Annex 2

Separate Print of Chapter B (The Earth's Geological Heritage) in the Application Dossier for Nomination to the Global Geoparks Network

Mt. Apoi Geopark – Japan

Summary

Mt. Apoi Geopark is located near the southern tip of Hokkaido, which is the northernmost island of the Japanese Archipelago. Mt. Apoi is 810 meters high and located at the southwestern end of the Hidaka Mountains, which are known as the backbone of Hokkaido.

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. Man has of course 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 feel global-scale dynamic ground motion. This motion has produced unique and valuable colonies of alpine flora on Mt. Apoi, fascinating climbers from across Japan. The area's geological heritage has also significantly affected the daily lives of local residents.

Chapter B describes the geological heritage of Mt. Apoi Geopark, including its peridotites, as well as the resulting ecosystem and cultural history.

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.

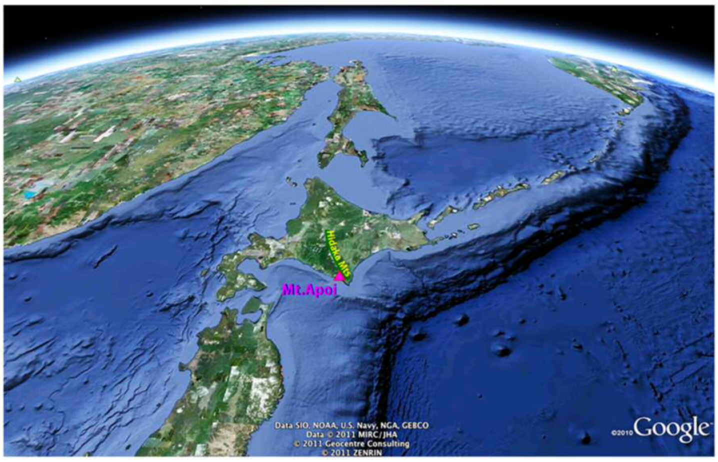


Fig. B-1 Topographical map around Hokkaido and Mt. Apoi (courtesy: Google Earth)

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.

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.

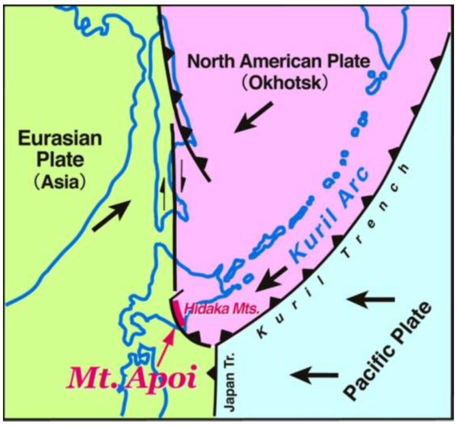


Fig. B-2 Map showing relationship of 3 major plates in areas near Hokkaido, at the beginning stage of the Hidaka mountain building (Niida, 1999). Mt. Apoi was located at the southwestern margin of the North American Plate, colliding on the Eurasian plates.

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.

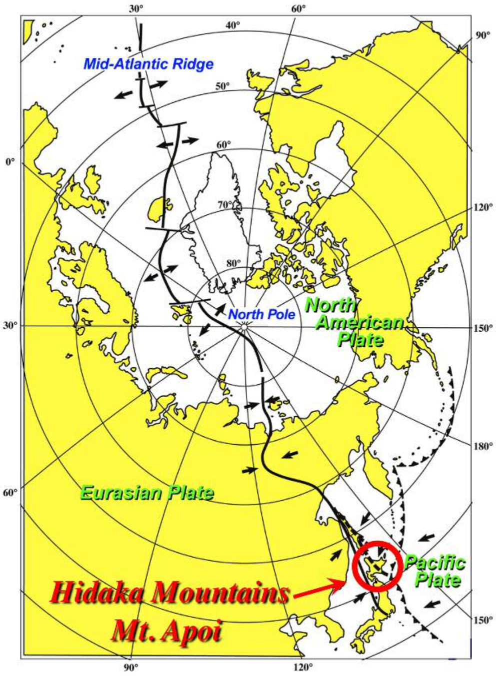


Fig. B-3 Map of the Northern Hemisphere of the Earth, showing the relationship between of the Northern American and Eurasian plates. (Niida, 2010). The thick solid line shows the present boundary between the Northern American and Eurasian plates. The thick broken line running along the central axial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

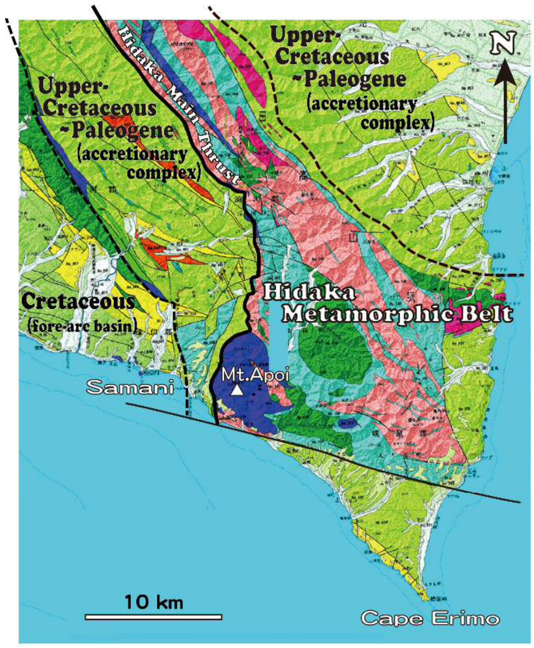


Fig. B-4 Simplified geological map of Mt. Apoi Geopark and the surrounding area, showing major geological units. Referred from the Seamless Digital Geological Map of Japan 1:200,000: Hokkaido (Geological Survey of Japan, 2003).

(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.

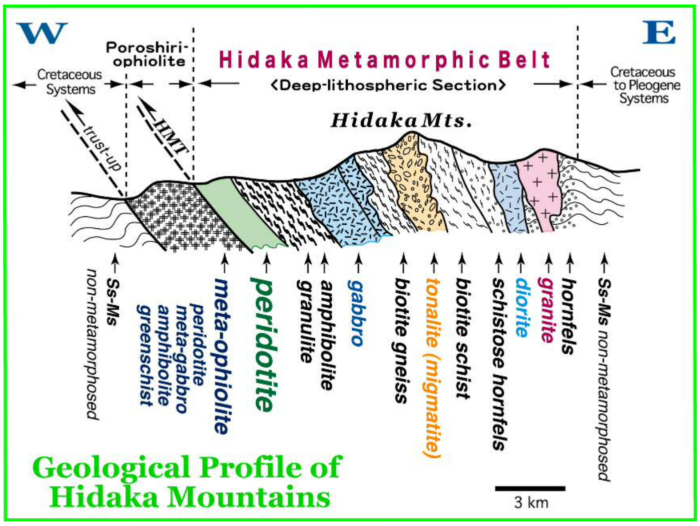


Fig. B-5 Geological cross-section of the Hidaka Mountains (Niida, 1997). HMT: Hidaka Main Thrust. This profile shows a geological sequence of the most representative metamorphic and plutonic rock types, which are typically observed in E-W traverse of the Hidaka mountain range. All the geological piles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

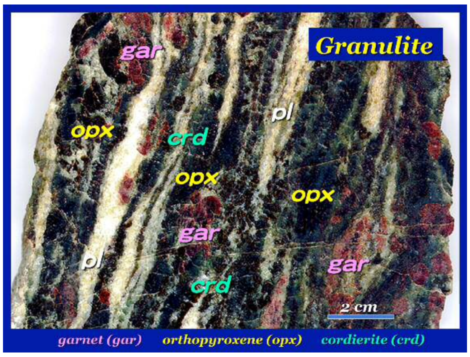


Fig. B-6 Granulite from the upper Horobetsu River, composed of garnet, orthopyroxene, cordierite and plagioclase. This represents a high - grade metamorphic rock from the lowermost crust.

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.

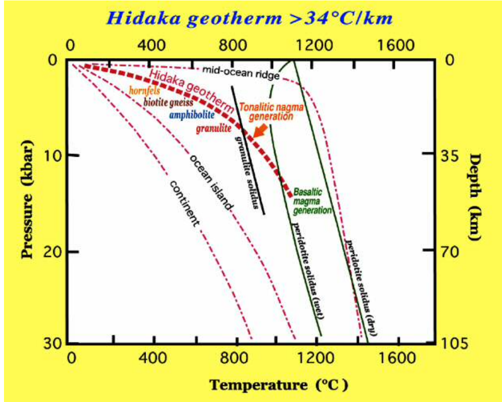


Fig. B-8 Temperature-pressure chart for metamorphic rocks from the Hidaka Mountains (Niida, 1999), showing a high geothermal gradient (approximately 34°C/km).

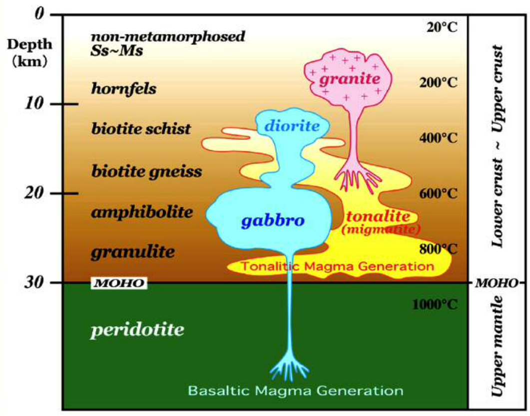


Fig. B-9 Reconstruction model for generations of the Hidaka metamorphic and igneous rocks (Niida, 1999), showing a spatial distribution of representative rock types. This corresponds to those in the geological cross-section (Fig. B-5).

(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.

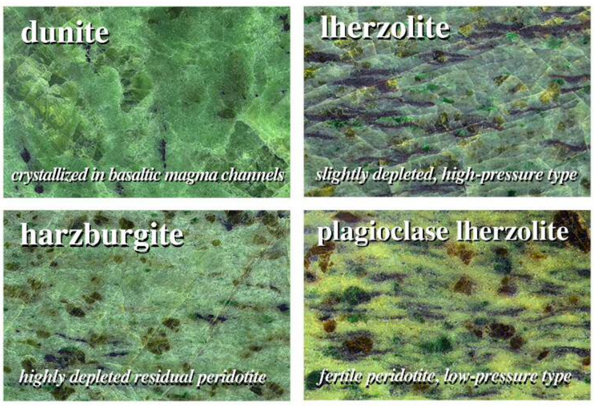


Fig. B-14 Four typical peridotite types of the Horoman complex

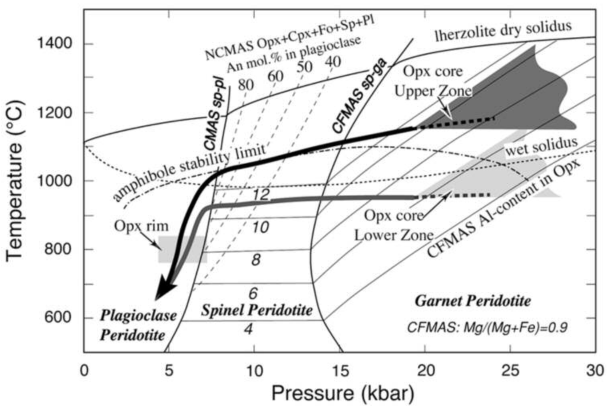


Fig. B-15 Pressure-temperature path, showing ascent history of the Horoman peridotite complex (Ozawa, 2004).

(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).

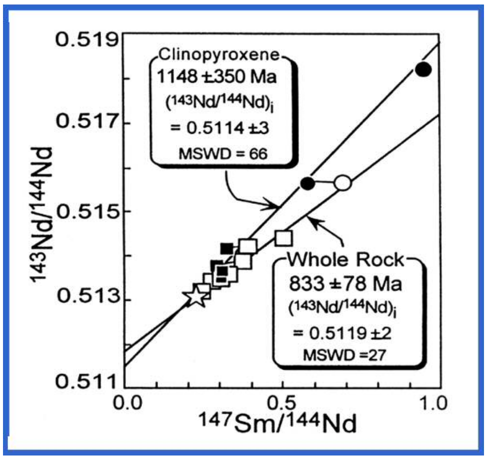


Fig. B-16 Nd-Sm isochrons showing age of the Horoman peridotites (Yoshikawa and Nakamura, 2000).

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").

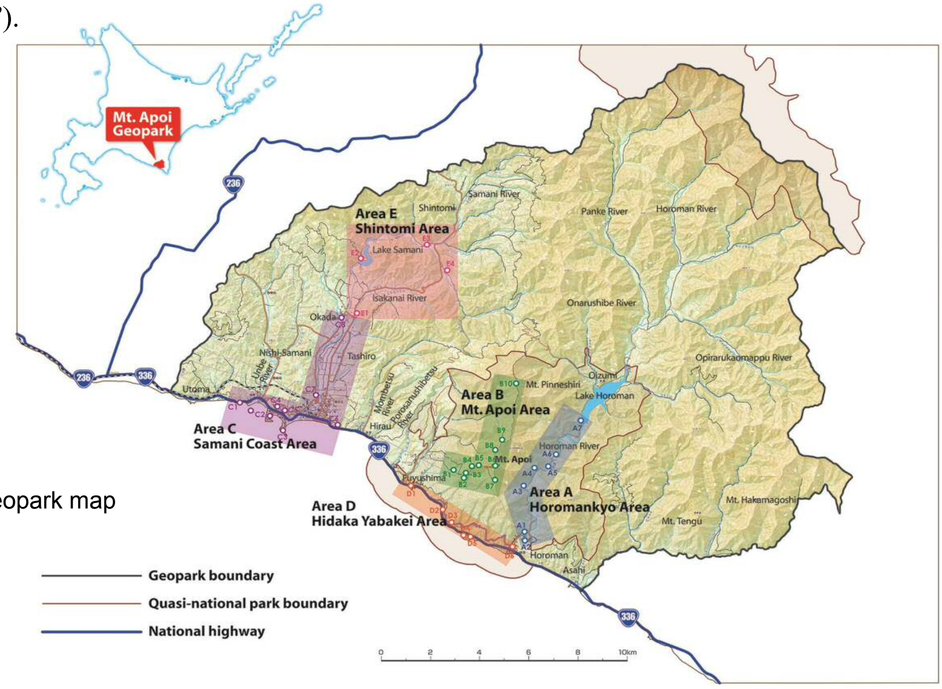


Fig. B-17　Mt.Apoi Geopark map

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)**

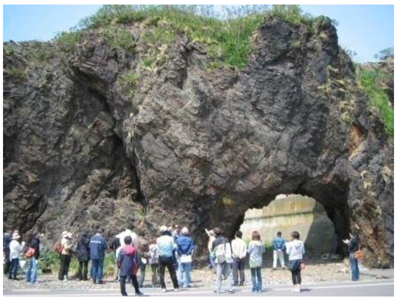
Sandstone and mudstone strata that formed in a Cretaceous fore-arc basin around 100 million years ago are observed at the old quarry behind Samani Elementary School. The hilly terrain in the western half of Mt. Apoi Geopark consists of sedimentary rock from this period and provides contrast with the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

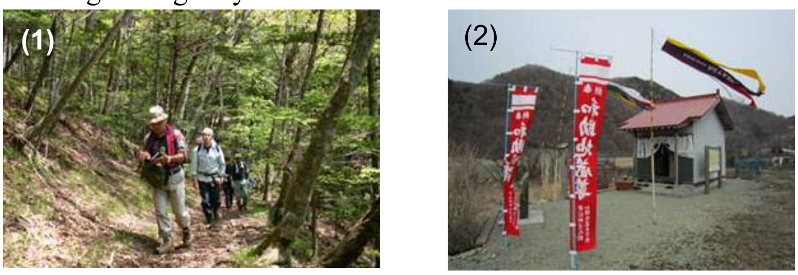


Fig. B-25 (1) Samani Mountain Path (built around 200 years ago); (2) a Wasuke Jizo statue at the Samani Mountain Path east trailhead (both Geosite D6)

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

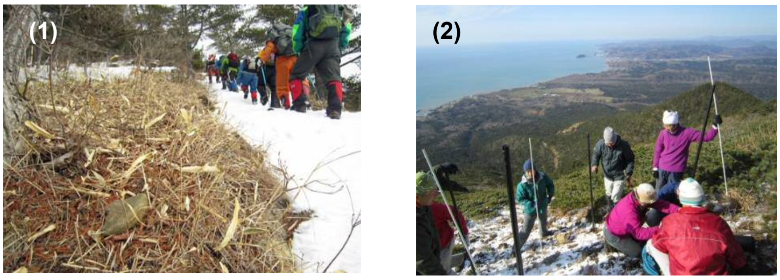


Fig. B-30 (1) Traces of bamboo grass grazed by Hokkaido sika deer; (2) installation of deer fences to support investigation of sika deer's impacts on alpine plants

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).

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-31 Apoimaimai (*Paraegista apoiensis*)

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

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.

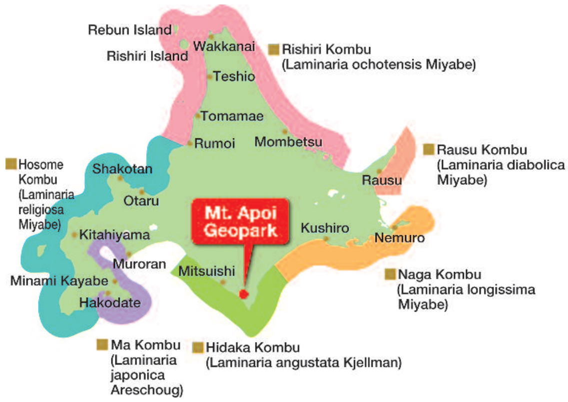


Fig. B-34 Distribution of local kombu kelp

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.

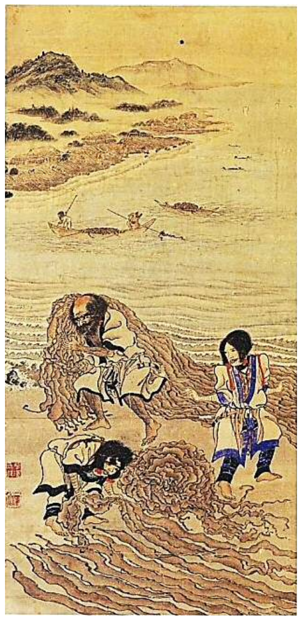


Fig. B-36
Kelp (Kombu) Harvesting
(Byozan Hirasawa, 1822–1876)

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.

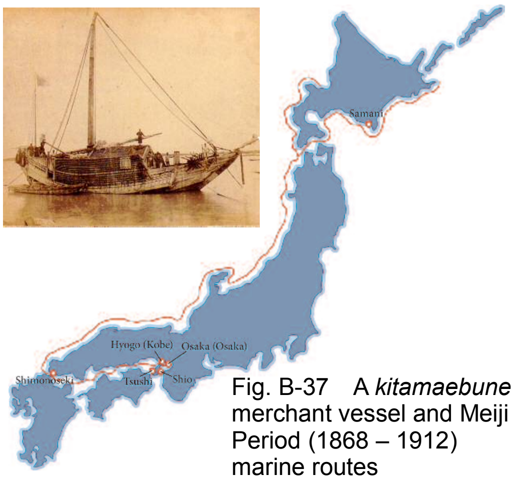


Fig. B-37 A *kitamaebune* merchant vessel and Meiji Period (1868 – 1912) marine routes


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.

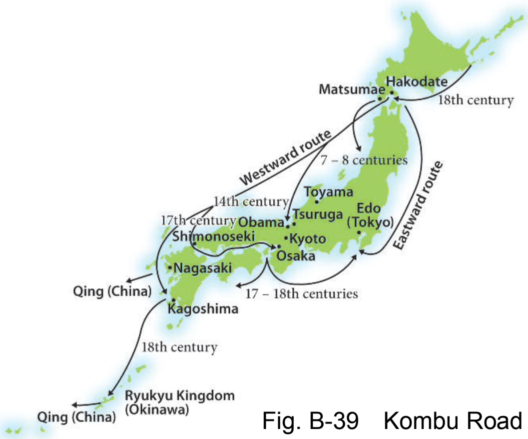


Fig. B-39 Kombu Road

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