part of Mt. Apoi as a complex. Naturally man has never set foot on the mantle because it is located deep under the earth’s surface. However, Mt. Apoi Geopark provides visitors with a window into the interior of the earth, allowing them to understand global-scale dynamic movements underneath the earth. These movements have produced unique and valuable colonies of alpine flora on Mt. Apoi that fascinate climbers from across Japan. The mountain also supports the daily lives of local residents.

The Mt. Apoi Geopark Promotion Council in the town of Samani hereby submits this application for the area to become a member of the Global Geoparks Network (GGN) as a globally unique place that provides insight into the depths of the earth. The application is based on the theme of narratives regarding our planet’s constitution, nature, and people connected by gifts from deep inside the earth (see B-2).

Fig. A-1 Location of Mt. Apoi Geopark

A-2. Location of the Proposed Geopark

Mt. Apoi Geopark is located near the southern tip of Hokkaido, which is the northernmost island of the Japanese Archipelago (Fig. A-1). Hokkaido is the second largest of the Japanese Archipelago’s many islands. This northern region is a leading domestic tourist destination and is home to the Toya Caldera and Usu Volcano Global Geopark, whose main theme is coexistence between people and the ever-changing earth.

Hokkaido is often likened to a ray fish due to its shape. Its backbone is the Hidaka Mountains, which have 1,500- to 2,000-meter peaks running 150 km from north to south. Mt. Apoi Geopark is located at the southwestern end of this range in the administrative district of Samani Town (Fig. A-2).

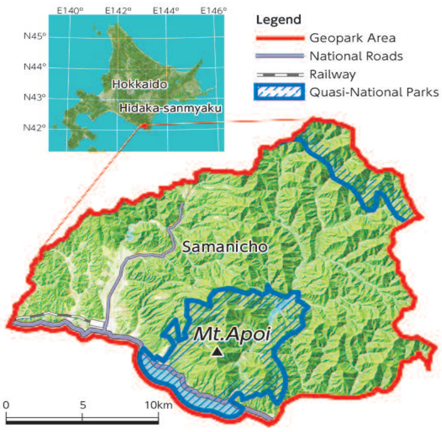

Fig. A-2 Mt. Apoi Geopark area

Geographic coordinates of the Mt.Apoi Geopark area

	Samani Town office	Eastern end	Western end	Southern end	Northern end
Longitude	142° 56' 02" E	143° 12' 11" E	142° 51' 49" E	143° 04' 04" E	143° 07' 01" E
Latitude	42° 07' 40" N	42° 06' 15" N	42° 08' 11" N	42° 03' 39" N	42° 15' 37" N
Altitude	0m - 1365m				

A-3. Surface area, physical and human geography characteristics of the proposed Geopark

A-3-1. Area of the Proposed Geopark

Mt. Apoi Geopark has a total area of 364.3 km^2, extending 20.6 km from north to south and 20.2 km from east to west, and has a Pacific coastline of 24.2 km. The area around Mt. Apoi is part (5,630 ha) of Hidaka-sanmyaku Erimo Quasi-National Park, the largest park of its kind in Japan (Fig. A-2).

A-3-2. Geographical Setting of the Proposed Geopark

The Hidaka Mountains formed when the North American Plate was pushed up onto the Eurasian Plate due to a collision between the two. As a result, the area to the west of the mountains (known as the Hidaka region), which was pushed by the overlying plate, is mostly hilly terrain and middle-relief mountains, with settlements concentrated in the coastal area and river basins (Fig. A-3).

About 92% of Mt. Apoi Geopark is forestland. The Apoi Mountains (Mt. Apoi: 810 m; Mt. Pinneshiri: 958 m) – a branch of the Hidaka Mountains – run from north to south in the eastern part of the Geopark. Despite being under 1,000 meters high, these peaks serve as local landmarks. Meanwhile, hilly terrain consisting of Cretaceous Period formations stretches over the western part of the Geopark, with settlements located along the coastline. The coast is characterized by a number of large intrusive-rock monoliths, creating a beautiful contrast with the Apoi Mountains.

Fig. A-3 Locations of the Hidaka Mountains and Mt. Apoi Geopark

A-3-3. Access

(1) Hokkaido

Access to Hokkaido is generally by air. The most convenient route from outside Japan involves flying to Hokkaido's New Chitose Airport via Narita, Tokyo or Kansai International Airport on Japan's main island of Honshu, but direct flights to New Chitose Airport also run from East Asia and Southeast Asia.

(2) Mt. Apoi Geopark

Train, bus and rental-car services are available from New Chitose Airport to Mt. Apoi Geopark. The train journey involves transfers and takes about 3.5 hours, while the bus or rental-car journey takes just 3 hours.

Railway and road travelers alike have opportunities to enjoy the beautiful landscapes of Hokkaido en route. The vast Yufutsu wilderness stretching to the south of New Chitose Airport consists of volcanic ash ground formed by eruptions of Shikotsu Volcano, Mt. Tarumae and other volcanoes, and is home to the Bibi River, Lake Utonai, Benten Marsh and other marshes. Lake Utonai is a fresh-water lagoon with an area of only about 2 km^2, but serves as an important stopover for waterfowl such as white-fronted geese and swans, and is a wetland site designated under the Ramsar Convention (1991).

After passing the Yufutsu wilderness, travelers head eastward along the coast to the west of the

Hidaka Mountains. Terraces extend along the coast and the surrounding area is dotted with farms where thoroughbred racehorses are raised. Farther along, the ridge of the Hidaka Mountains in the distance on the left gradually comes closer and meets with the Pacific Ocean at Mt. Apoi. Therefore, the railway ends at Mt. Apoi.

A-3-4. Social Economy

(1) Population

Samani Town, where Mt. Apoi Geopark is located, has a population of 5,114. This is almost half the peak figure of 10,163 recorded in 1955 (population census data, 1955 – 2010). The depopulation rate is particularly high for the most recent decade at approximately 1.8 percent a year (population census data, 2000 – 2010).

Although provincial depopulation affects the whole of Japan, it is pronounced in Samani due largely to a lack of people returning to the town because of its fragile industrial infrastructure.

(2) Economic Activity

The main local industries are fishing, mining, and manufacturing. While the annual production value of the latter two industries is 10,279 million yen (Census of Manufacturers, 2010), that of the fishing industry is only 2,480 million yen (Catch Statistics, 2011). Despite this disparity, the fishing industry can be considered to support the local economy in terms of the large number of jobs it creates and its significant ripple effects on the region's economic wellbeing. The tourist industry accounts for only a small part of the local economy, but an average of 100,000 visitors come to the region annually.

A-3-5. Natural environment

(1) Landscape

Mt. Apoi Geopark is located at the point where the Hidaka Mountains meet the sea. This flat area affords sweeping views of the Apoi Mountains (Fig. A-4) to the east and the main ridgeline of the southern part of the Hidaka Mountains to the north. In addition to the main ridgeline, the Apoi Mountains also form another sharp ridgeline unique to their main range (the Hidaka Mountains), creating a beautiful form against the sky. Meanwhile, the relatively monotonous coastline that stretches to the western part of the region drastically changes in Mt. Apoi Geopark with extensive sea cliffs to the south of Mt. Apoi. This scenic spot is known as Hidaka Yabakei.

The region is characterized by a combination of mountainous and coastal landscapes. This is exemplified by the view of rocky monoliths formed by coastal erosion and Mt. Apoi behind them (Fig. A-5) as seen from high ground in the western part of the region. Typical local scenes along the coast include fishing ports of varying sizes, traditional fishing villages, fishing boats on the sea and drying of kelp (a local specialty) (Fig. A-6).

Fig. A-4 Mt. Apoi – Mt. Pinneshiri

Fig. A-5 Rocky monoliths along the coast and Mt. Apoi

Fig. A-6 Family kelp drying

(2) Natural Monuments and Scenic Spots

The alpine plant communities found across the summit area of Mt. Apoi have been designated by the Japanese government as a Special Natural Monument of Japan. They consist of ultrabasic plants endemic to the mountain, such as Hidakaso (*Callianthemum miyabeanum*), Ezokozorina (*Hypochoeris crepidioides*) and Apoikuwagata (*Veronica schmidtiana var. yezoalpina form. exigua.*), a number of rare species, and alpine types that grow even at low altitudes on Mt. Apoi (Fig. A-7). The

Himechamadaraseseri (*Pyrgus malvae*) butterfly, whose habitat is Mt. Apoi and the surrounding area (i.e., the Apoi Mountains and Mt. Horoman), has also been designated as a Natural Monument of Japan. This is a northern species seen extensively in Eurasia, but in Japan is found only on Mt. Apoi and the surrounding area (Fig. A-8). The spread of Kitagoyo (*P. parviflora var. pentaphylla*) trees across the foot of Mt. Horoman is another Natural Monument of Japan known as the Northern Limit of Horoman Japanese White Pine's Habitat. Black woodpeckers and Blakiston's fish owls living in woodland areas of Mt. Apoi and the surrounding area as well as Steller's sea eagles, white-tailed eagles, bean geese, and white-fronted geese that fly to the region in winter are also Natural Monuments of Japan (Fig. A-9).

The region's concentration of Natural Monuments highlights the significance of its natural environment. It is also noteworthy that these rare biotic communities are closely related to geohistorical factors unique to Mt. Apoi and the surrounding area.

Fig. A-7 Hidakaso (*Callianthemum miyabeanum*) – an endemic species native to Mt. Apoi

Fig. A-8 Himechamadaraseseri (*Pyrgus malvae*) – a Natural Monument of Japan

Fig. A-9 Steller's sea eagle – a Natural Monument of Japan

(3) Climate

The region's climate, which is hemiboreal (Dfb) according to the Köppen classification, is strongly influenced by the sea. The average yearly temperature is 8.0°C, and the average temperature of the coldest month (January) is −2.5°C – considerably higher than other regions of Hokkaido. However, the temperature of even the warmest month (August) is below 20°C at 19.9°C. These characteristics arise because this sea-facing region is not affected by strong radiative cooling in winter, while dense fog brought in by winds passing over cold currents mitigates temperature increases in summer (Fig. A-10). The annual minimum temperature is around −11°C, and the 30°C level has been exceeded only three times in the recorded history of over 50 years. The annual average number of foggy days is 56, and many of these are in summer. The annual average number of days with maximum wind speeds of at least 10 meters is 121, which rises to 270 at Cape Erimo in the eastern part of the region. Annual precipitation is relatively low at around 1,000 mm, but shows a slight increasing tendency in summer. As the region faces the Pacific Ocean, the amount of snowfall is small; the average maximum snow depth is just 21 cm.

Fig. A-10 Sea fog – a common local sight in summer

(4) Ecosystems

The region is largely characterized by relatively limited economic activity and a smooth transition from a coastal environment to an alpine environment across a compact tract of land. The coast near Mt. Apoi and its surroundings remain particularly unspoiled, with characteristic continuity between local marine and terrestrial ecosystems. The region is predominantly covered by trees, with forests of evergreen coniferous or mixed coniferous and broad-leaved species stretching over Mt. Apoi, Mt. Horoman and the surrounding areas (Fig. A-11). The forest communities in this region represent one of the world's only habitats where Kitagoyo (P. parviflora var. pentaphylla; a cool temperate-zone species) and alpestrine Glehn's spruce trees grow together. This spectacular natural environment has brought Mt. Apoi and the surrounding area, including the coastal zone, designation as part of Hidaka-sanmyaku Erimo Quasi-National Park.

This region provides habitats for alpine plants and animals, such as the Japanese pika, that are normally not found in low altitudes, and also represents the eastern limit for numerous temperate-zone plants (e.g., *Stephanandra incise* and *Quercus serrata*). An extraordinary ecosystem characterized by the coexistence of northern and temperate flora and fauna has consequently formed, making the area a biodiversity hotspot. The presence of alpine plants at low altitudes is attributed to light snowfall and strong winds in winter, cool summer weather and unique geological conditions. The distribution of several temperate-zone plants in this region defies explanation based on present climatic conditions alone, and is therefore seen to reflect the ancient connection of land between Hokkaido and the northern Honshu region of Japan, which are today separated by the Tsugaru Strait.

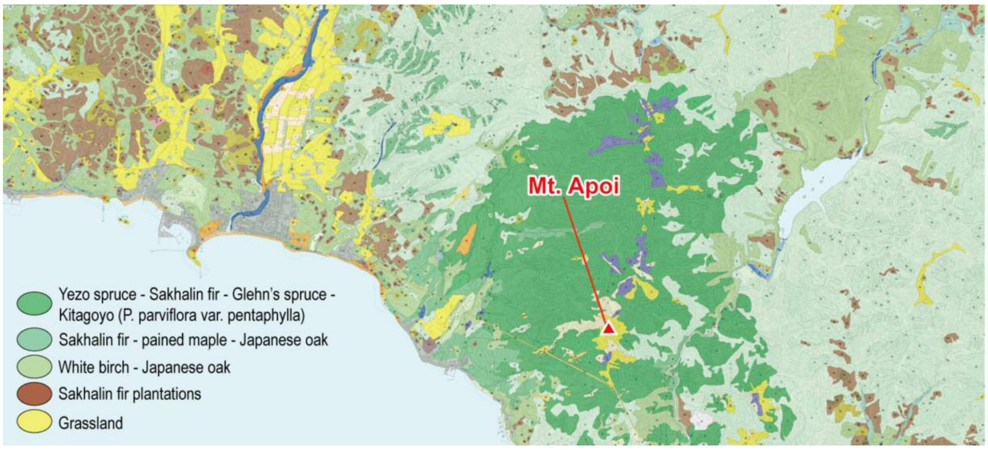

Fig. A-11 Vegetation map of Mt. Apoi and the surrounding area (source: National Survey on the Natural Environment (Vegetation Survey), Ministry of the Environment). The main local species are deciduous broad-leaved trees (e.g., Japanese oak), but coniferous trees dominate Mt. Apoi and its surroundings (mostly corresponding to the area of surface peridotite exposure).

A-3-6. History and Culture

(1) Historical Background

Hokkaido's indigenous Ainu people (those who lived in northern Japan before people of ethnic Japanese decent) carried on the traditions of the nearly 10,000 year long prehistoric Jomon period (12,000-300BC), and thus subsisted on hunting, fishing, and gathering. The relevant eras are the Epi-Jomon culture period (2nd century B.C. – 6th century A.D.), the Satsumon and Okhotsk culture periods (7th century – 12th century) and the Ainu culture period (13th century onward). Most Hokkaido place names are derived from the Ainu language, and oral folklore tells of the region's geology. Hokkaido is home to more than 500 known sites previously occupied by Ainu forts called *chashi*, and legends of such forts are also associated with Mt. Apoi Geopark (Fig. A-12).

Fig. A-12 Mt. Kannon – the setting of a *chashi* legend

Everyday aspects of Ainu culture are no longer passed down today due to the assimilation of Ainu people into Japanese society following the settlement of *wajin* (people of ethnic Japanese descent) from the main island of Honshu and elsewhere primarily in the 18th century. However, oral traditions (such as *yukar* epic poetry) and

Fig. A-13 Preserved elements of traditional Ainu culture other aspects of the culture have been passed down from generation to generation. Traditional Ainu dance, which has been preserved in the region, was designated as an Important Intangible Folk Cultural Property of Japan in 1984 (Fig. A-13).

(2) Culture and Customs

The region is home to numerous shrines dedicated to prayers for safe and bountiful fishing activities and good harvests. Small-scale festivals have long been held in settlements where these shrines are located (Fig. A-14).

The annual summer Apoi Fire Festival features the re-enactment of a legend in which Ainu people built a fire at the top of the mountain. This major event promotes enjoyment of the short local summer, with floats created by local communities being paraded through the region (Fig. A-15). Events at which local products are sold are also held in autumn.

In this region of sea and mountains, locals harvest wild edible greens in the mountains in spring and make *izushi* from salmon or other fish in winter. *Izushi* is a traditional preserved food made by fermenting fish with vegetables, rice, other ingredients and lactic acid. The recipe varies from family to family (Fig. A-16).

Fig. A-14 Annual Sumiyoshi Shrine Festival

Fig. A-15 Apoi Fire Festival

Fig. A-16 Production of salmon *izushi*

A-4. Organization in charge and management structure of the proposed Geopark

A-4-1. Management Body

Mt. Apoi Geopark is operated by the Mt. Apoi Geopark Promotion Council in Samani, which was established in July 2008 by the Samani municipal government and assembly, economic, industrial, and citizen councils, and other organizations. The Mayor of Samani serves as its President.

As a rule, a General Committee meeting is held once a year for the discussion and approval of budgetary matters and plans. The Executive Committee consists of the President, the Vice-President and subcommittee chairs, and makes coordinated decisions on business plans discussed by three subcommittees (the Planning and Finance Subcommittee, the Education and Public Awareness Subcommittee and the Tourism and Industry Subcommittee). The subcommittees create and formulate plans in conjunction with the Secretariat (Fig. A-17).

A-4-2. Secretariat Structure

The Secretariat is part of the Samani Town Government's Commerce, Industry and Tourism Department, and has staff tasked with the promotion of Mt. Apoi Geopark. As of November 2014, the Secretariat has six staff: one administrator, three clerks, one geological expert (with an MS degree in petrology) and one curator (botany). The Secretariat also has four clerks who additionally work for individual subcommittees. In fiscal year 2015, an expert in history will be hired to reinforce investigation and utilization efforts relating to local historical matters (e.g., Ainu culture).

A-4-3. Academic Support Structure

The Mt. Apoi Geopark Promotion Council in Samani receives academic support from experts on peridotites and alpine plants – two main features of Mt. Apoi Geopark (Fig. A-18).

Geology	
Shoji Arai	Faculty of Natural Systems, Institute of Science and Engineering, Kanazawa University
Tsuyoshi Toyoshima	Graduate School of Science and Technology, Niigata University
Eiichi Takazawa	Graduate School of Science and Technology, Niigata University
Takashi Sawaguchi	Department of Economics, Faculty of Economics, Toyo University
Kiyoaki Niida	GeoLab Mt. Apoi
Biology	
Takehiro Masuzawa	Faculty of Science, Shizuoka University
Ken Sato	Department of Life Science and Technology, Faculty of Engineering, Hokkai-Gakuen University
Masashi Ohara	Faculty of Environmental Earth Science, Hokkaido University
Yoshimi Takahashi	Researcher, former junior high school teacher

Fig. A-18 Academic support structure (advisors)

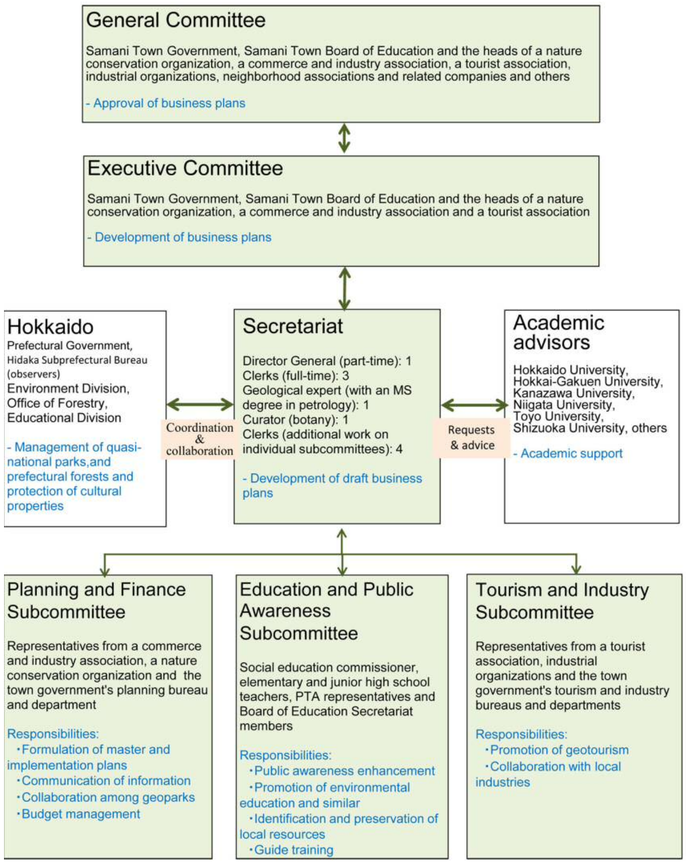

Fig. A-17 Organization of the Mt. Apoi Geopark Promotion Council in Samani

A-4-4. Budget and Finance

The Mt. Apoi Geopark Promotion Council in Samani is funded primarily by subsidies from the Samani Town Government, tour revenue and income from merchandise sales. Funding is allocated to the Council's operation, public awareness enhancement activities (e.g., workshops, campaigns, guide training), matters concerning geo tours and other considerations.

Meanwhile, guidebooks, pamphlets, signs, websites and other informational tools are developed by the Samani Town Government based on plans devised by the Mt. Apoi Geopark Promotion Council in Samani.

The Hokkaido Government is in charge of local preservation and environmental improvement efforts in the area designated as part of the quasi-national park.

A-5. Application Contact Person

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B. Geological Heritage

B-1. General geological description of the proposed Geopark

B-1-1. Geological position and background

Hokkaido is the northernmost island of Japan, and is located between the Pacific Ocean and the Asian Continent. The Hidaka Mountains in the central axial region of Hokkaido are characterized by 2,000-meter peaks, running from north to south, forming the island's backbone, and dividing into eastern and western Hokkaido. As shown in Fig. B-1, Mt. Apoi (altitude: 810.2 m; 42° 06' 28" N, 143° 01' 31" E) lies at the southern end of the Hidaka Mountains, facing the Pacific Ocean.

Looking at Hokkaido from the ocean floor of the Pacific, there are steep escarpments off of the Kuril Islands and Northern Honshu. The Kuril Trench (running from Kamchatka to eastern Hokkaido) intersects with the Japan Trench (running further southward from western Hokkaido to Honshu). Geographically speaking, this is the site where the Kuril arc is merging with the Honshu arc.

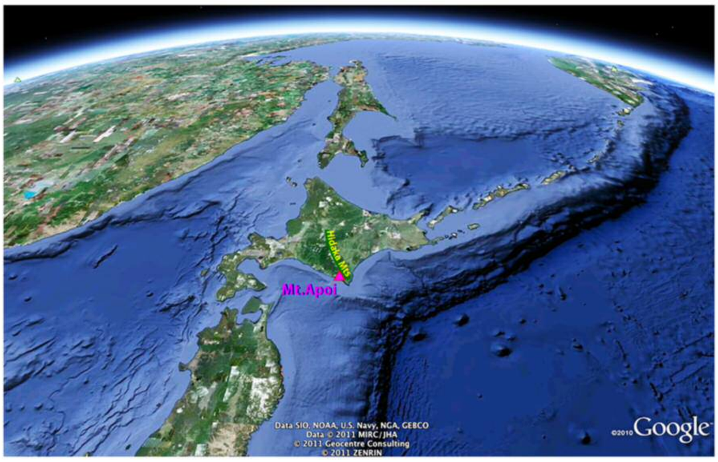


Fig. B-1 Topographical map around Hokkaido and Mt. Apoi (courtesy: Google Earth)

As shown in Fig. B-2, Hokkaido is located at a triple junction of three major plates covering the earth's Northern Hemisphere: the Pacific Plate, the North American Plate, and the Eurasian Plate. This section highlights the location of Mt. Apoi Geopark in relation to these plates. The Pacific Plate subducts to the northwest beneath the Japanese archipelago at the northwestern margin of the Pacific Ocean. The subduction rate is approximately 10 centimeters a year. As clearly shown in the map of Fig. B-1, Hokkaido was located at the boundary between the North American Plate and the Eurasian Plate, both of which stayed above the subduction slab of the Pacific Plate, at the beginning stage of the Hidaka Mountains building.

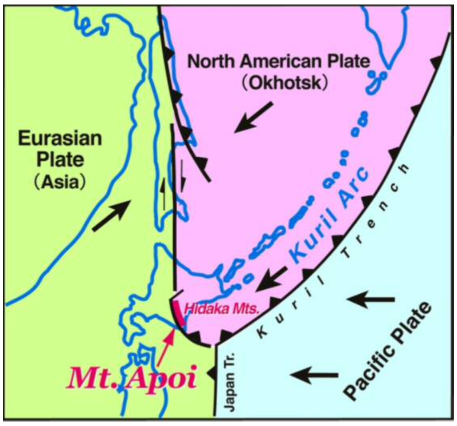


Fig. B-2 Map showing relationship of 3 major plates in areas near Hokkaido, at the beginning stage of the Hidaka mountain building (Niida, 1999). Mt. Apoi was located at the southwestern margin of the North American Plate, colliding on the Eurasian plates.

Figure B-3 (map of the Northern Hemisphere) shows an arrangement of these three major plates on a global scale. The northern extension of the plate boundary between the North American and the Eurasian plates can be traced to the Atlantic Ocean, on the other side of the globe. Here, successive submarine volcanic activity along the axis of the Mid-Atlantic Ridge creates an oceanic lithosphere (comprising the crust to the uppermost mantle) of the Atlantic Ocean floor. The average spreading rate is 2~3 centimeters a year on one side, which has continued steadily since the end of the Jurassic Period, when the seafloor spreading began to form the Atlantic Ocean.

As shown in Figure B-3, the divergent plate boundary of the Mid-Atlantic Ridge continues northward to the Arctic Ocean near the North Pole. The sense of divergence in plate motion changes into a convergent boundary, near the North Pole onward. In the area surrounding Hokkaido, the plate boundary between the two plates is located at the eastern margin of the Sea of Japan (thick solid line). At the present stage, the Eurasian Plate is considered to have begun a new subduction eastward beneath Hokkaido along the boundary. The other boundary along the central axial zone of Hokkaido (thick broken line in Fig. B-3) was there when the Hidaka Mountains started lifting up, 13 million years ago. Then, the western margin of the North American Plate is thought to have been thrust onto the Eurasian Plate to the west, resulting in the formation of the mountains.

B-1-2. Geological Overview

This section outlines the geological characteristics of Mt. Apoi Geopark and the surrounding area. The Hidaka Main Thrust (HMT) extends along the western foot of the Hidaka Mountains in the central part of Fig. B-4. The eastern and the western areas of the HMT have completely different geological features. Metamorphic and plutonic rocks are observed in the Hidaka Metamorphic Belt, covering the Hidaka Mountains to the east, while the western area is characterized by the Cretaceous fore-arc basin sedimentary rock and the accretionary complexes that formed on trench slopes from the late Cretaceous to the Paleogene period.

The HMT can be recognized as a global-scale mobile belt of the Earth. The location corresponds to the convergent plate boundary shown by the thick broken line over central Hokkaido in Fig. B-3 (map of the Northern Hemisphere). Therefore, Mt. Apoi Geopark is a showcase which is composed of two distinct geological formations that were created in different places of the different plates. Mt.Apoi Geopark gives an opportunity to experience the outcome of global-scale motion of the Earth for visitors.

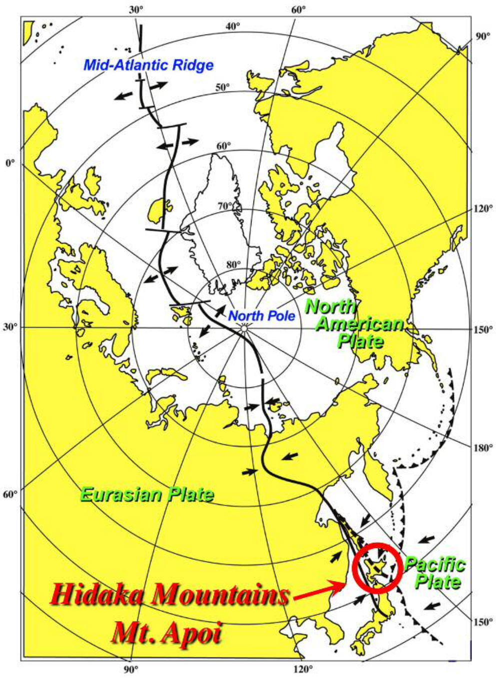


Fig. B-3 Map of the Northern Hemisphere of the Earth, showing the relationship between of the Northern American and Eurasian plates. (Niida, 2010). The thick solid line shows the present boundary between the Northern American and Eurasian plates. The thick broken line running along the central axial zone of Hokkaido indicates the plate boundary at the Hidaka mountains building stage (late Miocene). See Fig. B-2.

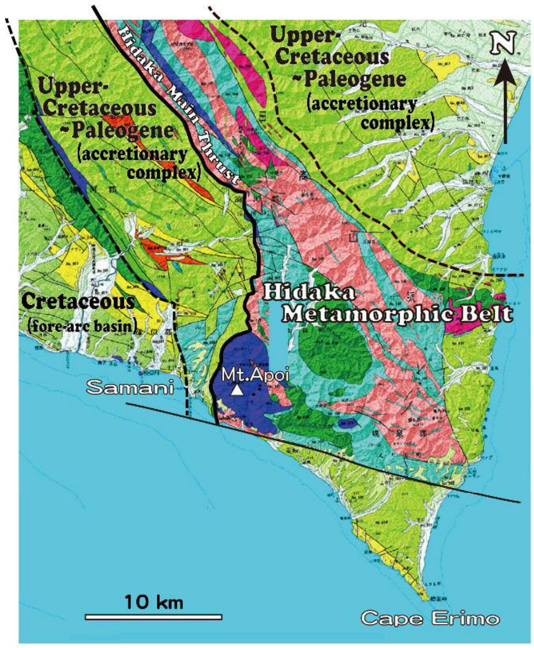


Fig. B-4 Simplified geological map of Mt. Apoi Geopark and the surrounding area, showing major geological units. Referred from the Seamless Digital Geological Map of Japan 1:200,000: Hokkaido (Geological Survey of Japan, 2003).

(1) Geological features of the Hidaka Mountains and local rocks

The Hidaka Metamorphic Belt extends from the Hidaka Main Thrust (HMT) to the eastern foot of the Hidaka Mountains as shown in Fig. B-4 (geological map). The Horoman peridotites derived from the upper mantle are exposed on the earth's surface at the base of the metamorphic belt, and are overlaid with a sequence of geological formations formed within the deep-seated Earth's crust to the east. These are granulites and amphibolite (high-grade metamorphic rocks representing the lower crust), biotite gneiss and biotite schist (representing the middle crust) and schistose hornfels and other hornfels (representing the upper crust). Large masses of gabbro that solidified in basaltic magma chambers in the lower crust are exposed on the western side of the Hidaka Mountains, and diorite and granite that formed in magma chambers in the shallow crust are exposed from the eastern side to the foot of the mountain range. The east-west geological cross-section of the Hidaka Mountains is shown in Figure B-5, indicating the most representative metamorphic and plutonic rock types in the Hidaka Mountains, as well as geological structures dipping eastward.

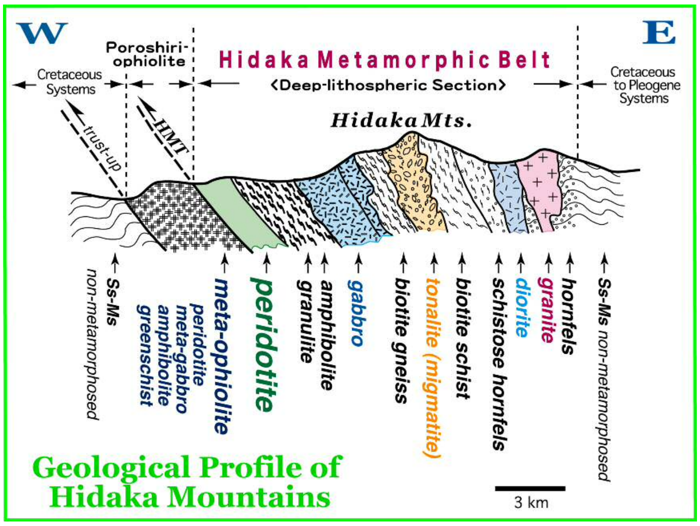


Fig. B-5 Geological cross-section of the Hidaka Mountains (Niida, 1997). HMT: Hidaka Main Thrust. This profile shows a geological sequence of the most representative metamorphic and plutonic rock types, which are typically observed in E-W traverse of the Hidaka mountain range. All the geological piles are dipping eastward.

This section highlights two valuable rock specimens collected from the Hidaka Mountains. The first is granulites, which is a high-grade metamorphic rock representing the lowermost crust (Fig. B-6). Granulites are primarily composed of garnet, orthopyroxene, cordierite and plagioclase, and the estimated equilibrium temperature and pressure based on geothermobarometry are T = 800°C and P = 7.5 kbar (Osanai, 1985). The other is sillimanite tonalite (Fig. B-7), which was crystallized from tonalitic magmas injected into biotite gneiss in the middle crust, containing large crystals of sillimanite.

Extensive research has been conducted to determine the age of the metamorphic and the igneous rocks by using radioactive isotopes. The Hidaka Metamorphic Belt is known as an extremely young formation based on the age determination indicating between 55 and 17 million years ago (from early Paleogene to middle Miocene) (The Geological Society of Japan, 2010).

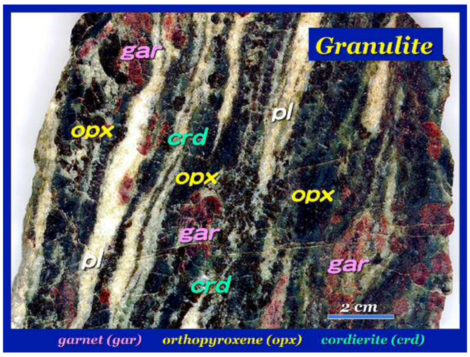


Fig. B-6 Granulite from the upper Horobetsu River, composed of garnet, orthopyroxene, cordierite and plagioclase. This represents a high - grade metamorphic rock from the lowermost crust.

Fig. B-7 Sillimanite tonalite from the beach at Chipira, containing columnar megacrysts of sillimanite. This represents a typical rock forming the middle crust of an active island arcs.

The temperature-pressure chart of Fig. B-8 plots the estimated equilibrium temperature and pressure for typical metamorphic rocks, such as granulites, amphibolite, biotite gneiss, schist and hornfels, obtained from the Hidaka Mountains (Osanai, 1985). The thick broken line shows a geothermal gradient (i.e., the rate of temperature increase with depth) during metamorphism within the Earth's crust. The highest geothermal gradient of metamorphic rock in the Hidaka Mountains is approximately 34°C/km as clearly shown in Fig. B-8. This is identical to that of the underground temperature gradient beneath the central axial ranges of an island arc with ongoing volcanic activity such as the Japanese island arc. Geothermal gradients of around 30°C/km are not as high as those observed in mid-ocean ridges, but are substantially higher than continental gradients (approx. 10°C/km) and oceanic island gradients (approx. 15°C/km).

The Hidaka Mountains are made up of geological units formed at the deeper interior of an island arc lithosphere. They are scientifically and educationally significant because they provide a visual representation of deep-seated lithospheric geology of a very active island arc. In the Hidaka Arc as shown in Fig. B-8, granulites and amphibolite in the lowermost crust partially melted when the underground temperature exceeded approximately 850°C, which is a melting point for felsic tonalite magma. In the Japanese archipelago and other tectonically active island arcs, metamorphic rock below 25 kilometers underground is heated to temperatures above the melting curve, causing melt generation. Here we can consider melting events generating in an active lower crust of an arc such as Japan.

In the Hidaka Mountains, regularly stratified geological formations are well preserved from the upper mantle to the shallow crust, where these metamorphic and igneous rocks formed. As a result, the geological event of magma generation beneath the island arc is possibly explained as shown in a reconstruction model of the Hidaka Mountains (Fig. B-9). In the Hidaka Mountains, the representative types of metamorphic and igneous rocks can be observed in outcrops on the earth's surface, providing outstanding opportunities for people to understand the depths of an island arc lithosphere.

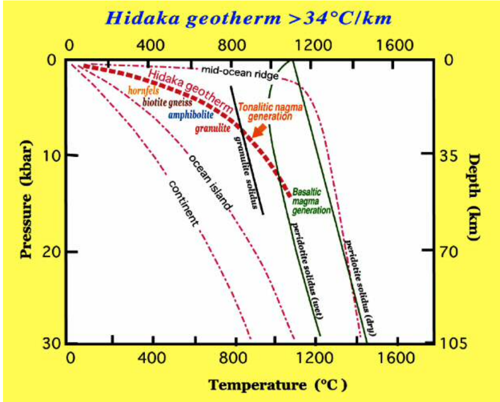


Fig. B-8 Temperature-pressure chart for metamorphic rocks from the Hidaka Mountains (Niida, 1999), showing a high geothermal gradient (approximately 34°C/km).

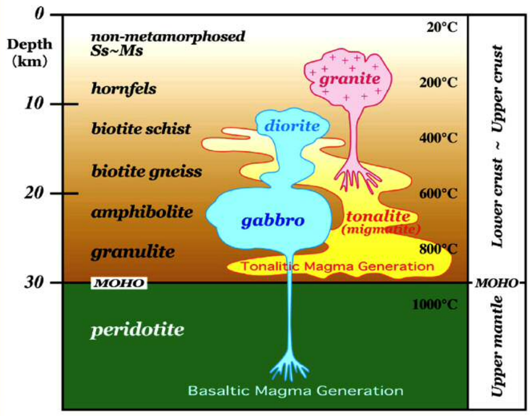


Fig. B-9 Reconstruction model for generations of the Hidaka metamorphic and igneous rocks (Niida, 1999), showing a spatial distribution of representative rock types. This corresponds to those in the geological cross-section (Fig. B-5).

(2) Geology of the western mountains foot to the coastal areas

The sedimentary rocks, observed in the areas from the foot of the Hidaka Mountains west of the Hidaka Main Thrust (HMT) to the coastal areas, are originated from the Cretaceous arc-trench systems (i.e., those in the Cretaceous fore-arc basin area, and the late Cretaceous to Paleogene accretionary complex area). This geology differs significantly from that of the Hidaka Metamorphic Belt, which includes metamorphic and plutonic rocks. The ages of the rocks are also different (The Geological Society of Japan, 2010). Accordingly, it is stressed that Mt. Apoi Geopark is a showcase of a level of geodiversity that clearly represents a typical arc-trench system.

(a) Cretaceous system (fore-arc basin area)

As shown in the geological map (Fig. B-4), sedimentary rocks (e.g., sandstone, mudstone, and their alternations) that originated in the Cretaceous fore-arc basin are distributed in the coastal area from Urakawa Town to Samani Town around the lower streams of the Horobetsu and the Samani rivers. The Cretaceous system in this region often corresponds to the Yezo Group (mostly to the Middle Yezo Group distributed along the central axial part of Hokkaido). In part of the region (i.e., that in the northwestern area of the figure), the Lower Yezo Group and the Sorachi Group are also distributed on a smaller scale. These areas belong to the southernmost region of the Sorachi-Yezo Belt in the tectonic division for Cretaceous systems in Hokkaido (The Geological Society of Japan, 2010).

Fig. B-10 Alternating sandstone and mudstone layers (Middle Yezo Group) behind Samani Elementary School.

(b) Upper Cretaceous – Paleogene System (accretionary complex area)

The late Cretaceous to Paleogene accretionary complex is distributed in areas across the middle to the upper streams of Horobetsu and Samani rivers in the foot of the Hidaka Mountains. The complex was formed from the late Cretaceous to the early Paleogene in the accretionary prisms near the trench slope of the Cretaceous arc-trench system. They consist mostly of sandstone and mudstone, and also include a large number of blocks of limestone, chert, basaltic pillow lava, and other types of greenstones everywhere. The rocks vary in size from gigantic (several hundred meters) to small (several centimeters), and are incorporated within a matrix of sandstone and mudstone. The blocks are exotic, having older ages from the Triassic to the Jurassic Period, and are considered to have formed in seamounts and oceanic islands on an old oceanic plate (The Geological Society of Japan, 2010). The Upper Cretaceous to Paleogene systems are also extensively distributed in areas to the northeast of the Hidaka Metamorphic Belt, and are characterized by transition to hornfels of the Hidaka Metamorphic Belt in the area shown by the broken line in Fig. B-4.

(c) Neogene System (sedimentary rocks and porphyrite dykes)

Neogene sedimentary rocks and porphyrite dykes are distributed in a limited small area of the coastal region, which is a residential area of Mt. Apoi Geopark. The sedimentary rocks are composed primarily of conglomerate, sandstone, and mudstone, containing shell fossils from shallow-sea habitats. The porphyrite dykes are observed in sandstones and mudstones in the Cretaceous System (the fore-arc basin area), forming a beautiful landscape of oddly shaped rocks along the Samani coast. As the porphyrite dykes at Mt. Kannon, Shiogama Tunnel, Rosoku-iwa, Oyako-iwa, Sobira-iwa, and Cape Enrumu are harder than the surrounding sedimentary host rocks, it forms landscapes of oddly shaped masses unaffected by coastal erosions.

Fig. B-11 A distinctive coastal landscape of Mt. Apoi Geopark formed by porphyrite dykes.

(3) Terraces at the foot of Mt. Apoi (Samani – Horoman coasts)

Fig. B-12 Marine terraces observed in coastal areas from the Samani coast to the Horoman coast at the southern foot of Mt. Apoi. (Terrace surfaces t1 – t4: after Kanie and Sakai (2002)).

Remarkable terraces can be observed from the Samani coast to the Horoman coast at the southwestern foot of Mt. Apoi. Figure B-12 is a view of Mt. Apoi from Cape Enrumu; flat coastal terraces can be seen at the foot of the mountain. The 1:50,000 Geological Map of Horoizumi shows four planes with the highest at an elevation over 300 meters and the lowest at 20 meters. The presence of marine terrace deposits consisting of gravel, sand and clay has been confirmed in the area (Hunahashi and Igi, 1956). The coastal terraces located in the area from the Samani coast to the Horoman coast were also examined in an article by Ouchi (1978) on the history of terrace development in areas near the Hidaka Mountains.

Fig. B-13 Terrace deposits covering the rock at Geosite D-1, Fuyushima's Ana-iwa. The yellow arrow points to pebble layers.

The terraces at the foot of the mountain, particularly in one of Samani's residential areas, are considered an important geological feature directly related to the natural environment involving local human and pre-human history. Accordingly, it is necessary to understand aspects of natural environmental transition closely related to local life, such as ground movement caused by an uplift of the Hidaka Mountains, which is a phenomenon that continued until relatively recently in geological terms, sea level changes brought by the cycle of glacial and interglacial periods, and relationships with the glacial landform of the Hidaka Mountains. Research is scheduled at locations of low terrace deposits less than 20 meters in height or less, such as at several sea cliffs located in the residential area of Mt. Apoi Geopark, as shown in Fig. B-13.

B-1-3. Outline of the Horoman Peridotite Complex

Peridotites are distributed along the Hidaka Main Thrust (HMT) of the Hidaka Mountains. The Horoman peridotite forms the largest complex, and similar masses of the Uenzaru, Pankenushi, Menashunbetsu, Nikanbetsu complexes are exposed. Small complexes are also known on the earth's surface in the middle of Pon-Nikanbetsu River and Abeyaki River. The complexes are bounded by faults in contact with high-grade metamorphic rocks and overlain by various kinds of metamorphic and plutonic rocks. All the peridotite complexes in the Hidaka Mountains have layered structures composed of a variety of peridotite types derived from the upper mantle 60 to 70 km deep from the Earth's surface (Niida, 2010).

(1) Peridotite types with three different origins

The Horoman peridotites are divided into three peridotite suites (Main Harzburgite-Lherzolite (MHL), Spinel-rich Dunite-Wehrlit (SDW), and Banded Dunite-Harzburgite (BDH)) based on the modal and chemical compositions of the minerals (Takahashi, 1991). These are considered to have been derived from the upper-mantle with individually three different origins (Niida, 2010).

(a) MHL suite

This peridotite suite is composed primarily of harzburgite, spinel lherzolite and plagioclase lherzolite, which occupies the majority of the Horoman complex (over 90% of the complex). Detailed studies of their whole-rock chemistry and chemical composition of the constituent minerals, such as olivine, orthopyroxene, clinopyroxene, and spinel, have been carried out. Basaltic melt components gradually decrease and the degrees of partial melting increase from plagioclase lherzolite through spinel lherzolite and to harzburgite. These characteristics in compositional change indicate that the MHL suite represents peridotites from the solid upper mantle with varying degrees of depletion of basaltic magma, from fertile undepleted plagioclase lherzolite to extremely depleted residual harzburgite.

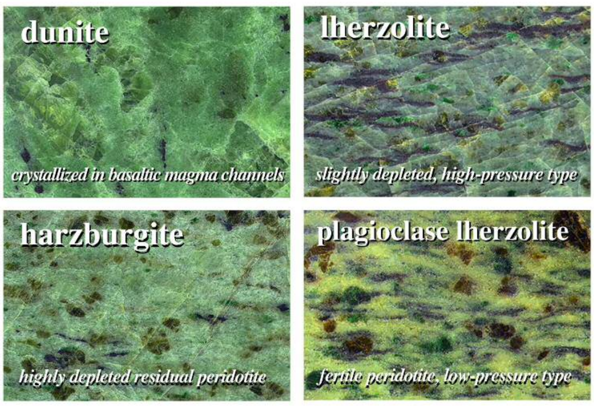


Fig. B-14 Four typical peridotite types of the Horoman complex

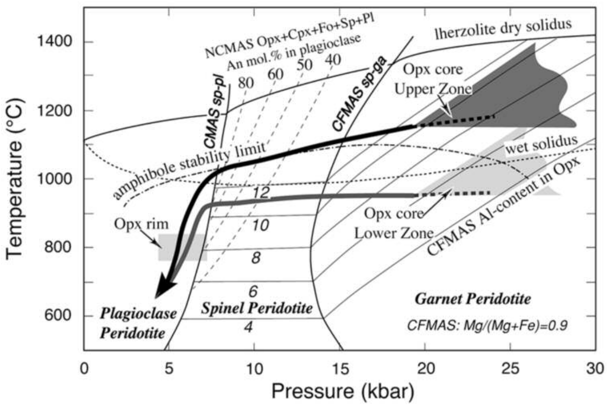


Fig. B-15 Pressure-temperature path, showing ascent history of the Horoman peridotite complex (Ozawa, 2004).

(b) SDW suite

This peridotite suite is mostly of spinel dunite containing clinopyroxene. Small amounts of wehrlitic peridotites are also found. It is characterized by a large number of idiomorphic spinel grains, and the peridotites are believed to be cumulates formed by the accumulation of crystals from basaltic magma based on the characteristic chemical composition of olivine and spinel.

(c) BDH suite

This peridotite suite includes harzburgite and olivine pyroxenite, and is characterized by absence of clinopyroxene. Characteristically, extremely high-Cr spinel and extremely high-Mg olivine are contained in this peridotite suite. Therefore, the BDH peridotite suite has been explained as cumulate crystallized from boninite and/or high-Mg andesite magmas.

(2) Magma channels in peridotite

Mafic rocks are found in various sizes in the Horoman peridotite complex. The mafic rock Type I (GB I) and Type II (GB II) have similar rare earth element (REE) contents and isotopic compositions with those of the Mid-Ocean Ridge Basalt (MORB). Harzburgite in the lower zone of the complex is accompanied by numerous numbers of dunite dykes. The dunite dykes have also attracted attention as rocks in magma channels that were formed by an ascent and migration of basaltic magma through the upper mantle peridotites (i.e., rocks crystallized in basaltic magma channels), as shown in the upper left-photo of Fig. B-14.

(3) Ascent history of the Horoman peridotite complex

The earliest ascent of the MHL suite in the Horoman peridotite complex is examined as the deepest record on pressure and temperature conditions of the upper mantle. The conditions of the garnet lherzolite stability field is clearly shown by symplectites with an external shape of euhedral garnet contained in orthopyroxene porphyroclasts within spinel lherzolite in the lower zone of the complex. Reddish-purple fine-grained aggregate layers (sp+opx+cpx) containing symplectites are also found in lherzolite, and are considered to be products of decompressional garnet breakdown. Detailed studies on pressure and temperature of the Horoman peridotites have been carried out, based on the compositional zoning of Al_2O_3 in orthopyroxene and clinopyroxene porphyroclasts and the compositional change of Al (cation) and Wo (mol. %). As shown in Fig. B-15, the ascent history indicates that the temperatures recorded in the upper zone of the complex are approximately 200°C higher than those in the lower zone, and that the maximum pressure is at least P = 20 kbar. Accordingly, the Horoman peridotite complex is considered to have been up-lifted from a depth greater than 60 km in the upper mantle.

(4) Age of the Horoman peridotites

The formation age of the Horoman peridotites is still an on-going subject, providing scientifically important information on the Earth's history (Niida, 2010). Although previously published ages are only a part of such endeavors, the Sm-Nd whole-rock isochron age determined from Light Rare Earth Element (LREE)-depleted plagioclase lherzolite and spinel lherzolite is 833±78 Ma (Fig. B-16). Likewise, the age determined from pyroxenes is 1.15 Ga (1.15 billion years). These ages are interpreted as those when the Horoman peridotites remained after major partial melting in the upper mantle beneath the mid-ocean ridge. Studies on $^{187}Os/^{188}Os$ -$^{187}Re/^{188}Os$ whole-rock isochron of peridotites and mafic rocks have reported apparent ages of 0.91±0.35 Ga (approx. 900 million years) and 1.12±0.24 Ga (approx. 1.1 billion years).

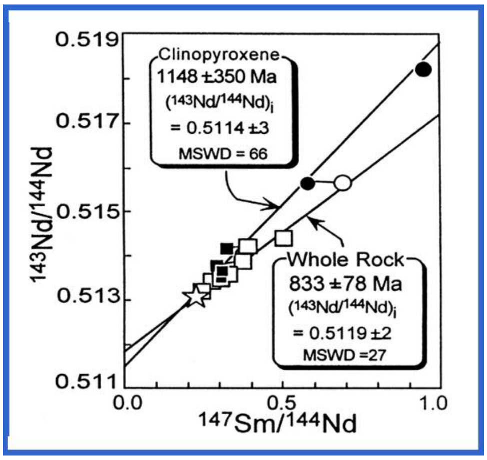


Fig. B-16 Nd-Sm isochrons showing age of the Horoman peridotites (Yoshikawa and Nakamura, 2000).

The presence of numerous veins of phlogopite in peridotites in the lower zone of the Horoman peridotite complex has been widely reported, and suggests that a compositional modification took place during the final stage of up-lifting from the upper mantle. The Rb-Sr isochron age (23.0±1.2 Ma) and ^{40}Ar-^{39}Ar plateau age (20.6±0.5 Ma) obtained from the veined peridotites indicate an age just before the building of the Hidaka Mountains.

B-2. Listing and description of geological sites within the proposed Geopark

Mt. Apoi Geopark has 35 geosites in 5 areas labeled from A to E (Fig. B-17). The geopark is characterized by the closely related themes outlined below. It is hoped that it will eventually lead to the revitalization of local communities through the establishment of self-sustaining symbiosis between nature and people.

Main theme:
A Story of Gifts from Deep Inside the Earth Connecting Land and People Together
Theme A: Peridotites – the interior and dynamic movement of the earth
Theme B: Alpine Plants – scarcity and the natural environment
Theme C: Human History – the community of nature and human life

As the individual characteristics of Mt. Apoi Geopark's 5 areas and 35 geosites have meaningful connections with the three themes, visits should ideally be planned with individual objectives in mind (e.g., research, geological field trips, hiking or scenic tours). This section highlights characteristics and typical geological sites of each area. For a complete list of geosites, see Appendix 2 ("Mt. Apoi Geopark Geosite List").

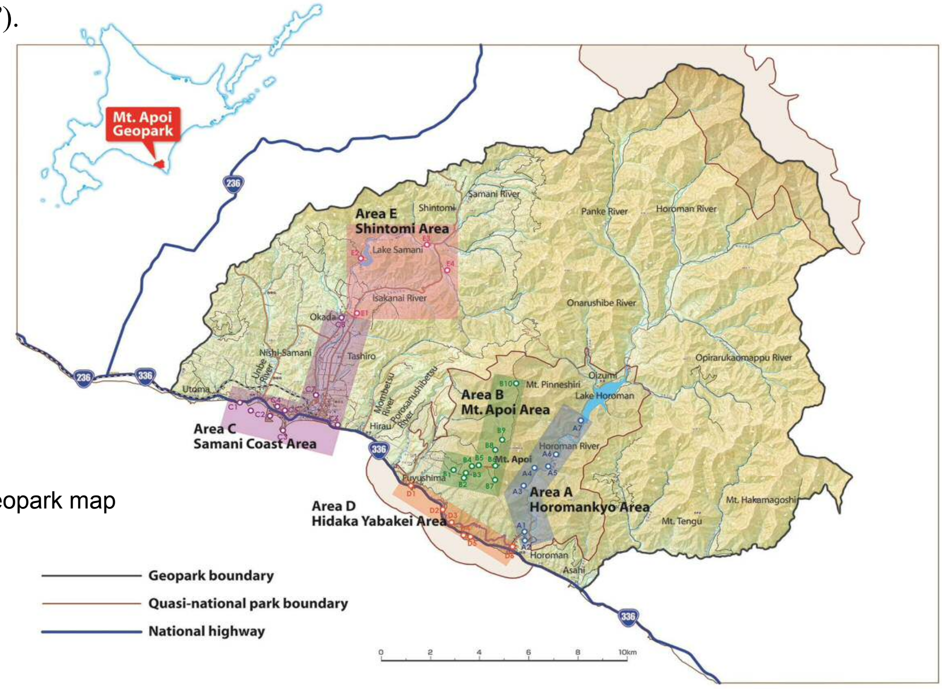


Fig. B-17 Mt.Apoi Geopark map

B-2-1. Area A Horomankyo Area : A gorge of peridotites

The peridotite Horomankyo Gorge is located in the lower and middle basins of the Horoman River, which runs from north to south over the central Horoman peridotite complex. It is a well-known site for peridotite viewing.

Geosite A3. Japanese White Pine Monument

(Typical lherzolite)

This riverside monument marks a habitat of Horoman Japanese white pines – a Natural Monument of Japan. The area is a type locality for lherzolite, which is a representative peridotite type known for its significant amounts of pyroxene: thin reddish-purple fine-grained mineral layers containing spinel-pyroxene symplectites (one to several millimeters in diameter) formed during decompressional garnet breakdown. The lherzolite here provides informations on the deepest part (approx. 60 – 70 km below the surface) of the mantle from which the Horoman peridotite derives.

Geosite A6. Horoman-gawa Inari Shrine

(Typical plagioclase lherzolite and mafic rocks)
Peridotites containing plagioclase and mafic rocks (Type GB I) several centimeters thick are observed on the riverbank 200 meters upstream of Inari Shrine. The plagioclase lherzolite has a high content of orthopyroxene (dark brown) and clinopyroxene (dark green), and its streaky white parts contain plagioclase. The peridotite here is considered to be free from partial melting of basaltic magma in the upper mantle, and is typical of the primitive mantle in terms of chemical composition. The outcrops here have large numbers of cylindrical potholes often found by rapid streams, creating a distinctive landscape.

B-2-2. Area B Mt. Apoi Area : A mountaineering route showcasing the scale of local peridotites

Mt. Apoi's terrain is characterized by layered peridotite and gabbroic mafic rocks. The layers are believed to have formed when mantle peridotite under high temperature conditions flowed or partially melted to become magma.

Geosite B5. Umanose flower fields **(Alpine plants and fine views)**

The western ridge of Mt. Apoi, known as *Umanose* (meaning "horse's back" in Japanese) has an altitude of around 580 meters. Colorful alpine plants influenced by peridotites are found along the trail from Umanose to the mountaintop. This location affords sweeping views of the ridge extending from the top of Mt. Apoi to the peak of Mt. Pinneshiri to the east, the backbone of the Hidaka Mountains to the north, and the Pacific Ocean to the south. These are splendid sights of the Hidaka Mountains and Mt. Apoi, which were formed by a collision of tectonic plates.

Geosite B8. Mt.Apoi to Mt.Yoshida

(The upper zone of the Horoman peridotite complex)
This geosite is characterized by a route along the northern ridge extending from the top of Mt. Apoi to the peak of Mt. Pinneshiri. The peridotites in this area are part of the uppermost zone of the Horoman complex, which is around 3,000 meters thick, and peridotites with a conspicuous layering of plagioclase lherzolite and mafic rocks are observed.

B-2-3. Area C Samani Coast Area : Landscapes of Cretaceous sedimentary strata and intrusive rock

The hilly terrain to the west of Mt. Apoi is characterized by Cretaceous fore-arc basin sedimentary rock (e.g., sandstone and mudstone), while Neogene sedimentary rock and porphyrite form the coastal area's unique landscape. Visitors can learn about the geological narratives hidden behind the area's different landscapes.

Geosite C1 –C 4. Cape Enrumu, Oyako-iwa and other oddly shaped rocks

(Porphyrite and dykes)
From Cape Enrumu to Shiogama and Fuyuni in the west, porphyrite dykes running through the surrounding Cretaceous sedimentary rocks has resulted in the presence of several large rocks along the shore. Magmatic intrusion occurred around 17 million years ago (in Miocene), and the current shapes were formed by coastal erosion.

The wave-cut platforms that appear around the rocks at low tide teem with marine life. Magnificent platy joints are also found at the cliffs behind Cape Enrumu.

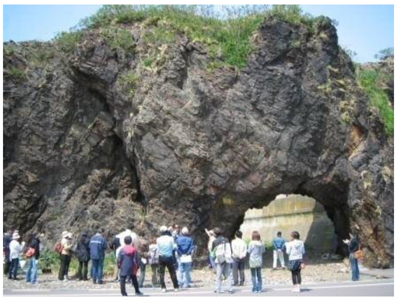
Geosite C7. Old quarry behind Samani Elementary School **(Fore-arc basin sediments)**

Sandstone and mudstone strata that formed in a Cretaceous fore-arc basin around 100 million years ago are observed at the old quarry behind Samani Elementary School. The hilly terrain in the western half of Mt. Apoi Geopark consists of sedimentary rock from this period and provides contrast with the Apoi Mountains to the east (i.e., the Hidaka Metamorphic Belt).

B-2-4. Area D Hidaka Yabakei Area : A tectonic plate collision site

Hidaka Yabakei is a 6-kilometer stretch of rugged coast with cliffs running from Ana-iwa rock in Fuyushima to the mouth of the Horoman River at the southern foot of Mt. Apoi. It is located at the old boundary between the Eurasian Plate and the North American Plate.

Geosite D1. Ana-iwa in Fuyushima **(Hornfels and marine terrace)**



Ana-iwa is a large rock with a hole running through it in Fuyushima Fishing Port. The place name Fuyushima derives from the Ainu terms *puyo* (hole) and *shuma* (stone). The hole is a sea cave through which surf boats traveled at high tide before the fishing port was built there. The rock is mostly of fine-grained sedimentary rock, but biotite formed when it was exposed to high temperatures deep in the earth and then metamorphosed into hornfels. Terrace deposits are found on top of Ana-iwa, and a small-scale coastal terrace is also located to its east.

Geosite D2 Fault at the Higashi Fuyushima Tunnel

(Serpentinite and metagabbro, and a convergent plate boundary)

This geosite is a fault fracture zone by a national highway. Metagabbro (in the Poroshiri Ophiolite Belt) is in the southwestern part of the outcrop, and fractured serpentinite can be seen in the upper part of its northern outcrop. The contact boundary between these rocks forms part of the Hidaka Main Thrust (HMT), and is considered part of the convergent plate boundary between the North American Plate and the Eurasian Plate.

Geosite D5. Geological fold at the Ruranbetsu Tunnel

(Hidaka Metamorphic Belt, amphibolite, biotite gneiss and terrace deposits)

In this rocky tract located at a rock shed, folded biotite gneiss and amphibolite of the Hidaka Metamorphic Belt can be observed. Amphibolite is a metamorphosed basaltic rock that originated on an old oceanic plate. Biotite gneiss is rock metamorphosed from terrigenous clastic sandstone and mudstone. These metamorphosed rocks are considered to have been derived from an accretionary prism that formed between the latest Cretaceous to the early Paleogene, and then metamorphosed. This geosite affords distant views of terrace deposits on the 100-meter-high sea cliffs, thereby highlighting the area's ground uplift.

B-2-5. Area E Shintomi Area : Rocks from far-off southern seas

The Shintomi Area is characterized by rocks formed at a Cretaceous accretionary prism, such as limestone and chert. The accretionary prism is formed from the surface layer of oceanic plate that is accreted onto a continental plate. Limestone, chert, and basalt derived from southern oceans, thousands of kilometers away, are mixed with terrigenous clastic sandstone and mudstone, forming a mixture of different rocks known as a mélange. This site is at the southern end of the Idonnappu Belt, which extends from south to north along the central axial zone of Hokkaido.

Geosite E1. Old mine of Ono Kogyo Co., Ltd.

(Limestone, an accretionary mélange complex)

This geosite features an outcrop at an old quarry located behind a limestone processing plant. A mélange with blocks of limestone surrounded by sandstone and mudstone can be observed. Prior approval is needed to access to this geosite.

Geosite E2. Lenticular sandstone at the Samani Dam

(Sandstone and mudstone, an accretionary mélange complex)

An outcrop of mudstone and sandstone observed along the road toward the Samani Dam parking lot. A typical mélange structure can be seen here, and lenticular sandstone without continuous bedding is observed in the mudstone bed.

Geosite E3. Chert in Shintomi

(Chert, an accretionary mélange complex)

Translucent gray chert is found along the road near the confluence of the Samani River and the Menashiesanbetsu River. Chert is dense and hard, and is composed mainly of very fine-grained quartz.

B-3. Details on the interest of these sites in terms of their international, national, regional or local value

B-3-1. A Global scale mobile belt

As shown in B-1-1, the geology of Mt. Apoi Geopark and the surrounding area results from global scale dynamic ground motion.

One of the largest global-scale mobile belts in the world is the Tethyan ophiolite belt, extending from the European Alps to Greece, Turkey, Iran, Oman, Pakistan, Indus Suture, Andaman, and the Great Sunda. Here, the Alps mountain ranges were formed by a well-documented collision between the African and the Eurasian continents, and the collision of the Indian continent and the Asian continent generated to the uplift of the Himalayas. The Hidaka Mountains in Hokkaido were also formed in a large mobile belt that divides the Northern Hemisphere almost vertically. The mountain building was a global-scale geological event that took place at a convergent boundary between the North American and the Eurasian plates. This suggests that the heavy peridotites located in the upper mantle were up-lifted onto the earth's surface from the depths of the North American Plate, thereby forming Mt. Apoi.

B-3-2. Global significance of the Hidaka Mountains

The most attractive geological features of the Hidaka Mountains are summarized in the recent monograph on "Geology of Japan" volume 1: Hokkaido (edited by the Geological Society of Japan, in

2010). The following four characteristic aspects are mostly based on Chapter 1 *Outline of Hokkaido* (Niida, 2010) and Chapter 4 *Geology and rocks in the Hidaka Collision Zone (Hidaka Mountains)* (Osanai et al., 2010)

1. Hidaka Mountains are composed of rocks derived from the deep-seated lithosphere beneath an active island arc.
2. The rocks are stratified in an original succession generated from the upper mantle to the shallow crust.
3. Such a regular sequence of lithospheric sections observed on the Earth's surface is very rare in the world.
4. The age is extremely young (55~17 Ma in Cenozoic). The original state of the rocks is well preserved in the Hidaka Mountains, having a lot of information about the deep lithosphere beneath island arcs.

B-3-3. Origins of the Horoman Peridotite Complex and its Academic Significance

The peridotites on and around Mt. Apoi are scientifically well known around the world as the Horoman peridotites, and are significant as a typical orogenic lherzolite. The Horoman peridotite complex extends approximately 8 km from east to west and about 10 km from north to south, covering the area along the ridgeline from Mt. Apoi to the north of Mt. Pinneshiri, and along the lower and middle streams of Horoman River, and the area near Mt. Horoman to the east (Niida, 2010).

The Horoman peridotites are characterized by a wide range of variety in peridotites types, including dunite, harzburgite, spinel lherzolite and plagioclase lherzolite. Petrologically, they are comparable to those in the composition range of upper mantle peridotites all over the world. These diverse types of peridotite are interlayered with a remarkable number of thin layers of pyroxenite and gabbroic mafic rocks. The total thickness of the layered peridotite complex attains around 3,000 meters. As the Horoman peridotites are young and pure, the chemical compositions and the textural patterns of minerals formed under the high-temperature and high-pressure conditions of the upper mantle are also well preserved. It is well known that the Horoman peridotite complex is one of the most studied peridotite masses in the world (Appendix 1: List of Horoman Peridotite Publications).

The aims of research on peridotite complexes cover a wide range, and relate to the foundations of earth science. They include elucidating processes of magma transport in the upper mantle, origins of compositional inhomogeneity of the upper mantle, mechanisms behind melt generation and melt extraction, and solid-melt reactions during melt segregation to the Earth's surface. A further aim is to clarify the formation, modification, and evolution of the initial mantle in the earth's history. The 4th International Orogenic Lherzolite Conference, held in Samani in 2002, was attended by around 100 scientists from 15 countries (Fig. B-18).

Fig. B-18 Memorial of the International Orogenic Lherzolite Conference held in Samani in 2002.

Fig. B-19 Geological map of the Horoman peridotite complex (Niida, 1984) and major observation sites.

B-4 Listing and description of other sites of natural, cultural and intangible heritage interest and how they are related to the geological sites and how they are integrated into the proposed Geopark

As described in B-2, Mt. Apoi Geopark has five areas, each with its own geological and geomorphological characteristics, and its own natural and cultural heritage elements. The geopark is associated with a natural environment and local lifestyles closely related to the area's peridotite and other geological / geomorphological characteristics. In this section, B-4-1 highlights non-geological elements by area, and the parts from B-4-2 to B-4-4 detail noteworthy natural and cultural heritage resources.

B-4-1. Summary of geosites with non-geological elements

(1) Horomankyo Area

The entire gorge is covered in primeval forest, making the landscape even more spectacular. Among other features, the area of Kitagoyo (P. parviflora var. pentaphylla) trees growing at the northern limit of their habitat across the side of Mt. Horoman is designated as a Natural Monument of Japan (Fig. B-20). The Kitagoyo trees also form a unique plant community developed under the strong influence of peridotites. Despite its low altitude, the area near a peridotite research site here provides a habitat to ultrabasic plants found in the alpine area on Mt. Apoi. Hydroelectric power facilities (Fig. B-21) built to leverage the gorge's landform highlight the relationship between local industry and topography.

Fig. B-20 Japanese white pine habitat in Horoman (designated as a Natural Monument of Japan; Geosite A3)

Fig. B-21 Horoman River Power Station No. 3 – a structure built to leverage the gorge's landform

(2) Mt.Apoi Area

This area is characterized by internationally recognized alpine plant communities, which developed under the influence of local ultrabasic peridotite. The flowers along the mountain trail here fascinate climbers with their beauty. Diverse vegetation along with a variety of ultrabasic plant communities is found in the area where peridotites are visible on the ground from near Rest Spot No. 4 to the mountaintop. The steep terrain makes the land feel higher than it actually is, and the upper part of Mt. Apoi affords sweeping views of the Pacific Ocean and the Hidaka Mountains (Fig. B-22). However, accelerated environmental change and anthropogenic factors caused the recent rapid decline of plant communities, prompting local residents and others to engage in plant protection and regeneration activities (Fig. B-23). In this area, visitors can learn about the importance of the natural environment and the link between the unique geological conditions and ecosystems.

Fig. B-22 (1) View from the Geosite B4 area; (2) Evidence of the influence of peridotites on Mt. Apoi's alpine plant community

Fig. B-23 Alpine plant regeneration initiative involving locals, researchers and the government (Geosite B2)

(3) Samani Coast Area

Intrusive-rock monoliths along the coast to the west of Mt. Apoi create a beautiful contrast with the mountain. This unique landscape is the source of numerous legends passed down by indigenous Ainu people, who have lived in harmony with nature here for hundreds of years. This area encompassing the rocky monoliths and Mt. Apoi became a major transit point for thriving maritime trade with Japan's main island of Honshu in the latter half of the 18th century, laying the foundations for its development today. In this area, visitors can learn about local history and lifestyles associated with the landform (Fig. B-24).

Fig. B-24 (1) One of the 33 stone statues of Kannon (the Buddhist deity of mercy), from which the name Mt. Kannon derives (Geosite C4); (2) Tojuin Temple – one of three temples established in Hokkaido by the Edo shogunate, and a structure that has witnessed the history of Hokkaido's development (Geosite C5); and (3) a restored traditional Ainu cise dwelling (Geosite C8)

(4) Hidaka Yabakei Area

Precipitous cliffs extend 6 km along the coast of the Pacific Ocean, into which the foot of Mt. Apoi plunges. This area is believed to be where the Eurasian Plate and the North American Plate once collided. It was also notoriously difficult to pass, dividing Hokkaido into eastern and western parts. The cliffs are home to the Samani Mountain Path, which was built around 200 years ago (Fig. B-25). At the bottom of the cliffs, high-quality Hidaka Kombu kelp (also known as Mitsuishi Kombu or Laminaria angustata Kjellman) grows on nutrients from the region's peridotite, and kelp drying grounds covered with crushed peridotite are extensively found here (Fig. B-26). This area highlights the history of locals who have overcome the issue of passing through the area and showcases the blessings brought by the landform.

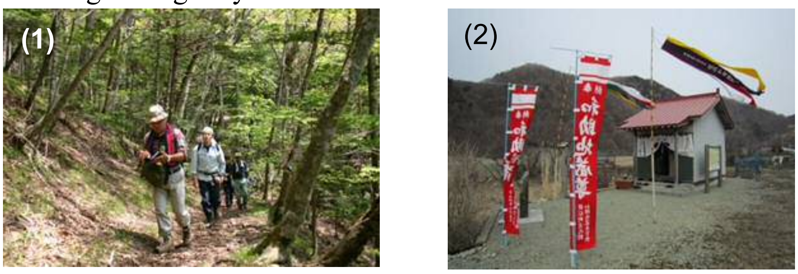


Fig. B-25 (1) Samani Mountain Path (built around 200 years ago); (2) a Wasuke Jizo statue at the Samani Mountain Path east trailhead (both Geosite D6)

Fig. B-26 Hidaka Kombu growing on nutrients from the region's peridotite

B-4-2. Unique ecosystems nurtured by the local geology

(1) Alpine Flora on Mt. Apoi

Mt. Apoi provides habitats to nearly 900 species of vascular plants. The most distinctive feature of its flora is the sheer variety of alpine plants present despite the mountain's altitude of only 810 meters. This is considered to stem from geological and climatic factors; the most salient of these is the unique geology of Mt. Apoi and the surrounding area, which is mainly composed of ultramafic rocks (peridotites). Peridotites have a remarkably high content of magnesium and nickel – elements known to inhibit plant growth. Undeveloped soils in the region also tend to have low

Fig. B-27 Sea fog engulfing Mt. Apoi in summer fertility due to their oligotrophic and dry nature. In addition, limited snowfall in winter tends to cause freeze-thaw action within soil in windswept ridge areas. This action affects plants directly and indirectly by damaging roots and destabilizing soil on slopes. The sea fog that often engulfs Mt. Apoi and the surrounding area also causes lower temperatures during the plant growth season (Fig. B-27). These multiple factors inhibit forest formation in areas around ridges, thereby leaving more room for alpine plant growth.

Mt. Apoi provides habitats to numerous endemic ultrabasic plants in areas around the ridge near its peak, forming a unique floral environment. These include Hidakaso (*Callianthemum miyabeanum*), Ezokozorina (*Hypochoeris crepidioides*) and Apoikuwagata (*Veronica schmidtiana var. yezoalpina form. exigua.*). In particular, plants such as Hidakaso (a species from the genus *Callianthemum*, which is localized in mid-latitude alpine environments in the Northern Hemisphere) and Ezokozorina (an endemic genus) are of academic significance. There are also four endemic species, one endemic subspecies, eight endemic variant species, and eight quasi-endemic species among others. Such a concentration of endemic species (including endemic subspecies, variant species, and others) is seen in few places worldwide (Fig. B-28). This diversity highlights the role of Mt. Apoi and the surrounding area as a stage for plant evolution. Relict species with markedly disjunct distribution, such as Kinrobai (*Potentilla fruticosa var. rigida*) and Ezorurimurasaki (*Eritrichium nipponicum var. yezoense*), also grow in the region. The unique environment of Mt. Apoi is seen to have served as a refugium for these plants, allowing them to survive today. Although the evolution of endemic species and the survival of disjunct-distribution species are clearly attributable at least in part to the geological and climatic factors detailed above, the geohistorical fact that the region has not been beneath the sea since the Tertiary period (approx. 15 million years ago) is also considered important.

It should further be noted that the region is a hotspot for rare wildlife, with over 50 endangered species living locally.

Fig. B-28　Plants endemic to Mt. Apoi

(2) Fauna on Mt. Apoi

Mt. Apoi and the surrounding area provide habitats to mammals, with brown bears at the top of the food chain. These include Hokkaido sika deer, Japanese pikas, and Hokkaido sables (*Martes zibellina brachyura*). Brown bears – Japan's largest terrestrial mammal – require vast areas of land and diverse environments for survival, ranging from seashores and waterfront areas to mountainous regions. Although these animals are not sighted so often on Mt. Apoi or in the surrounding area, the high frequency with which footprints, claw marks and other traces of activity are seen suggest that the region's favorable environment provides them with a supportive habitat. The close proximity of the salmon-rich Horoman River and the alpine zone of Mt. Apoi with its abundance of dwarf stone pine cones – both of which are important for brown bears – create an environment found in few places in Japan.

Often referred to as relics of the Ice Age, Japanese pikas are generally seen as an alpine species in Japan. However, they are also found in areas at an altitude of only 50 meters or so in the Horoman River basin, which is known as their lowest-altitude habitat in Hokkaido (Fig. B-29). Pikas inhabit the crevices between rocks on talus landforms, and geological conditions supporting the creation of such landforms are essential for their survival.

Hokkaido sika deer – Japan's largest herbivorous animal – are also a typical mammal found on Mt. Apoi and in the surrounding area. It is thought that they used to winter together in the region due to its limited snowfall. However, the sika deer population has recently grown significantly, leading to the disappearance of broad-leaved saplings and the decline of bamboo grass in woodland areas. There are also concerns over their possible impacts on rare plant species in alpine zones (Fig. B-30).

Fig. B-29 Japanese pika

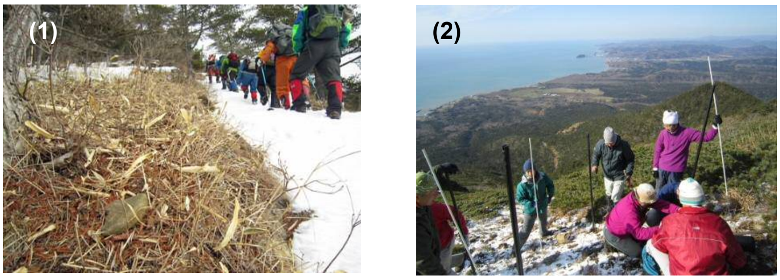


Fig. B-30 (1) Traces of bamboo grass grazed by Hokkaido sika deer; (2) installation of deer fences to support investigation of sika deer's impacts on alpine plants

Around 150 bird species are known to inhabit the region, and raptors such as falcons, buzzards and mountain hawk-eagles are often sighted. As falcons nest on precipitous terrain, the coastal cliffs near Mt. Apoi and in the surrounding area serve as prime nesting places. In winter, Steller's sea eagles and white-tailed eagles – both designated as Natural Monuments of Japan – fly from the Eurasian continent to the coastal area of Japan. Black woodpeckers – also a Natural Monument of Japan – are often seen in forests at the foot of the mountain. In the ridge area, spotted nutcrackers are frequently observed feeding on dwarf stone pine cones and Kitagoyo (*P. parviflora var. pentaphylla*) trees.

A small snail species named Apoimaimai (*Paraegista apoiensis*) inhabits Mt. Apoi and the surrounding area. It is endemic to the mountain and is found in cracks between peridotites (Fig. B-31). Its brown shell, which measures around a centimeter in diameter, has hard hairs on its surface. It is suggested that the region's unique geological environment, as represented by its peridotites, facilitated this speciation. A rare disjunct-distribution snail species known as Kadobarihimemaimai (*Ainohelix editha var.*) also inhabits Mt. Apoi and its surroundings (Fig. B-32).

Fig. B-31 Apoimaimai (*Paraegista apoiensis*)

Fig. B-32 Kadobarihime-maimai (*Ainohelix editha var.*)

A notable insect species is the Himechamadaraseseri (*Pyrgus malvae*) butterfly from the Hesperiidae family. It is found extensively in northern parts of the Eurasian Continent, but its only habitat in Japan is Mt. Apoi and the surrounding area (Fig. B-33). The larval food plant of this species is almost exclusively Kinrobai (*Potentilla fruticosa var. rigida*) – a rare species from the Rosaceae family. The region is also home to Apoikiashioobuyu (*Prosimulium apoina n. sp.*) – an insect described as a new species.

Fig. B-33 Himechamadaraseseri (*Pyrgus malvae*)

(3) Bounties of the Sea off Mt. Apoi

The coastal waters off the Hidaka region, where Mt. Apoi Geopark is located, contain seaweed beds providing habitats for *kombu* kelp and other forms of marine life. The *kombu* beds play a very important role in conserving biodiversity and enhancing fishery output by serving as places of primary production in this cold-sea area and acting as an environment for a variety of fish and shellfish.

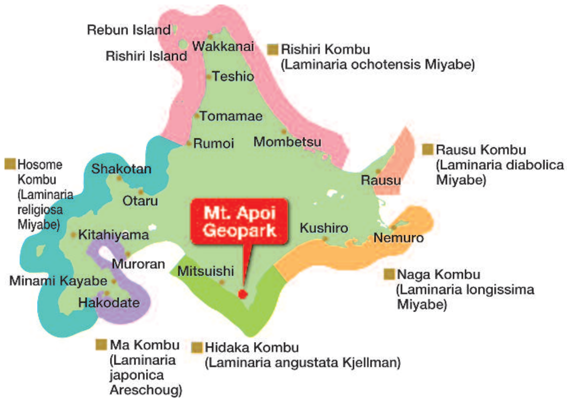


Fig. B-34 Distribution of local kombu kelp

The *kombu* kelp species found along the coast of Mt. Apoi Geopark are Chigaiso (*Alaria crassifolia Kjellman*), Aname (*Agarum clathratum Dumortier*), Sujime (*Costaria costata (C. Agardh) Saunders*) and Mitsuishi (*Laminaria angustata Kjellman*). Local growth of Ma Kombu (*Laminaria japonica Areschoug*) has also been observed. Among these, Mitsuishi Kombu, also known as Hidaka Kombu, is the main type of seaweed found in these beds and is an important resource, accounting for approximately 30 percent by value of the region's overall marine production. The species is not found outside Japan, and thrives mainly along the Pacific Coast of Hokkaido around Mt. Apoi Geopark (Fig. B-34). It generally grows with Chigaiso and Sujime kelp on rocks in relatively shallow waters from the intertidal zone to depths of 8 meters or so. In the coastal waters off Mt. Apoi Geopark, masses of long Mitsuishi Kombu kelp grow densely at depths of 3 meters and less. Its appearance when exposed at low tide is a magnificent sight (Fig. B-35). At the eastern end of its distributional range, the species is replaced by Naga Kombu (*Laminaria longissima Miyabe*). The results of recent molecular phylogenic studies have suggested that Mitsuishi Kombu evolved from Naga Kombu and underwent speciation into Ma Kombu along the Pacific Coast of western Hokkaido. It has a close phylogenetic relationship with Naga Kombu, and genetic analysis shows that the two species form a phyletic group among Japanese *kombu* types. No other species in the world are included in this group.


Fig. B-35 An exposed Mitsuishi Kombu community at low tide

Mitsuishi Kombu was first noted in a publication by Swedish botanist F. R. Kjellman based on his research on dried kelp for export to China. He had obtained the kelp from an English trading merchant in Hakodate during a visit to Japan on a scientific expedition ship in 1879. The kelp products he purchased are thought to have been Urakawa Kombu ("Uragaiva Combu"), Samani Kombu ("Shamani Combu") and Tokachi Kombu ("Tokatsu Combu"), suggesting that the species has been produced in the area from the Hidaka region to the eastern Tokachi region since then, and that the coastal area of Samani has long been a production area for this kelp variety.


Fig. B-36
Kelp (Kombu) Harvesting
(Byozan Hirasawa, 1822–1876)

B-4-3. Local History and Culture Relating to the Region's Geological Features

(1) Ainu Hardships and their Restoration as an Indigenous People

The culture of the indigenous Ainu people of Hokkaido is considered to have originated with the marine-centered Okhotsk culture (400-800CE) and Satsumon culture (600-1100CE), which was strongly influenced by the culture of Honshu (Japan's main island). While the Ainu subsisted on hunting, fishing, and gathering, they were also traders who traveled across the Tsugaru Strait to Honshu and across the Soya (La Perouse) Strait to Sakhalin and the Eurasian continent. Hokkaido was a crossroads of civilization where Japanese culture met with the culture of the continent (Northeast Asia). The goods Ainu people sold included pelts from land and sea animals (e.g., sea otters, seals, and sables), eagle and hawk tail feathers, salmon, and *kombu* kelp. From the Middle Ages onward in particular, kelp was a main trade item in the Hidaka region (Fig. B-36).

However, the increasing number of *wajin* (people of ethnic Japanese descent) from Honshu who settled in Hokkaido in subsequent years gradually wrested the initiative of free trade from the Ainu. When a trading system favoring *wajin* was established in the 18th century, Ainu people, who had been producers and trading partners with the *wajin*, were forced to work and suffered great hardships including discrimination and forced assimilation by the *wajin*.

In the 20th century, efforts to restore the Ainu as an indigenous people gained momentum. They were encouraged to engage in activities that would preserve their unique language and traditional rituals as well as other aspects of their culture. In Mt. Apoi Geopark as well, initiatives to promote the indigenous culture have remained ongoing, including the preservation of traditional dance and the restoration of *cise* (traditional Ainu dwellings) (see pp. 5 and 21).

(2) The Dawn of Samani Supported by Early-Modern Distribution Routes

In the 18th century, Japan witnessed full-scale development of its commodity economy and distribution. With Osaka, often called the "Kitchen of the Nation," and northern Japan connected by routes across the Sea of Japan, large volumes of goods were traded (Fig. B-37). The routes extended to the Kuril Islands just to the east of Hokkaido. Against this background, the region drew attention as an important trading hub connecting the Kuril Islands and Japan's main island of Honshu because Mt. Apoi was a landmark when viewed from the sea, and more importantly, Cape Enrumu (a land-tied island composed of intrusive rock) served as a natural port (Fig. B-38).

In 1799, the Edo Shogunate that ruled Japan took the southern half of Hokkaido under its direct control in response to a sense of urgency over Russia's ongoing southward expansion along the Kuril Islands via the Kamchatka Peninsula. The shogunate established a *kaisho* (outpost office) at the base of Cape Enrumu and built Tojuin Temple as part of efforts to win the hearts and minds of locals. To facilitate the dispatch of troops for Hokkaido's defense, the shogunate also constructed Hokkaido's first government-administered road, known as the Samani Mountain Path, on the sea cliffs (Hidaka Yabakei) to the south of Mt. Apoi.

These developments are discussed as important themes in local history, and documents describing them along with related structures and ancient structural remains have been designated as cultural properties in recognition of their value in terms of local historical heritage.

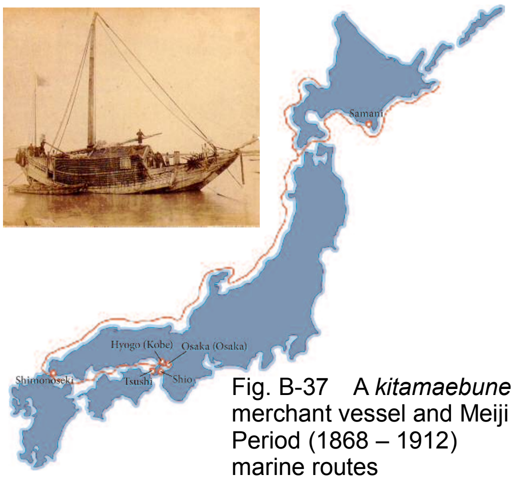


Fig. B-37 A *kitamaebune* merchant vessel and Meiji Period (1868 – 1912) marine routes

Fig. B-38 Cape Enrumu and Mt. Apoi, painted around 150 years ago ("Hokkaido Rekiken-zu," Samani)

(3) *Kombu* Kelp Harvesting – an aspect of local culture for the past 400 years

Commercial harvesting of local Mitsuishi Kombu is considered to have begun between the mid-17th century and the 18th century. Much of the *kombu* kelp harvested in those days was transported to Osaka in western Japan for the manufacture of *kizami-kombu* (dried shredded kelp), which laid the foundations for the city's development as a kelp processing center. As this kelp species contains high levels of iodine, it was also exported to China where iodine deficiency was a serious problem, and was used for goiter treatment (Fig. B-39). Its soft fiber also makes it suitable for simmered dishes, and it creates a mild flavor when used to make soup stock. Due to a variety of uses not shared by other species, Hidaka Kombu – the commercial name for Mitsuishi Kombu – is widely known in Japan and is an indispensable part of the national diet. It is versatile and popular with the general public, but the differences in the areas along the Hidaka coast where the kelp is harvest, known as shore disparity, leads to variations in its commercial value. Different shores are ranked as extra- high quality, high quality, medium and regular, and prices depend on where kelp is harvested. Today, extra-high and high-quality shores are found in Samani, where Mt. Apoi Geopark is located, and in towns adjacent to it on both sides. However, Samani is the only town where all fishery districts are ranked as high-quality or above (Fig. B-40). This rich resource supports the diet of the Japanese both qualitatively and quantitatively.

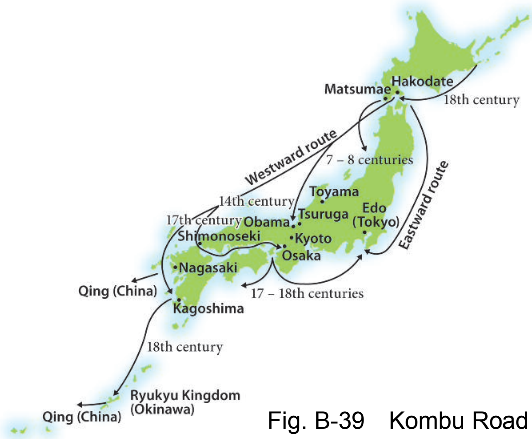


Fig. B-39 Kombu Road

Throughout the long history of Hidaka, Kombu harvesting and production areas have often faced difficulties. These have included devastation of fishing grounds by oil pollution, environmental degradation of fish habitats due to deforestation, and the decline of trade with China. However, these crises were overcome by the untiring efforts of local fishermen and related parties. Such work has involved fishing ground improvement, product enhancement resulting in the production of sand-free kelp, drying ground improvement, and market expansion campaigns. In this way, traditional local industry has been preserved (Fig. B-41).

Fig. B-40 Differences in the commercial value of Hidaka Kombu among different production areas

Fig. B-41 Kelp harvesting using hooks that have remained unchanged for 400 years

C. Geoconservation

C-1. Current or potential pressure on the proposed Geopark

C-1-1. Peridotite Mining

Peridotite mining has been under way for more than half a century at the southwestern margin of the Horoman peridotite complex (Figs. C-1 and C-2). As this rock is hard and fire-resistant with a high magnesium content, it is in great demand as an industrial material. The local quarry company – Toho Olivine Kogyo Co., Ltd. – supports the regional economy in its role as a local-capital company. The mined area so far covers approximately 330,000 m^2, which accounts for 0.8% of the total area of outcrops in the Horoman peridotite complex.

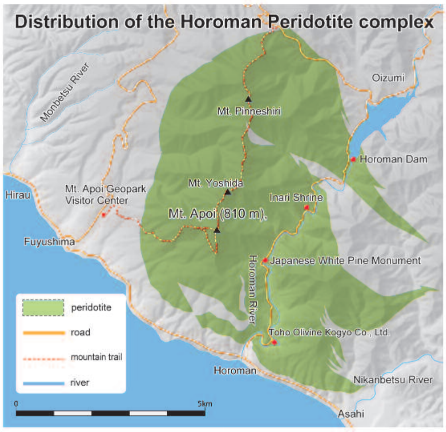


Fig. C-1 Extent of Horoman peridotite complex outcrops and quarry location

Fig. C-2 Peridotite quarry and plant

C-1-2. Decline of Alpine Flora

Along with peridotites, Mt. Apoi's alpine plant communities are valuable natural heritage resources of Mt. Apoi Geopark, but their decline is proceeding at a rapid pace (Fig. C-3). Although the cause of the decline is yet to be fully established, it is assumed that many years of plant harvesting by various hikers for personal gardens and flower shops has exacerbated a situation already made problematic by elements of environmental change such as global warming.

Fig. C-3 Disappearance of rocky areas (i.e., habitats for flowering plants) due to the expansion of dwarf stone pine habitats near the Umanose area of Mt. Apoi

C-2. Current status in terms of protection of geological sites within the proposed Geopark

C-2-1. Regulations Against Peridotite Mining

The peridotite quarry in Fig. C-1 is located in a Class III Special Zone of Hidaka-sanmyaku Erimo Quasi-National Park according to the Natural Parks Act (Fig. C-4). Any and all large-scale mining is essentially prohibited in such zones. However, the Hokkaido Prefectural Government granted special permission to mine in the minimum required area in consideration of the regional economic effects that could arise if the quarry operator withdrew from the area and the fact that the operator also worked there before it was designated as a quasi-national park. The minimum required area is interpreted as being around the current mining location, which is in the Horomankyo Area of Mt. Apoi Geopark but is not a geosite.

The Mt. Apoi Geopark website provides information on applying for individual permission to collect sand and stones within the quasi-national park, and on other matters concerning relevant regulations.

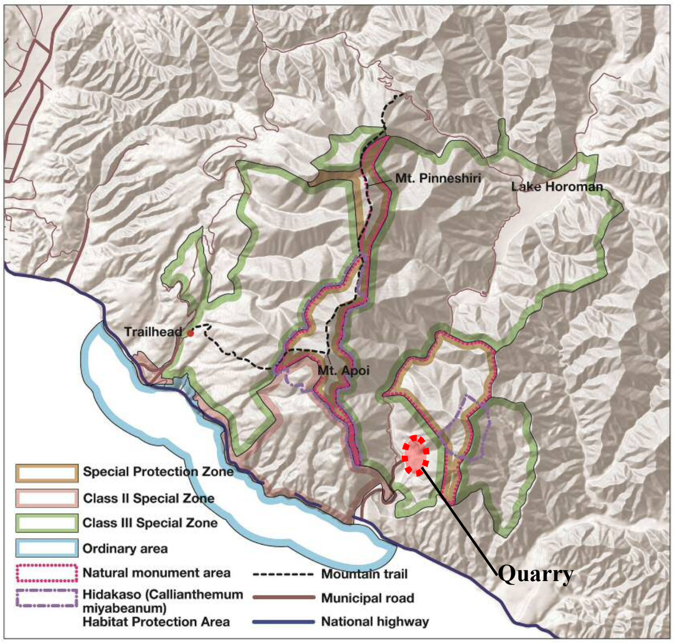


Fig. C-4　Scope of regulations in Hidaka-sanmyaku Erimo Quasi-National Park and quarry location

C-2-2. Protection and Restoration of Alpine Flora

As shown in Fig. C-4, Mt. Apoi and the surrounding area are part of Hidaka-sanmyaku Erimo Quasi-National Park. Development activities and any other changes to current conditions in the area are subject to regulation. In particular, the ridge from Mt. Apoi to Mt. Pinneshiri and the summit area of Mt. Horoman, where alpine plants grow, are designated as Special Protection Zones and are thus subject to highly stringent regulations. In these zones, the Hokkaido Prefectural Government (the quasi-national park's administrator) regularly makes patrols to check for illegal digging of flora. Members of the Mt. Apoi Supporters' Club (a member organization of the Mt. Apoi Geopark Promotion Council in Samani) engage in a range of initiatives, including patrols, mountain trail development, alpine plant restoration, investigation of deer-related plant damage, and public awareness activities (Fig. C-5).

The alpine plant restoration initiative is intended to secure habitats for growth by removing dwarf stone pines and other plants. Restoration testing involving experimental surface soil disturbance is also conducted (Fig. C-6).

Fig. C-5 Mt. Apoi Supporters' Club campaign to prevent illegal digging

Fig. C-6 (1) Samaniyukiwari (*Primula modesta var. samanimontana*) in bloom at the Alpine Plant Restoration Test Site; (2) test cutting of dwarf stone pines

C-3. Data on the management and maintenance of all heritage sites

Concerted efforts are made by both the public and private sectors to protect the environment of Mt. Apoi. Two rangers and an alpine patrol from the Hokkaido Prefectural Government, which is the quasi-national park administrator and landowner, regularly conduct checks in the area. Additionally, 15 members of the Mt. Apoi Supporters' Club conduct frequent patrols to prevent illegal alpine plant digging under commission from the Hokkaido Government.

In areas other than Mt. Apoi, local residents have implemented annual cleaning for more than 30 years, thereby helping to maintain the environment of Mt. Apoi Geopark (Fig. C-7).

Fig. C-7 Annual springtime cleanup volunteer operation

D. Economic Activity and Business Plans

D-1. Economic Activity in the proposed Geopark

D-1-1. Fisheries

The waters off Mt. Apoi Geopark are known as good fishing grounds thanks to the confluence of the warm Tsushima and Kuroshio currents and the cold Oyashio Current. The region's rich marine resources include salmon, cod, flounder and other fish, *kombu* kelp and other types of seaweed, and aquatic life such as octopuses and squid. Fisheries are a key local industry employing more than 500 people (significantly more than other industries) according to the 2010 population census, although the yield in fiscal year 2011 amounted to only around 2.5 billion yen (approx. 23 million US dollars). Due to a noticeable dwindling of resources in recent years, particular efforts have been made to enhance their sustainability. These have included fishing-ground improvement, aquaculture promotion, and the adjustment of fish catches.

D-1-2. Agriculture and Forestry

Geographically speaking, most of the region consists of rolling hills and mountainous terrain stretching from the Hidaka Mountains. Accordingly, only a fraction of the land is suitable for crop cultivation. However, local farmers are able to grow Apoi Rice using low amounts of agricultural chemicals and cultivate strawberries thanks to the cool temperate climate.

Over 90% of Mt. Apoi Geopark is covered by forestland, but production activities in forestry have become sluggish due to lower timber prices caused by an influx of imported wood and other factors. However, forests are systematically developed with public funding to maintain their multiple functions, such as watershed conservation, disaster prevention in mountainous areas, and the conservation of the area's living environments.

D-1-3. Mining and Manufacturing Industries

Industrial product shipment in fiscal year 2010 amounted to around 10 billion yen (approx. 93 million US dollars) – the highest in the Hidaka region. This is largely due to hydroelectric power generation capitalizing on the topography of the peridotite gorge, as well as peridotite and limestone mining in the permitted area.

D-1-4. Tourist Industry

Around 100,000 tourists who visit the region annually participate in many activities, including climbing Mt. Apoi, camping, and attending events. On average, 7,000 to 8,000 people climb Mt. Apoi every year, accounting for the core of long-stay tourism in the area. Despite the fundamental problem of a lack of accommodation, geopark activities have gradually helped to improve the region's preparedness to host visitors. These include the development of new products (e.g., souvenirs) and the establishment of a guide system. Accordingly, the number of tourists visiting the region is expected to grow in the future.

D-2. Existing and planned facilities for the proposed Geopark

D-2-1. Educational and Research Facilities

Mt. Apoi Geopark Visitor Center

In April 2013, the old visitor center for climbers on Mt. Apoi was renovated to create the Mt. Apoi Geopark Visitor Center. The center has drawn around 28,000 visitors over the past two years, during which it was in actual operation only for 16 months. As the principal facility of Mt. Apoi Geopark, it provides information and opportunities to learn about the region's geology and nature as well as related history and culture. Exhibit commentaries on geology are provided in two levels; they are essentially tailored to junior high school students, but simple illustrations are also shown to help elementary school students grasp the basics.

Samani Folk Museum

This museum showcases local history. It exhibits some remarkable pieces despite its small scale, including old documents held by Tojuin Temple (which are collectively designated as a National Important Cultural Property), Ainu artifacts, and documents of the Yamoto family that give insights into the early-modern days of Hokkaido's development. A historian will be employed in fiscal year 2015 to improve the exhibition environment through enhanced investigation and research.

Mt. Apoi Peridotite Plaza

This town-center outdoor rock museum primarily showcases polished peridotite, but also displays other cut and polished rocks from the Hidaka Mountains. All the specimens are highly polished to facilitate identification of the individual minerals contained within. The plaza is a popular site for university geological field trips.

GeoLAB Mt. Apoi

This laboratory in the science lab of a former elementary school showcases rock specimens collected over many years by a Horoman peridotite researcher who was an associate professor at Hokkaido University. It is a regional hub for earth science studies.

Mt. Apoi Research Support Center

This budget accommodation facility (500 yen per night) caters to researchers by supporting university field trips as well as fieldwork in Mt. Apoi Geopark and the surrounding area. The facility promotes exchanges between locals and researchers, and benefits local communities based on the fruits of research.

D-2-2. Geotourism and Tourist Facilities

Apoi Sanso Hotel

This hotel is the area's largest tourist accommodation facility. It also serves as a base camp for people climbing Mt. Apoi, and is located in Sanroku Park where the Mt. Apoi Geopark Visitor Center is also found.

Samani Tourist Information Center

This center in JR Samani Station (the railway line terminus) provides a wealth of information despite its limited size, such as details of Mt. Apoi Geopark and local excursions. The center is staffed by a guide and also sells local specialties and souvenirs.

Tojuin Temple – one of three temples established in Hokkaido by the Edo shogunate

This temple was established in 1806 by the ruling Edo Shogunate. It is one of three temples founded in Ezo (known today as Hokkaido) by the shogunate as part of efforts made to win the hearts and minds of locals due to fears of possible invasion by foreign troops (particularly Russians) into Hokkaido, which was recognized as a border island.

Mt. Apoi Geopark Visitor Center

The old visitor center for climbers on Mt. Apoi was renovated to create the Mt. Apoi Geopark Visitor Center and reopened in April 2013. As the principal facility of Mt. Apoi Geopark, the center fulfills the dual functions of giving information and providing learning opportunities.

Oyako-iwa Fureai Beach

This seaside beach is situated on the foreshore of the Oyako-iwa Rocks, which are seen as a symbol of the area along with Mt. Apoi. Tourists flock to the beach in summer.

Campsites

Non-demarcated campsites are located at the foot of Mt. Apoi, at Oyako-iwa Fureai Beach and at the Samani Dam.

D-3. Analysis of geotourism potential of the proposed Geopark

D-3-1. Strengths

- Mt. Apoi is highly significant in Japanese and international academia due to the large number of low-altitude endemic alpine plants that grow only here. This mountain of flowers fascinates those who climb it.
- Mt. Apoi is located at a point where the mantle deep in the earth was pushed onto the surface. Mt. Apoi Geopark is Japan's only area where the perception of global-scale dynamic ground movement differs from that experienced with volcanoes.
- The beautiful olive green peridotites visible above ground on Mt. Apoi are large even by international

standards, and are relatively pure in that they remain in the condition of their time in the mantle. They are a globally rare resource by which the inaccessible mantle can be viewed.
・The geopark features scenic landscapes with mountains providing striking contrast against coastal areas.
・The geopark area has witnessed the history of human societal development supported by its beautiful coastal terrain, and is therefore characterized by clear narratives connecting people with the earth.
・The geopark area is home to an established network of families engaging in agriculture, forestry and fisheries who can host students in their houses.

D-3-2. Weaknesses
・At first glance, the geopark area does not seem like a place to experience and learn about the Earth's dynamic movements
・Access to the area is inconvenient, as it is far from major cities and airports.
・There is room for improvement in terms of visitor readiness regarding the limited number of accommodation facilities, as well as the limited availability of local specialties, souvenirs, restaurants serving local food, guided tours, hands-on programs, and other products and services.

D-3-3. Future Vision
As Mt. Apoi Geopark suffers from population dispersion and insufficient preparedness to host tourists, there would be little geotourism potential if the Mt. Apoi Geopark Promotion Council in Samani simply waited for tourists to turn up. There is a need to identify target demographic visitors and develop locally unique excursions and hands-on programs to meet demand. In order to add value and extend periods of stay, geological narratives should also be provided to people who come to see Mt. Apoi's renowned alpine plant communities.

It is additionally important to develop appealing food and other products and to improve guidance among other services. The success or failure of hands-on tours depends on user-friendly guidance and unique, delicious, local food. Mt. Apoi Geopark's accommodation capacity must also be improved in collaboration with neighboring areas, and this should include the utilization of homestay programs for students. While enhancing visitor-readiness, the Mt. Apoi Geopark Promotion Council in Samani also plans to promote strategic marketing activities in order to develop geotourism as a key local industry.

D-4. Overview and policies for the sustainable development

D-4-1. Geo-tourism and economy
(1) Hands-on tours to attract tourists
The Mt. Apoi Geopark Promotion Council in Samani plans and implements guided tours for mountain climbing, footpath walking, vocational experiences, and other activities. These are intended to highlight the magnificence and bounty of the geo-heritage that underpins local life here through a variety of hands-on programs. In this regard, the Council will step up its efforts while incorporating creative ideas in these endeavors. In particular, in recognition of the geopark's unique coastal topography stemming from Mt. Apoi's proximity to the sea, steps are being taken to create infrastructure for the realization of marine geo-tours using fishing boats (Fig. D-1).

The geopark offers various tourist information resources, such as a dedicated website, literature (i.e., guidebook, handbook, pamphlet and leaflet publications), signboards, and a smartphone map app (Fig. D-2). Tools available in languages other than Japanese include a pamphlet (a partial translation of a Japanese pamphlet into English and Chinese), a leaflet (in English), signboards (in English) and a website (a partial translation of the Japanese website into English). Publication of a new English leaflet is also planned for fiscal year 2014, and more English information will be provided on the website and via the smartphone map app.


Fig. D-1 Experimental geo-tour using a fishing boat


Fig. D-2 Pictorial map information accessed using a smartphone app


Fig. D-3 Geopark guide

The remodeled Mt. Apoi Geopark Visitor Center is the primary facility from where geosite tours begin. However, as its location at the foot of Mt. Apoi may not be optimal for tourists, the Mt. Apoi Geopark Promotion Council in Samani plans to further enhance the information function of the Tourist Information Center in the town center. The Council will also provide information to guide visitors to the Tourist Information Center.

Presently, Mt. Apoi Geopark has 12 geopark guides. The Mt. Apoi Geopark Promotion Council in Samani, which is responsible for providing guide services, assigns guides to meet individual needs based on requests submitted using the form on the website (Fig. D-3). Requests for English-speaking guides are fulfilled by a local resident who is fluent in English and two assistant English teachers working at local elementary and junior high schools.

(2) Utilization of Local Industries

Tours have helped to raise the profile of local products by bringing visitors to commercial establishments in fisheries and other local industries for hands-on experience opportunities. As workers in various industries serve as geopark guides, they also enhance the entire area's involvement in efforts to promote geotourism. The Mt. Apoi Geopark Promotion Council in Samani will continue to develop tours in collaboration with local industries (Fig. D-4).


Fig. D-4 A tour to observe fixed-net fishing for chum salmon

Previously, fish, shellfish, and farm produce from the area were seldom sold over the counter or subjected to secondary processing for sales. However, a shop selling local fishermen's catches has now been established, and geopark-related souvenirs and other products have been developed. Additionally, to promote local cuisine, the Apoi Sanso Hotel has collaborated with a neighboring hotel to develop new menu items made with seasonal ingredients (Fig. D-5), and a restaurant serving food made with locally produced ingredients has been opened. The logo and mascots of Mt. Apoi Geopark are also used to provide added value to existing products. The Mt. Apoi Geopark Promotion Council in Samani will continue to promote relationships between the geopark and the local economy.


Fig. D-5 New menu fair hosted by a local hotel


Fig. D-6 Vocational experience involving high school students at a thoroughbred horse farm as part of programs in which students stay at the homes of agriculture, forestry and fisheries operators

(3) Hosting of School Field-Trip Students in Private Homes

Since fiscal year 2012, high school students on field trips from the western part of Japan's main island of Honshu have been hosted in Mt. Apoi Geopark. This initiative is intended to provide opportunities for students to stay in small groups at the homes of local farmers and fishermen to experience their work. Students from five schools visited the area in fiscal year 2014 (Fig. D-6). Although geotourism is not yet a part of these tours, such a development will be examined in light of the significant potential of private accommodation usage to combat the area's limited number of beds.

D-4-2. Geo-education : Education Capitalizing on Geo-Heritage

(1) School Education

The area has an elementary school and a junior high school (Samani Elementary School and Samani Junior High School) at which community studies of Mt. Apoi Geopark are promoted primarily as part of general studies.

In academic year 2013, groups of first-year students from Samani Junior High School investigated natural heritage resources (e.g., peridotites and alpine plants), local industries (e.g., hydroelectric power generation), and the history of the town, and then made poster presentations on their findings (Fig. D-7). Sixth-grade students at Samani Elementary School also developed geopark tour routes and made sightseeing pamphlets. In addition, sixth-graders at the neighboring Urakawa Elementary School studied the compositions of Mt. Apoi and the Hidaka Mountains in science classes (Fig. D-8).

At Urakawa High School, community studies on Mt. Apoi Geopark are part of the curriculum. Students there studied the origins of the Hidaka Mountains and alpine plants on Mt. Apoi in academic year 2013 (Fig. D-8). In future work, more systematic programs will be developed with emphasis on earth science and local area studies at school.

Education that makes use of the geopark is expected to have various positive effects, not only giving students an understanding of earth science but also developing their ability to pursue knowledge, enhance their communication skills, and broaden their perspectives. The local population is rapidly decreasing, due mainly to an outflow of school graduates and a low percentage of people coming back to the area. The Mt. Apoi Geopark Promotion Council in Samani plans to encourage people to return by promoting a range of educational initiatives focusing on the area, such as earth science studies.

Fig. D-7 Investigative learning at the visitor center (first-year students from Samani Junior High School)

Fig. D-8 Extra-curricular science lesson on geological composition (sixth-graders from Urakawa Elementary School)

Fig. D-9 Earth science class at Urakawa High School

(2) GeoLAB Mt. Apoi

In 2012, the GeoLAB Mt. Apoi laboratory was opened in a renovated classroom of an old elementary school at the foot of Mt. Apoi. The director, who was previously an associate professor at a Hokkaido University graduate school, has long researched the Horoman peridotites and organizes public workshops in conjunction with a curator in geology (Fig. D-10). GeoLAB Mt. Apoi also supports researchers visiting the geopark in its role as a local research hub.

Fig. D-10 Public workshop at the GeoLAB Mt. Apoi laboratory

(3) Disaster Management Education

The Great East Japan Earthquake caused unprecedented damage to Japan and left deep scars in Mt. Apoi Geopark. The 3.3-meter-high tsunami that hit the area around 30 minutes after the earthquake caused more than 700 million yen worth of damage (approx. 6.5 million US dollars) to the inundated area around the fishing port (Fig. D-11). Fortunately there were no human casualties thanks to prompt evacuation.

Because Samani is located to the southwest of the Hidaka Mountains and facing the Pacific Ocean, the area is occasionally affected by trench earthquakes. This has prompted the local government to take a range of disaster management initiatives, including the formulation of a local disaster management plan, the installation of a disaster prevention radio system in the coastal area, the establishment of disaster management organizations and the implementation of disaster drills. However, the Great East Japan Earthquake necessitated fundamental reviews of these efforts. New initiatives currently under development include the formulation of a tsunami evacuation plan and a hazard map, the implementation of evacuation drills, the installation of sea level signs, emergency stockpiling and the designation of evacuation routes (Fig. D-12). Ongoing efforts will be made to ensure that local residents share accurate information on disasters and remember the damage caused in 2011.

Fig. D-11 Samani Fishing Port – a site damaged by the Great East Japan Earthquake

Fig. D-12 One of 130 sea level signs installed in the area

D-4-3. Geo-heritage and researcher support

The area has supported exchanges with researchers primarily in geology and ecology since before the geopark designation. In 2013, a total of 344 researchers and university students from 30 institutions visited Mt. Apoi Geopark (Fig. D-13). The expansion of exchanges is largely attributed to the Mt. Apoi Research Support Center – a self-catering accommodation facility at the foot of Mt. Apoi. Its exceptionally low prices (500 yen per night, 250 yen per night for the 15th night onward) are popular with researchers investigating the area and those on university geological field trips (Fig. D-14).

Thanks to this support, three international conferences on earth science have been held in the area (the 2nd Joint Meeting of the Korean and Japanese Structure and Tectonic Research Group in 1999, the 4th International Workshop on Orogenic Lherzolite and Mantle Processes in 2002, and the Ocean Drilling Program (ODP) Leg 209 post-cruise meeting in 2005). The area was also commended by the Japanese Association of Mineralogists, Petrologists and Economic Geologists in 2002 and the Geological Society of Japan in 2003 (Fig. D-15) for its efforts to support research.

The Mt. Apoi Geopark website provides researcher support resources such as forms to request accommodation at Mt. Apoi Research Support Center, information on the regulatory procedures to be followed for access to the quasi-national park and other areas, and a database of academic papers. Renovation of the aging Research Support Center is also planned. Efforts will be continued to support researchers in order to ensure the conservation of geological and natural heritage resources and benefit local communities through research.

Fig. D-13 One of many university field trips annually conducted in Mt. Apoi Geopark

Fig. D-14 Mt. Apoi Research Support Center

Fig. D-15 ODP Leg 209 post-cruise meeting (2005)

D-5. Policies for, and examples of, community empowerment (involvement and consultation) in the proposed Geopark

D-5-1. Public Workshops

To support sustainable development in provincial areas, local residents must have affection for and a sense of identity with their hometowns. To this end, in 2010 the Mt. Apoi Geopark Promotion Council in Samani introduced Hometown Geo-workshop lectures to highlight the area's appeal. Over the past four years, around 1,500 local residents have attended workshops designed to provide education on the area and support the development of guides. Attendees learn about all the resources of Mt. Apoi Geopark (geological, ecological, and human) via presentations given by university professors and researchers as well as by local residents, including teachers, experts, company owners, office workers, shopkeepers, fishermen, and even the head priest of a temple. Inviting locals to present has helped to promote public awareness and participation in geopark-related activities (Fig. D-16).

Fig. D-16 Hometown Geo-workshop lectures:
(1) the head priest of Tojuin Temple gives a lecture;
(2) a local historian explains the origins and history of coastal rocks from Mt. Kannon (Geosite C4);
(3) a technical expert describes the mechanism behind hydroelectric power generation leveraging the gorge landform

Although the focus of the workshops has been shifted more toward guide training in fiscal year 2014, local residents in various fields will continue to present in their roles as Samani experts. This will help to increase the number of local residents who come to the geopark as a place to learn about and enjoy local history and resources.

D-5-2. Local Resource Conservation and Utilization based on Public Participation

In the area's key industry of fisheries, *kombu* kelp harvesting is a traditional activity that has continued since the Ainu culture period. The harvesting method is quite simple: a fisherman in a surf boat with an outboard engine pulls the seaweed from rocks using a long-handled hook and spreads it over a pebbled site for sun-drying. Once the kelp is dry, it is simply cut to the right length, bound according to quality and shipped. As sun-drying of kelp is labor-intensive, many locals work part-time to complete the task (these part-timers are referred to as *okamawari*, meaning "post-harvesting land-based workers"). As such, kelp harvesting forms an essential part of local culture as well as supporting the regional economy.

The two initiatives described below are implemented at Mt. Apoi Geopark to ensure the conservation and utilization of kelp.

(1) Kelp Forum

The annual Hidaka Kombu Forum highlights the crop's role in supporting the local economy and regional culture. Attended by local fishermen and residents, it is intended to promote consideration for the future of kelp, which is an important part of Japan's food culture. The forum has also been held in Sapporo, which is a major neighboring area of consumption (Fig. D-17). The event features discussions on various kelp-related topics such as resource conservation, production, processing, and recipes.


Fig. D-17 Hidaka Kombu Forum in Sapporo (2011)

(2) Conclusion of a Comprehensive Partnership Agreement with Hokkaido University

Among Hidaka Kombu-producing areas, Mt. Apoi Geopark ranks highly both qualitatively and quantitatively. In particular, the sea cliff area at the southern foot of Mt. Apoi is known for producing some of the highest-quality Hidaka Kombu available. The reason why such outstanding kelp grows in the marine zone is yet to be understood, but the peridotite (ultramafic rock) of Mt. Apoi is considered to be a factor. Generally, soil derived from ultramafic rock has a high content of metals such as iron and magnesium, which are both important for kelp growth even in extremely small quantities.

Fig. D-18 Environmental survey by the Hokkaido University Field Science Center for Northern Biosphere

Against this backdrop, the government of Samani Town – the home of Mt. Apoi Geopark – concluded a comprehensive partnership agreement with the Hokkaido University Field Science Center for Northern Biosphere to jointly investigate the causal relationships between favorable kelp growth and local conditions (Fig. D-18).

The decline and disappearance of kelp beds due to changes in the marine environment have become serious issues across Hokkaido. Although such beds are still extensively found in the coastal area of Mt. Apoi Geopark thanks to the area's unique environmental conditions, the protection of these underwater forests requires understanding and conservation of the entire area, including the terrestrial zone.

Collaborative survey work conducted by the university and local fishermen has led to a review of approaches in the fishing industry based on recognition of the need for resource conservation and motivation to provide added value for consumers.

D-5-3. Exchanges with other geoparks

(1) Japanese Geoparks Network

Japan currently has 7 Global Geoparks and 28 Japanese Geoparks, all of which engage in lively mutual exchanges. Mt. Apoi Geopark staff also work to improve local quality through exchanges and collaboration with other geoparks. Such efforts have included proactive participation in research meetings and the dispatch of guides for training at the Toya Caldera and Usu Volcano Global Geopark in fiscal year 2013 (Fig. D-19).

Fig. D-19 Guide training at Mt. Showa-Shinzan (Toya Caldera and Usu Volcano Global Geopark)

(2) Global Geoparks Network

Representatives of the Mt. Apoi Geopark Promotion Council in Samani have attended the International UNESCO Conference on Global Geoparks since its fourth meeting in Langkawi, and continue to make presentations as part of efforts toward Global Geoparks Network (GGN) membership. The Council seeks active exchanges with other regions based on the peridotite characteristics of the area. At the 2014 6th International UNESCO Conference on Global Geoparks in Stonehammer, Canada, the Council held discussions with representatives of northern Italy's Sesia-Val Grande Geopark, which is also a peridotite site, with the idea to engage in further exchanges in the future (Fig. D-20).

In July 2014, the Council hosted a lecture meeting and a special exhibition highlighting the geological features and geotourism of Oman in the Middle East (Fig. D-21). The events showcased the Oman ophiolite complex (consisting of sequences of material from the oceanic crust and upper mantle on the earth's surface), which is often researched in reference to the Horoman peridotite complex, and were held in collaboration with the Tokyo Embassy of the Sultanate of Oman.

Fig. D-20 With representatives from Sesia-Val Grande Geopark (Stonehammer)

Fig. D-21 (1) Lecture meeting and (2) special exhibition on the geology and geotourism of Oman held at Mt. Apoi Geo Park

D-6. Policies for, and examples of, community empowerment (involvement and consultation) in the proposed Geopark

D-6-1. Public Relations Activities

The Mt. Apoi Geopark Promotion Council in Samani engages in a variety of public relations initiatives to promote the concept of geoparks and associated activities.

The Council provides detailed information via its website and works to publicize its daily activities via a blog and a Facebook page. Principal efforts for communication with local residents include presentations, geosite guidance, and PR campaigns at local gatherings, and other events such as photo contests featuring beautiful Mt. Apoi Geopark landscapes (Fig. D-22) are organized. When planning events, the Council also places importance on press releases and promotion to media outlets.

Mt. Apoi Geopark has two mascots that help to raise its profile. They have become established as a local PR medium and appear on the sides of buses, traffic safety flags, clear document files and designated paid garbage bags (Fig. D-23).

The Promotion Council will continue its public relations activities, its hosting of symposiums, and its other initiatives to further enhance public interest in the geopark.

Fig. D-22 Photo contest poster

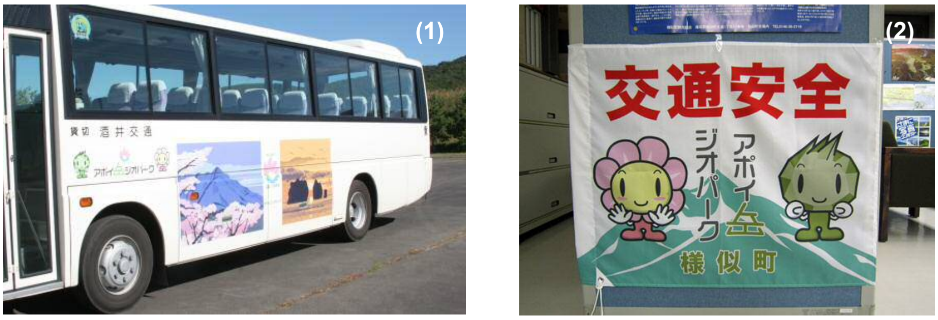


Fig. D-23 Geopark mascot utilization:
(1) on the side of a bus; (2) on a traffic safety flag

D-6-2. Merchandise Development

A variety of products bearing Mt. Apoi Geopark's logo and mascots have been developed, including cell phone straps, badges, polo shirts, sake, rice, honey and confectionery (Fig. D-24). A local company has also developed a high-end take-home gift made with a local brand of whelk and includes information on Mt. Apoi Geopark on its PR label (Fig. D-25).

Fig. D-24 Geopark related merchandise

The Mt. Apoi Geopark Promotion Council in Samani will continue to encourage local companies to develop geopark-related products while stepping up its collaboration with stakeholders in efforts such as the introduction of Mt. Apoi Geopark recommended product stickers on various local products.

Fig. D-25 Whelks (a Samani specialty) pickled in spicy soy sauce with a label featuring Mt. Apoi Geopark

E. Interest and arguments for joining the GGN

The Mt. Apoi Geopark Promotion Council in Samani offers a number of advantages for the Global Geoparks Network (GGN) that would result from its membership.

One of the main characteristics of Mt. Apoi Geopark lies in the unique opportunity for visitors to see, walk through, and come into contact with the otherwise inaccessible world of the earth's deep mantle. Its location in Japan and therefore within a mobile belt gives the area a feeling of global-scale dynamic ground movement, creating an experience different from that felt in the vicinity of volcanoes.

Although peridotites are found in various parts of the world, and especially in mobile belts, few are like those of Mt. Apoi. Here, they are of a certain size and are visible above the ground, and also maintain information about the mantle thanks to their non-metamorphosis. As a result, international conferences attended by peridotite researchers from around the world have been held in the area. The Mt. Apoi Geopark Promotion Council in Samani hopes to establish collaborative international relations with regions where peridotites are present by actively promoting this valuable geological heritage on a global scale.

Another main characteristic of Mt. Apoi Geopark is found in its unique ecosystems, which are greatly influenced by geological and geomorphological resources. Mt. Apoi is home to an amazingly diverse range of alpine plant species considering its low altitude and the isolated, small area of its alpine zone. The presence of numerous endemic (variant), disjunct-distribution, and rare species in the region highlights Mt. Apoi's role as a stage for plant evolution. In other words, these species would not be present without the area's special peridotite rock and the mountain's formation. Few places on earth exhibit such strong links between geological and geomorphological resources and ecosystems; Mt. Apoi Geopark exemplifies a range of geo-narratives and guidance methods that create these ties.

The value of the geopark's connections among geological and geomorphological resources, nature, and people would also represent a significant contribution to the GGN.

As described earlier, the main theme of Mt. Apoi Geopark is *A Story of Gifts from Deep Inside the Earth connecting Land and People Together*. This expresses the close relations between local residents and peridotites appearing from far below the earth's surface as a result of global-scale dynamic ground movement. It also encompasses the Promotion Council's efforts for community revitalization based on sustainable, symbiotic relations between nature and people.

Main theme:

A Story of Gifts from Deep Inside the Earth Connecting Land and People Together

Theme A: Peridotites – the interior and dynamic movement of the Earth

Theme B: Alpine Plants – scarcity and the natural environment

Theme C: Human History – the community of nature and human life

The unique geological features of peridotite and the climate of Mt. Apoi allow alpine plants to grow on this modest 810-meter peak. Local alpine plant communities including Hidakaso (*Callianthemum miyabeanum*) and other endemic species have been collectively designated as a Special Natural Monument of Japan. The pretty flowers found on the rugged peridotite terrain highlight the close relations between geological resources and ecosystems. A number of rocky monoliths along the coast to the west of Mt. Apoi form unique landscapes. These landforms, which were created at almost the same time as Mt. Apoi due to crustal movement and subsequent coastal erosion, gave rise to a fine natural port that led to the development of the area today. The rich variety of minerals contained in peridotites also supports a wealth of marine resources, and the local peridotite landforms have led to the development of renewable energy and consequent support for local industries.

In this way, the area has a variety of narratives to offer despite its limited scale. Mt. Apoi Geopark promotes various educational initiatives and geotourism using these narratives in its role as a Japanese geopark. In the meantime, the extensive involvement of residents in such activities has enhanced the identity of local communities, which is one of the aims of geopark promotion. Mt. Apoi Geopark is located in a very small town with a population of just 5,000. Against this background, the Mt. Apoi Geopark Promotion Council in Samani hopes to prove that the geopark concept helps to enhance the sustainability of local communities.

The Council hereby submits its GGN membership application for Mt. Apoi Geopark. We hope that membership will help people around the world to experience the magnificent natural phenomena of gifts from the deep inside the earth and see locals living together with the geo-heritage toward the ultimate goal of achieving sustainable development in the area.

The Mt. Apoi Geopark Promotion Council in Samani hereby expresses its desire to join the Global Geoparks Network in order to achieve these goals and make a truly global contribution.

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Appendix 1 List of Horoman Peridotite Publications

The Horoman peridotite complex has extremely high academic value. It is one of the world's most studied peridotite masses, and this list includes numerous related papers published in renowned international journals. The aims and details of research works on the peridotite complex are varied, and relate to of earth science. They include processes of magma movement in the upper mantle, origins of the upper mantle's compositional inhomogeneity, mechanisms behind melt generation and melt extraction, and solid-melt reactions during melt segregation, ascent and transfer as well as the formation, modification and evolution of the initial mantle in the earth's history.

To clarify the trends and challenges of research on the Horoman peridotites, publications in this list are organized by theme under the following nine headings:

1. Pioneer/comprehensive research on geology and petrology the Horoman peridotite complex as a whole
2. Examination of the petrological and mineralogical properties and origins of the Horoman peridotites
3. Elucidation of metasomatism (compositional modification during the island-arc stage) in the Horoman peridotites
4. Elucidation of symplectites (decompressional modification and the ascent processes) in the Horoman peridotites
5. Examination on geochemical properties and origins of the Horoman peridotites
6. Examination on evolutionary history of the Horoman peridotites based on isotope geochemistry and dating
7. Examination of compositional modification resulting from basaltic magma generation and melt migration, ascent and transportation
8. Analysis of textual patterns in the Horoman peridotites and their deformation and flow within the mantle

   Regional geology, petrology, structures, tectonics and other aspects of the Hidaka Mountains, including the Horoman peridotite complex

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List of Horoman Peridotite Publications

1. Pioneer/comprehensive research on geology and petrology of the Horoman peridotite complex as a whole

Yamamoto, H., Nakamori, N., Terabayashi, M., Rehman, H.U., Ishikawa, M., Kaneko, Y., Matsui, T., 2010. Subhorizontal tectonic framework of the Horoman peridotite complex and enveloping crustal rocks, south-central Hokkaido, Japan. *Island Arc*, **19**, 458-469.

Morishita, T., Ozawa, K. and Obata, M., 2010. A recent trend in sciences on mantlederived materials, with special emphases on refertilization, rheology, and ophiolite problems: a report of the Fifth International Conference on Orogenic Lherzolite. *Japanese Magazine of Mineralogical and Petrological Sciences,* **39**, 85-103. (In Japanese with English abstract)

Niida, K., 2009, JGN'Mt. Apoi Geopark: Attractions for science, education, and geotourism. *In: East Asian Geoparks-Vision, Problems and Prospects, ed by Jiun-Chuan Lin. Geogr. Soc. China*, 274-286.

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2. Examination of petrological and mineralogical properties and origins of the Horoman peridotites

Kitakaze, A., Itho, H., Komatsu, R., 2011. Horomanite, (Fe, Ni, Co, Cu)$_9$S$_8$, and samaniite, Cu$_2$(Fe,Ni)$_7$S$_8$, new mineral species from the Horoman peridotite massif, Hokkaido, Japan. *Journal of Mineralogical and Petrological Sciences*, **106**, 204-210.

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3. Elucidation of metasomatism (compositional modification during the island-arc stage) in the Horoman peridotites

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7. Examination of compositional modification resulting from basaltic magma generation and melt migration, ascent and transportation

Niida, K., Green, D. H., Yoshikawa, M., and Eggins, S. M., 2006, Dunite channels in the Horoman peridotites, Japan: Textural and geochemical constraints on melt/fluid transport through the lithosphere. *Geochim. Cosmochim. Acta*, **70**, 445.

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Takizawa, S., 1997, Flow fold of the Horoman peridotite complex, Hokkaido, Japan. *Mem. Geol. Soc. Japan*, **47**: 209-218. (In Japanese with English abstract)

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Niida, K., 1975a, Textures and olivine fabrics of the Horoman ultramafic rocks, Japan. *J. Japan Assoc. Min. Petr. Econ. Geol.*, **70**, 265-285.

9. Regional geology, petrology, structures, tectonics and other aspects of the Hidaka Mountains, including the Horoman peridotite complex

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Appendix 2　　Mt. Apoi Geopark Geosite List

Area	No.	Geosite	Era	Rock types	Geological/topographical features	Education	Tourism	Research	Quasi-national park area	Information board	Remarks
Horomankyo	A1	Power Station No. 2	Precambrian –	Harzburgite – Lherzolite	Horoman Peridotite Complex in the Hidaka Metamorphic Belt: lowermost zone, gorge	○		○		●	
	A2	River beach near the quarry	Precambrian –	Peridotite, gabbro	Horoman Peridotite Complex in the Hidaka Metamorphic Belt: gorge, boulders	○		○		●	
	A3	Japanese White Pine Monument	Precambrian –	Lherzolite	Horoman Peridotite Complex in the Hidaka Metamorphic Belt: high-pressure type, gorge	○	○	○	Class III Special Zone	●	Natural Monument of Japan
	A4	Fudo-no-sawa	Precambrian –	Harzburgite Plagioclase lherzolite	Horoman Peridotite Complex in the Hidaka Metamorphic Belt: gorge	○		○	Class III Special Zone	●	
	A5	Dam of Power Station No. 2	Precambrian –	Dunite Harzburgite	Horoman Peridotite Complex in the Hidaka Metamorphic Belt: contact-related magma channel, gorge			○	Class III Special Zone	●	
	A6	Horoman-gawa Inari Shrine	Precambrian –	Plagioclase lherzolite Mafic rock Type GB I	Horoman Peridotite Complex in the Hidaka Metamorphic Belt: low-pressure type, gorge, potholes	○	○	○	Class III Special Zone	●	
	A7	Horoman Dam (dam of Power Station No. 3)	Paleogene – Neogene	Gneiss, amphibolite Gabbro, tonalite	Hidaka Metamorphic Belt: lower to middle parts of the Middle Zone	○	○		Class III Special Zone	●	
Mt. Apoi	B1	Rest Spot No. 4				○	○		Class III Special Zone	●	
	B2	Alpine Plant Regeneration Test Site				○		○	Class III Special Zone	●	
	B3	Fifth-stage mountain lodge	Precambrian –	Plagioclase lherzolite	Horoman Peridotite Complex in the Hidaka Metamorphic Belt: upper zone	○	○	○	Special Protection Zone	●	Special Natural Monument of Japan, Japan's Top 100 Geological Features
	B4	Sixth to seventh stages	Precambrian –	High-Mg peridotite Mafic rock Types GB I/II/IV	Horoman Peridotite Complex in the Hidaka Metamorphic Belt: magma channel	○		○	Special Protection Zone	●	Special Natural Monument of Japan, Japan's Top 100 Geological Features
	B5	Umanose flower fields	Precambrian –	Peridotite	Horoman Peridotite Complex in the Hidaka Metamorphic Belt: peridotite massif	○	○		Special Protection Zone	●	Special Natural Monument of Japan, Japan's Top 100 Geological Features
	B6	Mt. Apoi			Top of Mt. Apoi	○	○		Special Protection Zone	●	Special Natural Monument of Japan, Japan's Top 100 Geological Features
	B7	Horoman flower fields			Ridge landform in the southern part of the Hidaka Mountains	○	○	○	Special Protection Zone	●	Special Natural Monument of Japan, Japan's Top 100 Geological Features
	B8	Apoi to Yoshida	Precambrian –	Plagioclase lherzolite Mafic rock Type GB I	Horoman Peridotite Complex in the Hidaka Metamorphic Belt: upper zone		○	○	Special Protection Zone	●	Special Natural Monument of Japan, Japan's Top 100 Geological Features
	B9	Mt. Yoshida	Precambrian –	Plagioclase lherzolite	Horoman Peridotite Complex in the Hidaka Metamorphic Belt: uppermost zone		○	○	Special Protection Zone	●	Special Natural Monument of Japan, Japan's Top 100 Geological Features
	B10	Pinneshiri	Precambrian –	Plagioclase lherzolite	Horoman Peridotite Complex in the Hidaka Metamorphic Belt: northern half		○	○	Special Protection Zone	●	Special Natural Monument of Japan, Japan's Top 100 Geological Features

Area	No.	Geosite	Era	Rock types	Geological/topographical features	Education	Tourism	Research	Quasi-national park area	Information board	Remarks
Samani Coast	C1	Shiogama Tunnel and Rosoku-iwa	Neogene	Porphyrite	Dike intruding into the Cretaceous System (Yezo Group)	○	○			●	Municipal place of scenic beauty
	C2	Oyako-iwa and Sobira-iwa	Neogene	Porphyrite	Dike intruding into the Cretaceous System (Yezo Group)	○	○			●	Municipal place of scenic beauty
	C3	Cape Enrumu	Neogene	Porphyrite	Dike intruding into the Cretaceous System (Yezo Group), peridotite massif	○	○			●	Municipal place of scenic beauty, Hokkaido Remarkable Geosites 100
	C4	Mt. Kannon	Neogene	Porphyrite	Dike intruding into the Cretaceous System (Yezo Group), erosion	○	○			●	Municipal place of scenic beauty
	C5	Tojuin Temple				○	○				Municipal cultural property
	C6	Byobu Cliff in Hirau	Neogene	Conglomerate, sandstone, mudstone	Shallow sea sediment containing shell fossils	○		○		●	
	C7	Old quarry behind Samani Elementary School	Cretaceous	Sandstone, mudstone	Cretaceous (Yezo Group) fore-arc basin area	○				●	Hokkaido Remarkable Geosites 100
	C8	Okada District *cise* (traditional Ainu dwelling)				○	○			●	
Hidaka Yabakei	D1	Ana-iwa in Fuyushima	Paleogene	Hornfels	Idonnappu Belt: Fuyushima metamorphic rocks, sea cave	○	○		Ordinary area	●	Hokkaido Remarkable Geosites 100
	D2	Fault at the Higashi Fuyushima Tunnel	Neogene	Black mudstone, serpentinite, metagabbro	Hidaka Main Thrust (HMT) Former plate boundary	○		○	Class II Special Zone	●	
	D3	Metagabbro at the Kotoni Tunnel	Cretaceous	Metagabbro	Poroshiri Ophiolite Belt	○		○	Class II Special Zone	●	
	D4	Granite at the Taisho Tunnel	Paleogene	Granite	Hidaka Metamorphic Belt: lower part of the Middle Zone	○	○		Class II Special Zone	●	
	D5	Geological fold at the Ruranbetsu Tunnel	Paleogene – Neogene	Amphibolite, biotite gneiss	Hidaka Metamorphic Belt: lower part of the Middle Zone, sea cliff	○		○	Class II Special Zone	●	Hokkaido Remarkable Geosites 100
	D6	Samani Mountain Path and Wasuke Jizo				○	○			●	Municipal cultural property
Shintomi	E1	Old mine of Ono Kogyo Co., Ltd.	Triassic Cretaceous – Paleogene	Limestone, mudstone, sandstone	Idonnappu Belt, accretionary prism mélange	○				●	
	E2	Lenticular sandstone at the Samani Dam	Cretaceous – Paleogene	Sandstone, mudstone	Idonnappu Belt, accretionary prism mélange	○		○		●	
	E3	Chert in Shintomi	Jurassic Cretaceous – Paleogene	Chert	Idonnappu Belt, accretionary prism mélange	○		○		●	
	E4	Limestone blocks in Matsuokazawa	Triassic Cretaceous – Paleogene	Limestone, mudstone, sandstone	Idonnappu Belt, accretionary prism mélange	○				●	