

#### Fault: Beppu Benten Pond



At the location of Beppu Benten Pond, there is a geological boundary (fault), and water springs forth along this fault. This water is believed to flow underground from the area around Mt. Hanao. The red color seen at the bottom of the pond is due to the porocess of freshwater algae called *Hildenbrandia rubra*, a near-threatened species, which is attached to the surface of the stones. As rivers are scarce in this area, this spring has long served as a valuable water source for the region.

#### **Overprotective:** The granitoid gneiss (orthogneiss) of Hirano



Granite, under high pressure and temperature deep underground, transforms into granitoid gneiss, also known as orthogneiss. Originally, this rock formed part of a continent, but it became incorporated into serpentinite. Since it is surrounded by serpentinite, one could say that this rock was "overprotected" during its development. This rock, formed around 400-430 million years ago, is the oldest in Yamaguchi Prefecture, though not especially old on a global scale, considering that the Earth's history spans 4.6 billion years.

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#### Slimy: The serpentinite of Hirano



Peridotite, which lies deep underground, reacts with water to become serpentinite. This reaction makes it lighter, causing it to rise from deep underground. On its way up, it incoporated orthogneiss. Its slimy surface and snake-like patterns is where the name "serpentinite" comes from. It is used as aggregate for concrete, and was once mined for asbestos extraction.

#### **Gigantic:** Akiyoshido Cave



Akiyoshido Cave stretches over 11 km, making it the second longest limestone cave in Japan. However, compared to the enormous caves overseas that span several hundred kilometers, it is not exceptionally large. The orientation of Akiyoshido Cave aligns with the many faults found in this region as faults and cracks in the limestone are where caves begin to form. Due to the unique organisms inhabiting its underground waters, the cave is reconized under the Ramsar Convention as a Wetland of International Importance.

> Three-Dimensional: Taishodo Cave



Taishodo Cave was discovered in Taisho 10 (1921), which is how it got its name. The cave entrance lies in a large depression in the forest. Inside, the cave features over 100 meters of elevation difference and has a multi-layered, three-dimensional structure. This cave lacks large stalactites and has seen little erosion or sediment inflow since its formation, allowing visitors to observe features close to their original condition.

### Praying for rain: Kagekiyo Hole (Kagekiyodo Cave)



The Misumida River flows through Kagekiyo Hole, having entered the cave from a sinkhole above, and emerges again as a river on the surface after passing through the cave. The brown stalactites here get their color from the mud carried along with the river. Fossils of corals and crinoids (sea lillies) can be seen on the ceilings and walls. In the past, people entred this cave to pray for rain during droughts. Even now, the names of those who prayed during the Edo period (17th-mid-19th century) remain inscribed on the cave ceilings.

#### Fusulinid: Kaerimizu



Limestone, when dissolved by rainwater, forms funnel-shaped depressions called dolines, often tens of meters wide. When dolines merge and grow larger, the resulting landform is called an uvala- one such example of this is Kaerimizu. Its name comes from the spring water that springs up and flows along the ground for a few meters before seeping back into the ground. In 1923, the geologist Yoshiaki Ozawa studied the strata containing fusulinid fossils here, which led to the discovery that the limestone of Akiyoshidai is overturned.

#### Intrusion: The granite of Ofuku



When granitic magma intrudes areas where limestone is present, the surrounding limestone is heated and transformed into marble. The magma then slowly cools and solidifies into granite. Similarly, when granitic magma intrudes coal-bearing strata, it stimulates the carbonization of coal. Highly carbonized coal produces little smoke. The heat once held by the granite of Ofuku formed marble and anthractie (smokeless coal).

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Dacite: Mito Waterfall

Mito Waterfall consists of five consecutive waterfalls, with a total height difference of 11 meters. These step-like waterfalls are known as cascades, and are distinct from single- vertical falls. At this site, dacite -a type of volcanic rock- is exposed. However, the formation of these steps is not necessarily influenced by geological structures such as fractures in the dacite.

#### **Rolling around:** The Great Rocks of Magura



The geology of this area is composed of diorite, a rock formed from magma that solidified deep underground. This diorite weathers along fractures, gradually forming large, rounded boulders. As the surface soil is later washed away, a landscape dotted with massive boulders emerges.

#### Hot spot: The basalt of Miyanobaba



The limestone of Akiyoshidai originally formed as an atoll reef. For such an atoll reef to form in the open ocean, it needs a volcanic island as its base. In the ocean floor, there are places where magma rises from beneath the Earth's crust -these are called hot spots. Volcanoes that form at hot spots are always composed of basalt. The basalt visible at Miaynobaba is a remnant of a submarine volcano. The submarine volcano made the existence of the limestone of Akiyoshidai possible.

#### Anthracite: Momonoki Strip Mine Ruins



Coal is formed when plant remains accumulate without decaying, and are transformed into a rock under high pressure and high termperature underground. Globally, most coal was deposited during the Late Paleozoic Carboniferous period (360-300 million years ago), but much of Japan's coal is younger, from the Paleogene period of the Cenozoic (66-23 million years ago). However, the coal in this area was formed during the Triassic period (250-200 millions years ago). Because this coal underwent advanced carbonization, it produces little smoke and is classified as anthracite.

#### Ancient cockroach: The fossiliferous siltstone of Okubata



The strata here were deposited between 230 and 2200 milion years ago and contain many fossils of insects and plants from that time. Among them, *Triassoblatta okafuji* is the oldest cockroach fossil ever discovered in Japan. These layers were deposited after a period of mass extinction, and they provide insights into the types of organisms that revived and flourished after the mass extinction.

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#### Black chert: The chert of Kamisobara



Chert comes in a variety of colors, and black chert is found in this region. Chert is formed from the silica-rich skeletons and shells of plankton that slowly accumulate on the seafloor and become rock. The presence of chert suggests that a deep and wide ocean surrounded the original atoll reef that was situated around the limestone of Akiyoshidai, where plankton remains settled and were preserved.

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#### Turbidite: The sandstone of Ayagi

Sand and mud from the continent flow into the sea near the shore, forming sedimentary layers. When dense flows of sand and mud travel down the slope of the sea floor, they leave deposits that reflect the characteristics of these underwater currents. These deposits are called turbidites.

#### Stromatolite: Mt. Kanmuri



This 377-meter-high mountain lies within the karst plateau (Akiyoshidai). From its summit, one can see classic karst features such as the limestone pillars of Jigokudai and the dolines of Umakorobi. Striped patterns made by sponge-like organisms that live in the ocean can be seen on the surfaces of the limestone at the summit. Because the strata are overturned, these structures now face the opposite direction from their original formation. They are sometimes referred to as stromatolites.

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#### **Contact metamorphism:** Chojanishiki Quarry Ruins

At the Chojanishiki Quarry Ruins, marble was once quarried to be used for construction and crafts. About 100 million years ago, magma underground heated the existing limestone, turning it into marble. When magma comes into contact with pre-existing rocks and alters it through heat, this process is known as contact metamorphism.

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#### Melange:

#### The limestone block-containing mudstone of Higashi-Shibukura



Here, large limestone block-containing industone of Higasin-Sinbukura Here, large limestone blocks, several meters in diameter, are embedded within mudstone layers. These limestones originated as coral reefs in far southern seas. Carried by oceanic plate movements, these massive blocks were fragmented during collisions with continental landmasses and became embedded in muddy seafloor deposits. A rock that contains a mixture of various rock types that have changed shape and mixed together is called a melange.



#### Towering: The lime kiln ruins of Ofuku

Lime was produced here during the late 19th century to the mid-20th century. Limestone was quarried from the mountains southeast of the lime kilns, and anthracite was mined from the northern to western strata to use as fuel for the kilns. The lime produced here was used as fertilizer for rice paddies, as a material for cement, and for construction materials (plaster).

#### Mud avalanche: The terraced paddy fields of Oishi



These terraced rice paddies are located at an open mountain valley. In the past, a mixture of mud and water repeatedly flowed down the valley. These flows are known as debris flows. The landform here is called a debris flow fan. The name "Oishi" (meaning "big stone") likely originates from large boulders that were transported here by such flows. Despite the steep slopes, people have constructed multiple levels of terraces for rice cultivation.

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#### Iris: Nitanda Reservoir (Water Iris Field)



A biologically valuable wetalnd plant community has formed in this reservoir, which was built near a mountain ridge to store agricultural water. Around 15 species of plants have been recorded here, inluding iris, East Asian yellow water-lily, watershield, and blunt-leaved bog-moss. The irises bloom rom mid-May to early June.

#### Skarn: Naganobori Copper Mine Ruins



When magma that forms granitic rocks intrudes into an area with limestone, the boiling fluid that derives from magma dissolves the limestone. This causes the fluid's pH to approach neutral, and metals in the fluid settle as sulfides. This forms what is known as a skarn deposit. At this time, copper was intermittently mined from the 8th century to the mid-20th century. The copper mined here was used as a raw material for the Great Buddha of Nara.

## Uvala:

#### Yowara Uvala and Hamlet



The Yowara Hamlet lies at the bottom of a basin surrounded by mountains. Normally, such lowlands in the mountainous areas are formed by rivers, but no such rivers are found here. This large depression is formed by the dissolution of limestone, and is known as uvala. As water is scarce here, people used to practice dry-field farming, such as tobacco cultivation, and also raised horses and silkworms.

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#### Nagato Fuji: Mt. Hanao



Mt. Hanao is called "Nagato Fuji" becasue its pointy summit stands out and is easily reconizable from afar. The summit is made from volcanic andesite rock. Because andesite resists erosion, the mountain has retained its triangular shape. This geological structure resembles a cap placed over something, and is referred to as a caprock structure.

#### Landmark: Chojaga Forest



Field burning is carried out annually on Akiyoshidai, creating a wide expanse of grassland. Within it lies a dense forest dominated by many *Machilus thunbergii* bay trees, covering about 3,000 m<sup>2</sup>. According to legend, a chieftain (choja) once lived here, giving the forest the name "Chojaga Forest". Since it stands out in the vast grassland, it likely served as a landmark for travelers in the area.

#### **Doline:** The doline fields of Kaerimizu



On Akiyoshidai, farming is conducted in depressions called dolines, which are formed by the dissolution of limestone. These fields are locally known as depression fields or hole depressions. In the past, most dolines were used for farming, but now only a few are. The strongly acidic, clay-rich soil typical of limestone areas is improved by mixing in grass cut from nearby, and crops such as grains and vegetables have been grown in them. Today, root vegetables like burdock and taro are cultivated.

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**Flock together:** Akiyoshidai Karst Observatory

Countless white limestone blocks can be seen across Akiyoshidai, which resemble a flock of sheep. Such limestone surfaces are called karrenfeld, meaning an area where karrens exist. If you approach one of these blocks, you will see many vertical grooves on the limestone surfaces fromed by dissolution. These grooves are called karren.

#### Sucked in: Ofukudo Cave





#### Gradual: Suijin Pond



This pond is located on the edge of the limestone that makes up Akiyoshidai. Its water comes from springs originating in the limestone area. As surface water flow is minimal in limestone regions, these springs are valuable sources of water for agriculture. The god of water is enshrined here to give thanks for the water.

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Suijin Park (Guardian god of breast milk) At Suijin Park, stalactites are enshrined as a guardian deity for breast milk. Water containing dissolvled calcium carbonate from limestone drips down, gradually forming icicle-like stalactites. Because these stalactites resemble breasts, there is a legend that drinking this water helps initiate and increase the flow of breast milk.

Drip: