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Survey Team Report

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Overview

The Jomon people entered the Fossa Magna from Itoigawa, and reached the area around Lake Suwa, looking up at the mountains of the Northern Alps. They then advanced further to the southern part of the Yatsugatake Mountain range, where they established settlements on the vast gentle slopes. The Jomon people used the Fossa Magna as a corridor.

Perhaps the Yatsugatake volcano was in a long period of dormancy. On the south side of its vast gentle slope, Mt. Kai-Komagatake of the Southern Alps rises as a mountain where the gods reside. The Jomon people may have lived their daily lives gazing in awe at the Komagatake Mountains in front of them and gathered wild grapes in abundance from the surrounding area. The wild grapes would have soon into a fruit wine. They learned to drink the wine and commune with the mountain gods. Later, the Yayoi people, who had knowledge of rice cultivation, replaced the Jomon people. The Yayoi people brewed mouthfuls of sake from rice, creating the prototype for sake.

On the other hand, Yamanashi has a unique geographical feature, the Fossa Magna, with the Kofu Basin in the center. This leads to Yamanashi's abundant supply of pure water. This research clearly shows that the unique topography and geology of Yamanashi has nurtured pure water.

Specifically,

1) The existence of the Kofu Basin, which is surrounded by mountains, is cited as a topographical factor. Pure water is formed by flowing into the basin which has a funnel-shaped topography.

2) Geological factors include pure water created by volcanic ash layers from the Yatsugatake volcano and Mt. Fuji and by sandy soil in the weathered Kofu Granite Body (geology of southern Fossa Magna).

Pure water (Seisui) is an important raw material, along with rice and koji.


八ヶ岳山麓水系
瑞牆山・金峰山麓水系
秩父山麓水系
赤岳
瑞牆山
金峰山
雲取山
駒ヶ岳
御坂山地
南アルプス山麓水系
富士山伏流水
富士山
富士山麓水系

Part Ⅰ The origins of water and sake in Yamanashi

- From the view of Geologist -

HISADA, Ken-ichiro

Preface - Alcohol born with the evolution of the Earth and Life

This report is an attempt to review the water of Yamanashi Prefecture from a geological standpoint. Geology is generally concerned with prehistoric times, but here we will explore the connection between geology and sake, one of the masterpieces of Japanese culture. To begin with, when did alcohol first appear on earth? In fact, it can be said that fermentation occurred on the Earth, which was born 4.6 billion years ago, along with the evolution of life about 3.8 billion years ago. The Kojien dictionary defines "fermentation" as "a process in which yeast, bacteria, and other microorganisms break down organic compounds to produce alcohol, organic acids, carbon dioxide, and other gases". In other words, it is a phenomenon in which carbohydrates are broken down by microorganisms without the participation of oxygen, resulting in the production of alcohol. For the planet Earth, this fermentation played an important role in the translation from an anoxic to "21% of today's atmosphere is oxygen".

Life (prokaryotes) is thought to have emerged as early as 3.5 billion years ago in the early history of the earth, although there is no direct evidence. Prokaryotes are thought to have evolved into eukaryotes, but the details remain unknown. Solid evidence of eukaryotes has been found in rocks that are approximately 1.4 billion years old. Prokaryotic cells are small (0.2 to 1 μm) and do not have a cell nucleus, and they breathe and photosynthesize on cell membranes that do not like oxygen. On the other hand, eukaryotic cells, on the other hand, are large (1-10 μm) and carry out respiration and photosynthesis in small organelles within the cell. Eukaryotic cells are organisms that utilize oxygen and are equipped with metabolic mechanisms (all

chemical changes and energy conversion that occur in living organisms). These unicellular organisms evolved into multicellular organisms 600 million years ago. Thus, in the process of reaching the current level of oxygen from a state of anoxic state, life has evolved. From another perspective, the evolution of life has been brought about by the use of oxygen, which can be described as an energy revolution, in life activities (Langmuir & Broecker, 2014). The first step out of the anoxic state is alcohol fermentation. This made it possible to use the energy of the planets and the sun to produce their own food.

Carbon dioxide + Hydrogen + Solar Energy → Glucose (Carbohydrates) + Water

This is photosynthesis by anaerobic bacteria, and the glucose produced is metabolized to generate ATP (adenosine triphosphate).

Glucose → Ethanol + Carbon dioxide + 2ATP

This is indeed fermentation (note that no oxygen is produced). Here, ATP is a molecule filled with energy, while ethanol is a kind of "waste product" that just happened to be produced. Later, oxygen-evolving photosynthesis and a mechanism to utilize oxygen were developed, making it possible to produce 18 times as much ATP.

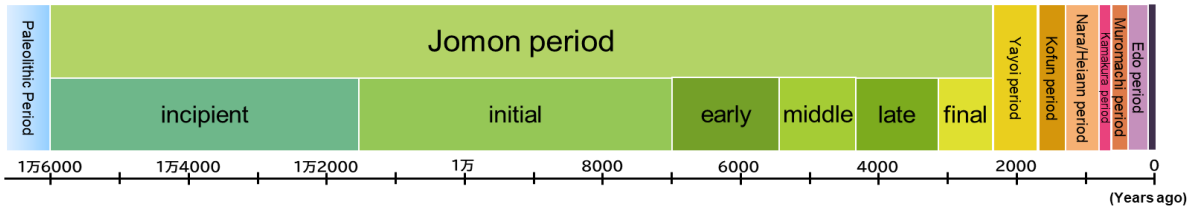
Glucose + Oxygen → Carbon dioxide + Water + 36ATP

This is a very useful mechanism for organisms to produce energy-filled molecules and led to the emergence of multicellular organisms about 600 million years ago. And we humans are still alive today as a result of the evolution of these organisms.

Incidentally, there are billions of prokaryotes living in our bodies, and it is said that the number of prokaryotes living on the surface of one person is greater than the entire population of the earth. With such memories of the beginning of life, it may be natural for us to love alcohol-fermented products.

We humans are called Homo sapiens. Homo sapiens is said to have appeared in East Africa about 300,000 to 200,000 years ago, and from there, as in the world today, they spread to "humans" living everywhere. Incidentally, the foothills of Mt. Yatsugatake from Yamanashi Prefecture to Nagano Prefecture, were an area where the Jomon people were active. Especially in the middle Jomon period, about 5,000 years ago, they established a culture of earthenware with a high artistic quality. In addition, the "sake" culture was already in its infancy at that time.

Here, "sake" means ethanol. Ethanol is the customary name for "alcohol" and is referred to as ethyl alcohol in the International Chemical Nomenclature. Methanol, known by its confusing name, has been designated as a deleterious substance. "Sake" here does not necessarily mean Japanese Sake. In this report, we will proceed from the perspective of whether Yamanashi Prefecture corresponds to the origin of "sake".



Gods, the Jomon people, and the Chubu Highlands – the origin of Japanese sake culture

The "*Obsidian and the Prehistoric Dwellers of the Chubu Highlands*" (Yamanashi and Nagano Prefectures) was recognized as a Japanese Heritage Site in 2018. The sites and cultural assets such as earthenware and clay figures that represent Japan's Jomon culture cultivated through distribution and exchange via obsidian in the two prefectures have been highly valued. The numerous earthenware and clay figurines that have been excavated testify to the prosperity of the Jomon people's lifestyle. Why, then, were the remains of the Jomon period concentrated in the area between Lake Suwa in Nagano Prefecture and the Kofu Basin?

The concentration of these sites can also be seen in studies of population density during the Jomon period. Kawabata (2009) showed that during the middle Jomon period, the population per 100 km^2 in the Chubu region of Nagano, Gifu and Yamanashi prefectures was 200-300 people, and 300-450 people in the Kanto region of Ibaraki, Tochigi, Gunma, Saitama, Tokyo, Kanagawa and Chiba prefectures. He also mentions the difference in population density between western Japan and eastern Japan during the Jomon period, pointing out that the population of western Japan is less than one-tenth of that of eastern Japan.

What is the reason for this difference in population density between western and eastern Japan? There is no doubt that the Jomon people lived a hunter-gatherer lifestyle, so it is understandable that there are reasons to believe that population density would be higher in the central part of eastern Japan, where mountainous terrain is more widespread. Are there any other reasons?

Here, focusing on the Japanese Heritage Site " *Obsidian and the Prehistoric Dwellers of the Chubu Highlands*", we have assumed the scenario flow of "Sake – Gods – Mountains". Following this scenario, we would like to search for the origin of sake in the Chubu Highlands. First, let's eplore the gods of the Jomon period.

How did animism and Gods originate?

Nakazawa (2021) describes the birth of the gods, as introduced in "*symbolic revolution*" by archaeologist Jacques Cauvin as follows:

> Archaeologist Jacques Cauvin believes that these gods were created by a "symbolic revolution" that must have been realized within the human mind prior to the agricultural revolution. The revolution does not change the neural organization of the evolved brain that was formed at the time of the Paleolithic leap. It only changes the way it is used. The symbolic revolution that takes place inside the mind frees the connection between reality and symbols, creates a divergence between them. Symbols do not merely reflect reality, but they add "meaning" to reality and multiply it into symbols. At this time, man discovered that the world can be enriched and multiplied by meaning, and he began to create new images of the gods as if to express this as well.

Mr. Nakazawa further stated that:

> However, after the symbolic revolution, human beings came to believe that this world could multiply. Proliferation first took place in the realm of meaning, creating the "religion" we know so well, followed by an agricultural revolution in the field of production…

As you can see from the chronology above, the Jomon period began approximately 16,500 years ago in terms of calendar years. It is a period of about 13,000 years or more until the Yayoi period, when typical paddy cultivation begins. The coldest period in the Japanese Islands is said to have been about 23,000 years ago, when the temperature was about 7°C lower than today. About 10,000 years ago, the Earth's climate began to warm rapidly, and sea level rose sharply (Holocene glacial retreat), and about 6,000 years ago, sea levels were several meters higher than they are today (Jomon sea level rise).

On the other hand, the Jomon culture in Yamanashi Prefecture is said to have been most prolific during the middle Jomon period. This means that the Jomon people migrated to the

central mountains during the warmer part of the Jomon period while hunting. The Jomon people were also hunters, and it is thought that they had an animistic (spiritist) view of religion. However, the symbolic revolution brought about a change in the Jomon people's spiritual structure. A spiritual surplus, a stronghold of the mind, was born. This was the birth of God.

The unique artistry of the Jomon period and the origin of sake

From the ruins of the middle Jomon period in the highlands of central Japan, a group of highly artistic earthenware used for the brewing of fruit wine has been excavated. You can feel the foundation of the sublime culture of the Jomon world that has never been seen before. And it can be inferred that the advanced and unique artistry of the Jomon people of the Chubu Highlands and the origin of sake are inseparable.

Regarding the highly and unique artistry, Nakazawa (2021) states:

> In the hunter-gatherer world, human beings lived as if they were enveloped in the cyclical process of nature, and any excess or proliferation that deviated from this cyclical process was controlled. By the Symbolic Revolution, the Jomon mind had already been modified into a structure that was full of proliferation, but that proliferation and excess were exclusively used in the realm of ritual and artistic expression. As a fusion of ritual and art, they created stunning shapes on the surface of the earthenware. The unparalleled freedom and expressiveness of Jomon earthenware is linked to the fact that the Jomon did not engage in organized agriculture. As if to suggest this, the unrestrained creativity of Jomon pottery disappeared as the Yayoi, "agricultural Neolithic people," spread across the Japanese Islands.

Thus, Nakazawa (2021) points out that the Jomon people of the Central Highlands were free and uninhibited and highly expressive. Evidence of this can be seen in the earthenware of the middle Jomon period excavated.

Various styles of earthenware (deep bowl type, human body pattern, perforated flange type, water smoke pattern, bowl type, bowl type with stand, human face decoration, deep bowl type with face decoration, hanging type with face decoration, childbirth pattern, stone stick, hanging type, fold pattern, large deep bowl type, face decoration, deep bowl type with handle and face decoration, face decoration and handle type, perforated flange type with human body pattern, clay figure decoration, water smoke handle type with human face, tower handle type, deep bowl type with snake body protrusion, etc.) and a collection of clay figurines, the cone-shaped clay figurines are all from the middle Jomon period. "*Let's Travel through Jomon Art!* " (supervised

by Miwa, 2022) introduces this variety of Jomon period excavated items. The originality and artistic quality of the artifacts are remarkable and are truly worthy of the title "Jomon Art".

The most noteworthy item here is the perforated flange (Yukou-Tsubatsuki) type earthenware. Various opinions have been expressed regarding the use of these perforated flange type vessels, but the most likely use is as brewing sake utensils (Yamanashi Prefectural Archeological Museum, 1984).

The following is a quotation from a commentary in a special exhibition at the Yamanashi Prefectural Archeological Museum:

> "*Perforated earthenware with flanges as sake drinking utensils.*"
>
> The reason why this perforated flange type earthenware is considered to be a sake brewing implement is because of the discovery of carbide that appear to be wild grape berries in the vessel, as well as its unique vessel shape. The small holes on the mouth rim are not bondage holes of any kind and are thought to be venting holes for fermentation. The flattened rim of the mouth is a lid holder, which was necessary to keep the interior as hermetically sealed as possible. Fermentation requires the contradictory conditions of sealing the interior and creating a situation where outside air can enter (small holes). The flanges were thought to reinforce the weakened areas by perforation, and the pigments were thought to prevent the loss of moisture.
>
> It is thought to be conscious of constant heat retention, and this state is also one of the conditions that promote fermentation. The same results were obtained in the brewing experiments for the blackening of the interior.
>
> As for the small holes and the flanges, as mentioned above, they exist in a conscious state, and are not practical. Thus, based on the attributes of the perforated flange type earthenware, it is reasonable to consider it as a tool for making sake. Assuming that the sake made in this earthenware was not made by adding sugar with honey or other ingredients, the alcohol content would have been much lower than that of today's sake. Even so, the Jomon people, who knew of no other alcohol, must have been intoxicated. It is imagined that it would have had a sufficient effect during "festivals".

Thus, it can be seen that perforated flange type earthenware was used for the purpose of fermentation of fruits such as mountain grapes. Incidentally, what was the meaning of "festivals" in the Jomon period? There is no evidence to confirm this, but we can speculate from an archaeological standpoint.

The connection between the gods and alcohol

What then was the connection between the gods and the ancients through alcoholic beverages? Koizumi (2012) writes in his book "*The Meaning of Eating*" that "what is the purpose of offering sake to the gods? It's to get your wishes heard… But if we ask for something without giving anything, God may not listen to us... You need a gift that pleases…God, yes, alcohol." and "God rejoices when he drinks alcohol, but human also feels joy when he drinks, and when he drinks alcohol, he feels excitement and comfort that he cannot normally experience".

In his book "*The World of Japanese Sake*", Koizumi (2021) also states the following:

> In primitive societies, once people acquired the wisdom of food, clothing, and shelter, they gradually began to live together in villages out of necessity and a sense of camaraderie, and leading to the formation of primitive nations. As this group life becomes more organized, it usually follows a path of worshiping and uniting around an absolute symbol called "God". They prayed before the gods, swore oaths, and gave thanks to the gods with awe, offering sacrifices to repay them.
>
> When alcohol appears at just the right moment, one experiences a euphoria never experienced before. We capture a mystery that transcends reality, and we even feel that we are one step closer to God, if only for a short while. Often, the connection is made between God, religious rituals, and alcohol, and the sacrifices and blood offered to God are transformed into alcohol.

In this way, the Jomon people began as villages formed by their relatives, and in the process of cultivating field and paddy rice, they enhanced their symbolic gods and spirituality. In doing so, the mystical sensation of intoxication from drinking made them feel a sense of oneness with the gods.

Jomon people migration to Fossa Magna

Why, then, were the ancient peoples attracted to the Chubu Highlands deep in the interior of the Japanese Islands? Why did they go inland? They may have been seeking an encounter with the mountain gods. And there must have been a theory of landscape that attracted them. The aforementioned Nakazawa (2021) states the following:

However, when they reached Itoigawa from Toyama Bay and saw the great valley created by the Central Rift Valley* continuing deeper and deeper inland, how many Azumi people** did not flinch even for a moment? If they continue further into the area, they may never see the sea. There may not be a large lake where one can fish.

(* Hisada's note: the scientific name is Fossa Magna, meaning "great rift valley")

(** Hisada's note: Nakazawa's theory that the ancient Japanese (Wajin) moved from the Japan Sea to the Azumino area)

Eventually, the ancient Japanese (Wajin), who cultivated paddy rice, reached Shinshu by following the great rift valley called the Fossa Magna. This is what Mr. Nakazawa calls the northern course. In addition to the north course, there are also known to exist the south course from the Pacific Ocean up the Tenryu River, and the Kisoji course from Ise Bay through Owari and Gifu. According to Nakazawa (2021), the ancient people who traveled inland from the Pacific Ocean side led a hunting lifestyle based on fish gathering. Nakazawa describes (2021) it as follows:

Since entering the Central Rift Valley, anglers have seen a series of huge peaks that have never been seen before, with the ideal shape of the Kannabi*. They had never seen such a long mountain range of 3,000 m high peaks as the Northern Alps. Among them, the beautiful mountain of Mt. Hotaka, which boasts an altitude of 3,190 m, stands out.

(* Hisada’s note: In ancient times, a place where divine spirits rested, such as a small mountain or a forest.)

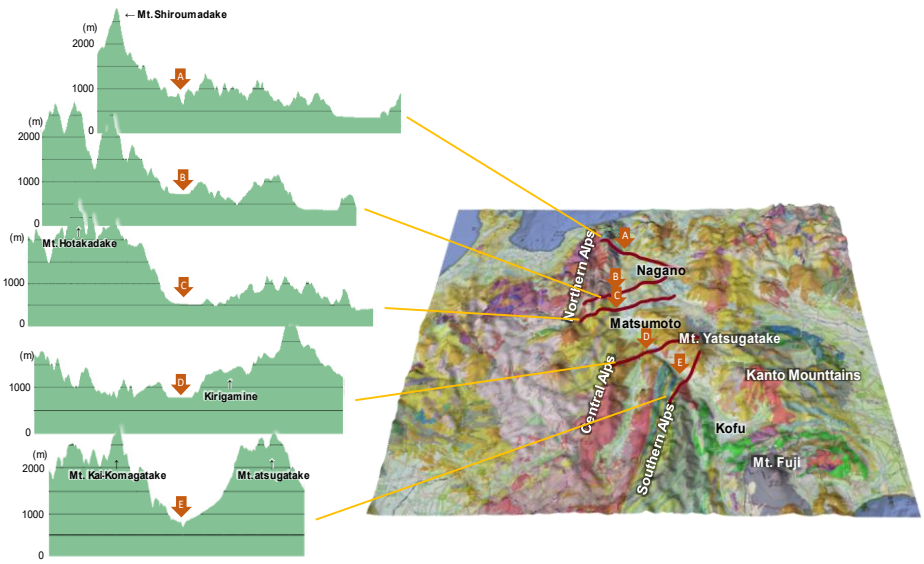
The ancients Japanese (Wajin) had entered the Kamikochi region. The scenery of the lake and the mountains surrounding it may have been an irresistible attraction for those of southern descent. In the mountains south of Lake Suwa, they may have found a place in their hearts of the sea and mountains. They moved further along a corridor called Fossa Magna. Then, they reached a vast gently sloping area at the foot of Mt. Yatsugatake. from there, they proceeded to the Kofu Basin in a southeasterly direction, tracing the Great Rift Valley that crosses the Japan Islands called Fossa Magna, with the Itoigawa - Shizuoka Tectonic Line running along the Fuji River basin (or more precisely, the Hayakawa basin) as its western boundary.

This kind of migration was not limited to the ancient Japanese (Wajin). As the Jomon remains in the Chubu Highlands show, the Jomon people were already living as indigenous peoples before the ancient Japanese (Wajin). This means that the Jomon people, like the ancient Japanese (Wajin), must have been influenced from the Fossa Magna in the same spiritual way. It is possible that a large settlement of Jomon people was formed in the Chubu Highlands at the

foot of Mt. Yatsugatake because of the Fossa Magna Corridor. The people who gathered there may have been overwhelmed by the famous Mt. Kai-komagatake in the Southern Alps, which is located opposite Mt. Yatsugatake, and were moved by its mysteriousness and believed in the existence of God. We think that's why they started brewing sake.

The sense of overwhelm can also be understood in the topographic cross sections. of the five topographic cross sections shown below, the bottom one is a cross section through Mt. Minami-Yatsugatake and Mt. Kai-komagatake . The highlands to the left in each figure are the Northern and Southern Alps. The most striking feature here is the bottom figure. There is Mt. Kai-komagatake, which is higher than the other two, and on the north side, there is a magnificent unobstructed gentle slope created by the Southern Yatsugatake Mountains. It seems quite natural that the Jomon people would build a settlement here.

View of Mt. Kai-Komagatake from the Kinsei ruins



The Great Rift Valley across the Japan Archipelago, Fossa Magna with the Itoigawa-Shizuoka Tectonic Line as its western edge

(Created using the Geographical Survey Institute Map, Seamless geological map (GSJ))

One of the world's best terrain "Fossa Magna" - The Great Cloister of the Jomon

The route from Itoigawa on the Japan Sea side to the Matsumoto and Suwa basins that described above may have played a role in the prosperity of the Chubu Highlands of Yamanashi Prefecture. It was the entry route of the first settlers, and it may have been used as a transportation route for materials such as jade from the Himegawa River. In other words, the Jomon culture nurtured in the Chubu Highlands, and the birth of sake, which was the result of interaction with the gods, evokes "the origin of the sake culture - Yamanashi".

The Fossa Magna is a major landform of the Japanese Islands, and its formation is a matter of geological history of the Japanese Islands over the past several tens of millions of years. From now on, I will introduce, from a geologist's point of view, how the geomorphology and geology of the Fossa Magna contributed to the production of even better sake brewing water. Let's start with the story of the discovery of Fossa Magna.

The discoverer and godfather of the Fossa Magna was Heinrich Edmund Naumann, one of the hired foreigners of the Meiji era. He eventually became a professor in the Department of Geology at Tokyo Imperial University.

The following is written in the diary at the time of the discovery (November 13, 1875): The itinerary for that day was to descend from Shishiiwa in Nobeyama, Nagano Prefecture towards Sutama, Yamanashi Prefecture.

> I was standing on the edge of a broad lowland. On the other side of the river, huge mountains, some 3,000 meters or more in height, were superimposed on top of each other. Their steep slopes dropped into the lowlands in sharp, clear lines. There was no doubt that a stream must run from northwest to southeast along the foot of the mountains. To the left, branch and lateral ridges jutted out into the lowlands from the mountains we had crossed. In the distance to the south-southeast, the huge Mt. Fuji towered high in the sky. At that moment, I was fully aware that I was facing a remarkably strange terrain. However, I could not even imagine that it was a ditch-like land that ran completely across the island arc, and that many volcanoes, especially Mt. Fuji, the largest volcano in Japan, were born from the middle of the land, and that a long transverse lowland with parasitic organisms called volcanoes was created through the orogeny process (translated by Yajima, 2019).

The topography across the central part of the Japanese Islands is truly worthy of being called the Great Rift Valley.

The Great Cloister of the Jomon - Fossa Magna

As mentioned above, the Fossa Magna extends from Itoigawa on the Japan Sea side, through Lake Suwa to the Kofu Basin, and southward along the Fuji River to Shizuoka. The Central Highlands are located at the western end of the central part of the Fossa Magna. In a strictly geological sense, the western margin of the Fossa Magna is separated by a reverse fault called the Itoigawa-Shizuoka Tectonic Line (hereinafter referred to as the Itoshizu Line). A reverse fault is a phenomenon in which rocks shift so that older rocks are placed on top of younger rocks. As a result, the mountains on the west side of the Itoshizu Line are formed from old strata (the formation of the Southern Alps will be described later), and the east side is formed from young rocks extend.

Where is the eastern margin of the Fossa Magna? This is a very difficult question. Currently, it is thought to be the Kashiwazaki-Chiba Tectonic Line connecting Kashiwazaki City, Niigata Prefecture and Chiba City, Chiba Prefecture. However, the Kashiwazaki-Chiba Tectonic Line in the Kanto region is widely covered by the strata that make up the Kanto Plain, so it is not clearly known.

If we assume that the Fossa Magna extends between the Itoigawa-Shizuoka Tectonic Line and the Kashiwazaki-Chiba Tectonic Line, the width of the Fossa Magna is 50 km to 200 km. Inside Fossa Magna is a massif formed from a large old rocks called the Kanto Mountains. Moreover, the direction of extension of the rocks in the Kanto Mountains differs between the west and east sides of the Itoshizu Line. Looking at the geological map of the Chubu and Tohoku regions, the direction of the rocks of the Kanto Mountains runs from northwest to southeast, but on both sides of it, the direction of the rocks is almost north-south. This is just like an N-shape. The left "I" of the "N" corresponds to the mountain range of the Southern Alps, known as the roof of Japan. The other I on the right corresponds to the Joetsu Mountains beyond the Kashiwazaki-Chiba Tectonic Line. The rightward slanting line is the Kanto Mountains. The Jomon Great Cloister is the left part of the N-shaped I.

How was Fossa Magna formed?

How was the Fossa Magna formed? The Fossa Magna zone is divided into the southern and

northern parts by the Matsumoto area in Nagano Prefecture. They are called the northern Fossa Magna and the southern Fossa Magna. The tectonic development history of the northern Fossa Magna is as follows.

According to Takano and Nakajima (2019), there are three stages: stage 1, which is about 16 to 12.5 Ma (Ma means million years ago); stage 2, which is about 12.5 to 6.5 Ma; stage 3, which is about 6.5 to 1 Ma; and stage 4, which is after 1 Ma. The first and second stages are the formation period of the Sea of Japan and the post-formation period (both stages are under stretched fields), the third stage is the compression period due to inverted tectonics, and the fourth stage is the period when the current topography became apparent. The overall sedimentary basin shape is a slightly elongated fan-shaped that extends into the Sea of Japan with Matsumoto as the top of the fan (Shin-Etsu Sedimentary Basin). In this Shin-Etsu Sedimentary Basin, clastic material flowed mainly from the Central Uplift Zone (including the Kanto Mountains) and the Hida Mountains (including the Northern Alps).

On the other hand, the situation in the southern Fossa Magna is quite different. In other words, if the northern Fossa Magna is a crustal movement related to the fracture that formed the Sea of Japan, the southern Fossa Magna is a zone formed by at least two volcanic island collisions.

The area from Matsumoto to Lake Suwa, to the Kofu Basin, and further south to the Fuji River basin is the western half of the southern Fossa Magna range. This zone includes the Izu Peninsula, the Hakone Volcanoes, Mt. Fuji, the Tanzawa-Misaka-Koma Mountains and the Yatsugatake Mountains range. The Izu Peninsula and the Tanzawa-Misaka-Koma Mountains are thought to have been former volcanic islands on the Philippine Sea Plate that collided with and were incorporated into the Honshu Arc (collision accretion). The chronological sequence of these geological events, centering on the Misaka Mountains on the south side of the Kofu Basin, is shown below.

[Sagami-ko accretionary age (approx. 30 million years ago)] (equivalent to Stage 0 of the northern Fossa Magna)

The strata widely distributed along the southern bank of the Sasago River, a tributary of the Katsura River, are called the Sasago Formation. According to Yagi (2000), who studied this area extensively, the Sasago Formation is composed of shale, sandstone, and tuff, and these strata are considered to be Oligocene trench-fill deposits deposited in the oceanic trench about 30 million years ago. Yagi (2000) found Eocene radiolarians from Funabashi-sawa, but concluded that

fossils were reworked due to their poor preservation. As a result, Yagi (2000) concluded that the Oligocene age of the radiolarian fossils reported by Takahashi and Ishii (1993) from the area to the south of the JR Sasago Station and along the prefectural Kuronoda forest road is the depositional age of the Sasago Formation. In the Sagami-ko accretionary complex, the Sea of Japan had not yet been formed, and the present-day Japanese islands were "attached" to the eastern margin of the Asian continent. How was the Sea of Japan formed? The formation of the Sea of Japan determined the formation of the Fossa Magna, which became the Jomon Great Cloister.

The serpentine of the Circum-Izu massif serpentine belt (Arai, 1994) is thought to have been formed by the rise of the upper mantle (peridotite) under the Shikoku Ocean Basin near the plate boundary with the expansion of the Izu-Ogasawara arc about 30 million to 15 million years ago, and then joined the Honshu side with the formation and expansion of the Sea of Japan.

How then was the Sea of Japan formed? Several theories have been proposed, but here we introduce the Fossa Magna aulacogen theory by Shiki and Tateishi (1991). Aulacogen is a "grooved fault basin" used by Soviet geologists in the 1940s.

The Fossa Magna aulacogen formation history describes it as follows (Shiki and Tateishi (1991):

(1) Prior to 23 Ma, there was uplift and intrusion of the mantle asthenosphere (the relatively weak zone just below the plate), and the surface of a wide area including the present Japan Arc and continental crustal fragments in the Sea of Japan was uplifted into a dome (or a slightly elongated dome shape).

(2) As a result, the crust was broken radially and parallel to the continental margin, and further rifted (linear large-scale rift). Mantle material flowed to the surface from these rifts. Among these lifts were a group of lifts on the present Green Tuff surface and the Fossa Magna.

(3) The more inner of these rifts subsequently opened to create the Sea of Japan basin assemblage. In relation to this, between 22 and 15 Ma, Northeast Japan rotated counterclockwise and SW Japan shifted in parallel. Around 15Ma, SW Japan also rotated sharply clockwise. The Green Tuff region (region of volcanic ejecta spreading during the formation of the Sea of Japan; rocks are green in color) and the Fossa Magna rift trough (a large groove-like feature) were also deepened at this time.

(4) However, after 15 Ma, the subduction conditions of the Pacific and Philippine Sea plates changed, probably due to the outflow of a large amount of mantle material, and

the rift of the Green Tuff region "failed" to expand. The rift of the Fossa Magna also changed to the aulacogen by the collision of the Izu-Ogasawara "bar". (omitted below)

Thus, the continental crust at the eastern margin of the Asian continent is covered by hot material rising from the deep subsurface, the original shape of the Sea of Japan was formed just as the surface of a rice cake lifts up and breaks when heated. When it broke, it broke in three directions (it is said that when a continent breaks, it always breaks in three directions), two of which entered the Sea of Japan, and the other one crossed the Japanese Islands. In other words, the prototype of the Fossa Magna is the aulacogen. These large movements occurred on the Sea of Japan side.

On the other hand, a new seafloor was born on the Pacific Ocean side. This is the Shikoku Ocean Basin. The Shikoku Ocean Basin was created when the north-south oriented Kyushu-Palau Ridge separated from the east-west. The plate boundary (trench) between the Japanese Islands and the Shikoku Basin caused lateral displacement. Around 30 million years ago, the paleo Izu-Ogasawara Arc (volcanic arc) was formed by the subduction of the Pacific Plate on the east side of the Shikoku Ocean Basin. Near the northern end of the paleo Izu-Ogasawara Arc is the Misaka Volcanic Island, which forms present-day the Tanzawa Mountains, the Misaka Mountains, and the Koma Mountains.

[Misaka Volcanic Island Period] (corresponds to Stage 1 of the northern Fossa Magna)

Up to 12 million years ago, volcanic materials were deposited on the volcanic islands of the present-day Izu-Ogasawara arc and the surrounding oceans. The Nishi-Yatsushiro Group (also known as the Misaka Group), which forms the main part of the Misaka Mountains, reaches a maximum thickness of 8000 m. According to Mizuno and Katada (1958), the geologic history of the Nishi-Yatsushiro Group can be divided into (1) a period of basaltic and andesitic igneous activity, (2) a period of mud sedimentation and basaltic andesitic igneous activity, (3) a period of dacitic igneous activity and the formation of coarse-grained clastic rocks (sandstones), and (4) a period of later. In particular, the period after (3) is considered to be the "anticlinal uplift of the entire area," and the strata are arranged around the lower strata (southwestern part), with younger strata exposed toward the east. Such volcanic islands are not limited to the Misaka Volcanic Island but are thought to have formed similar volcanic island assemblage at Mt. Kushigata and Tanzawa Mountains.

[Southern Fossa Magna Collision Era] (corresponding to stages 2 and 3 of the northern Fossa Magna)

Twelve or fifteen million years ago, the southern Fossa Magna of the Koma Mountains-Misaka Mountains-Tanzawa Mountains collided with the Honshu Arc. The boundary of the collision is the Tonoki-Aikawa Line. Subsequently, the Izu (Peninsula) massif collided with the southern part of the Koma Mountains-Misaka Mountains-Tanzawa Mountains zone a million years ago.

[Kofu granite magma intrusion age (approx. 12 million years ago)] (equivalent to stages 2 and 3 of the northern Fossa Magna)

The Kofu granite body is said to have been intruded in 17-7 Ma, and the tonalite (a type of granite) in the Tanzawa Mountains in 4-16 Ma (Tamura, 2011). Considering that the Koma Mountains- Misaka-Tanzawa massif (southern Fossa Magna) collided with the Honshu Arc before 12 or 15 Ma, the Kofu granitic body was formed by melting and reactivation of the central crust of the Izu-Ogasawara Arc on the Philippine Sea Plate (Paleogene) during the collision when the central crust of the Izu-Ogasawara Arc on the Philippine Sea Plate (plutonic rocks formed in the Paleogene) (Tamura, 2011).

[Kofu Basin Period] (equivalent to Stage 4 of the Northern Fossa Magna)

Between 780,000 and 130,000 years ago, which is considered to be the middle Pleistocene (Chibanian stage), The Kofu Basin, surrounded by the Southern Alps, Kanto Mountains, and the Misaka Mountains, is thought to have been a lake (Fukuchi, 2019). The active fault zone in the Sone Hills became active after about 10,000 years ago. The volcanoes surrounding the basin played a significant role in the formation of the Kofu Basin.

Mt. Akadake and Mt. Kayagatake (Kurofuji) of the Yatsugatake mountain range and Mt. Fuji, which form the volcanic front* of the Pacific Plate, are erupting.

(*volcanic front: The sequence of volcanoes closest to the trench among the volcano assemblages that occur in the process of plate subduction in the trench, the generation and rise of magma, and the formation of volcanoes.)

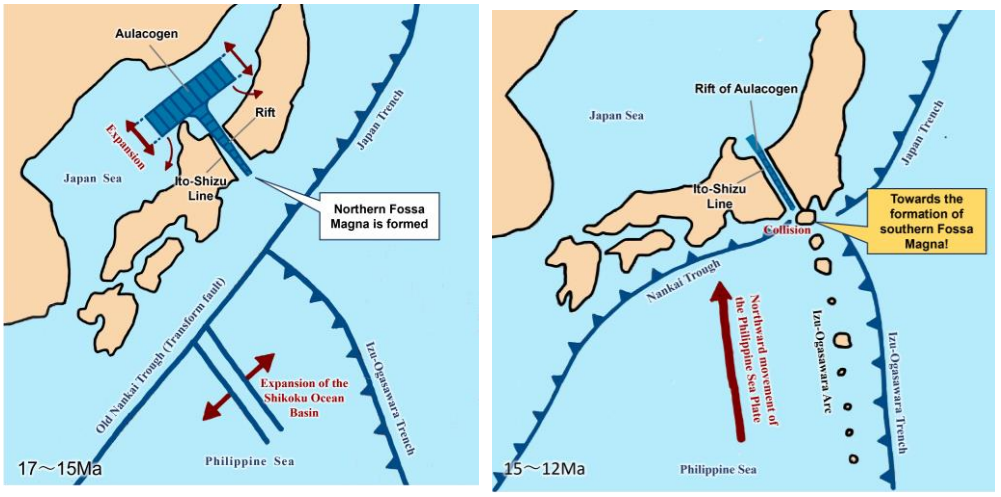
Mt. Kayagatake, also called Kurofuji, and the details of its eruption period are unknown. Studies of the Kurofuji pyroclastic flow indicate that Kurofuji was active about 1 million to 500,000 years ago. The Yatsugatake Mountain range consists of the Yatsugatake volcanoes that stretch from north to south, and is divided into north Yatsugatake and south Yatsugatake by the Natsuzawa Pass (Nagano Prefecture) in the center. The volcanoes are divided into two stages, the older-Yatsugatake stage and the younger-Yatsugatake stage, according to the period of eruptive activity. Mt. Yokodake is located in the Kita-Yatsugatake area, and Mt. Akadake is located in the Minami-Yatsugatake area, which is the border between Yamanashi and Nagano

prefectures. The older-Yatsugatake stage was active about 1.3 Ma, and the younger-Yatsugatake stage about 200,000 years ago.

Studies of volcanic ejecta from the younger-Yatsugatake stage have shown that most of the craters are located in the central part of the Yatsugatake volcanic chain. The latest volcanic ejecta, dating to about 29,000- years ago, is from the northernmost part of the Yatsugatake volcanic chain, near Mt. Yokodake.

Mt. Fuji is a stratovolcano covered with ash and lava from numerous eruptions.The volcano's history includes the following stages: Sen-Komitake(pre Komitake), Komitake, Ko-Fuji(old Fuji), and Shin-Fuji(new Fuji). Sen-Komitake is the oldest of these volcanoes, formed several hundred thousand years ago during the Pleistocene. Ko-Fuji continued to erupt from around 80,000 to 15,000 years ago and grew to an elevation of less than 3,000 m as a result of the accumulation of ash from the eruptions.

Thus, the geological development of the Fossa Magna is very complex. In summary, the southern Fossa Magna is characterized by accretionary collision zones. On the other hand, the northern Fossa Magna records the formation history of the Sea of Japan. Fujioka (2018) describes the northern Fossa Magna as having formed "in situ", while the southern Fossa Magna migrated "from elsewhere". The volcanic sediments of the southern Fossa Magna are almost the same as those found near the present-day volcanic islands of Izu and Ogasawara. These sediments were transported from far to the south and moved northward across the ocean to the location of the southern Fossa Magna.



How Fossa Magna is made (Modified from Fujioka (2018))

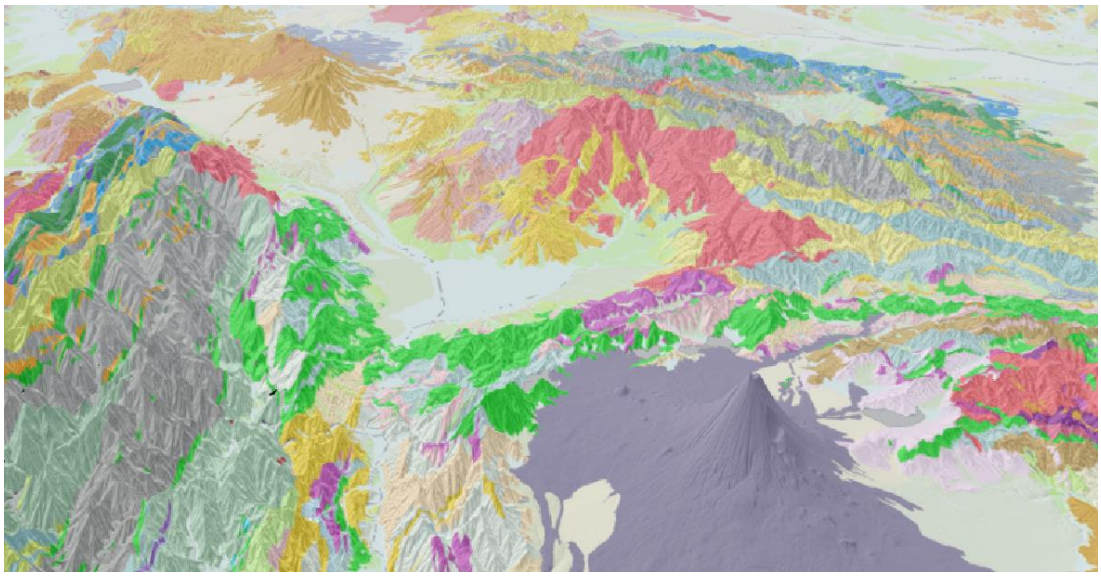
Fujioka (2018) further connected the southeastern extension of the aulacogen to the trench

triple junction where the Pacific Plate, the Philippine Sea Plate, and the North American Plate meet, and related it to the plate off Boso. Fujioka (2018) estimates that the Fossa Magna was formed after 15 million years ago, by connecting the aulacogen in the Sea of Japan and the trench triple junction off Boso. He calls the Fossa Magna "a great landform unparalleled in the world. I will not go into details, but after 1 million years ago, strong east-west compression occurred in northeastern Japan, and as a result, the Fossa Magna uplifted the Akashi Mountains in the Southern Alps and formed the Northern Alps and Central Alps.

Therefore, Yatsugatake volcano was formed around 200,000 years ago, but the uplift of the Southern Alps, including Mt. Kai-Komagatake, which rises in front of the volcano, started even older, around 1 million years ago.

Relationship between water quality of sake brewing water in Yamanashi Prefecture and Geology

Water for sake brewing flows from precipitation to surface water and then to groundwater, where it is collected as spring water and well water. Groundwater in the form of flowing groundwater may flow through bedrock, resulting in the transfer of chemical components such as dissolved and precipitated material between the rock and groundwater. In other words, the



3D geological map of the area around the Kofu Basin

(Created from the Japan Seamless Geological Map)

geologic rocks in the precipitation or recharge area can have a considerable impact on water quality. Residence time is an important factor in the migration of chemical constituents. If the residence time is short, the water will flow away before the chemical substance can dissolve or precipitate. On the other hand, if the residence time is long, the chemical substance can be sufficiently dissolved.

Regarding the brewing of Japanese sake, Baumert (2022) cites (1) cold winters, (2) management technology, technical capabilities, and financial strength, and (3) pure water as the location criteria for sake breweries. In this report, we focus on pure water, "Sei-sui". It can be said that the topography and geology of Yamanashi Prefecture is suitable for the conditions that produce this “Sei-sui”. We will also explain this suitability from the viewpoint of topography and geology.

[Topography]

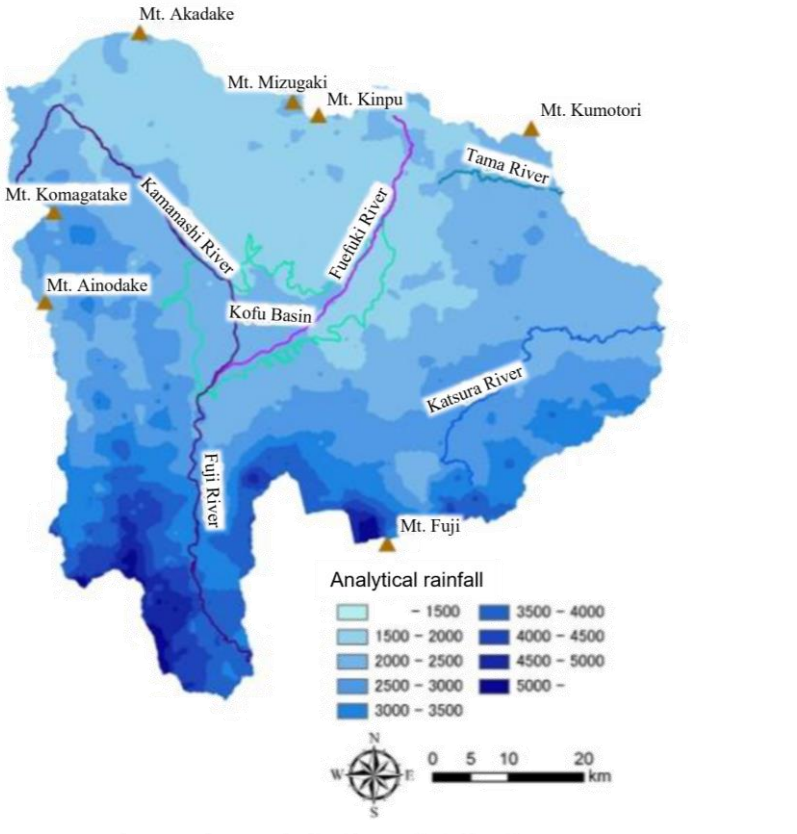
The topography of Yamanashi Prefecture can be summarized as "the Kofu Basin and surrounding highlands. Its geological significance is explained in the previous chapter.

What is the difference in height from the basin below 500 m altitude to the surrounding highland mountains? In fact, you can see that the height difference is more than 1,500 meters. The Kofu Basin collects water from the Kamanashi River and Fuefuki River systems. In particular, the water source of the Kamanashi River systems are Mt. Komagatake (2,960m) and Mt. Hououzan (2,841m) on the southern side of the Kamanashi River and from the Mt. Yatsugatake (2,899m) and Mt. Chigatake (1,704m) on the northern side of the Kamanashi River. The Fuefuki River system has its source in the basin surrounded by the highest peaks of the Oku-chichibu mountain range: Mt. Kita-oku-senjodake (2,601m), Mt. Koubushigadake (2,475m), and Mt. Daibosatsu-zan (2,057m). On the other hand, the Misaka Mountains (highest peak: Mt. Kurodake, 1,793 m) rise to the south of the Kofu Basin from east to west, and the Koma Mountains (highest peak: Mt. Kushigata-yama, 2,052 m) rise from north to south on the west side. The Kamanashi River and the Fuefuki River merge and flow south between these two mountains as the Fuji River. In addition to the Fuji River basin, Yamanashi Prefecture has three other river basins: the Fuji foothill system (the closed area around the Fuji Five Lakes, excluding Lake Yamanaka), the Katsura River system, which has its source in the subterranean system of Mt. Fuji and Tama-gawa River system, which has its source in Mt. Kasatori-

yama(1,953 m). The Fuji River joins the Hayakawa River at Minobu, which has its source at Mt. Senjogadake (3,032 m) and Mt. Ainodake (3,189 m), the main ridges of the Southern Alps.

The Kofu Basin is made up of 13 alluvial fans (Nakayama and Takagi, 1987). In order of area, the 13 alluvial fans are the Kamashi-gawa, the Midai-gawa, the Kane-gawa, the Fuefuki-gawa, the Omu-gawa, the Asa-kawa, the Hi-kawa, the Ara-kawa, the To-gawa, the Mitarai, the Oma-kawa, the Ai-kawa, and the Ojira-gawa, and the total area of these alluvial fans is about half that of the Kofu Basin (total area 375 km^{2}Among them). Among them, the Midai-gawa alluvial fan is formd by the Midai-gawa River flowing out of the Koma Mountains, while the Asa-kawa and Kane-gawa fans are formd by the Asa-kawa and Kane-gawa rivers flowing out of the Misaka Mountains.

How does such a terrain surrounded by mountains effect the water supply? Before considering this, let us discuss precipitation in Yamanashi Prefecture.

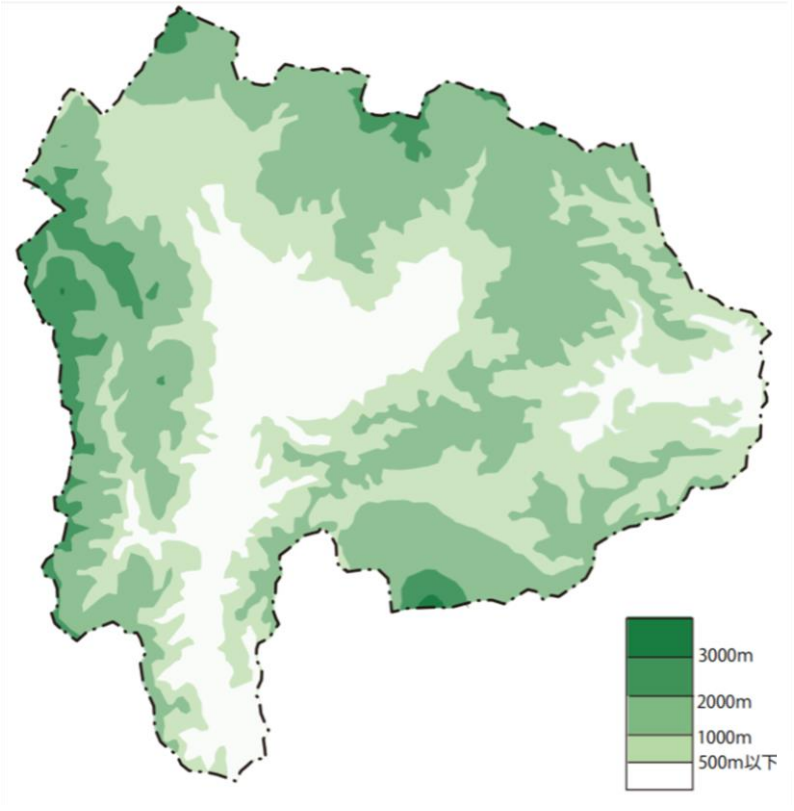


Annual precipitation distribution map

Source: Survey on Water Resources (2023/24) Yamanashi Prefecture

The annual precipitation in Yamanashi Prefecture is around 1,200 mm, which is considerably less than the national average of 1,700 mm (according to one report, the prefecture ranks third

among prefectures with low precipitation). Why then, is it so little? This is due to topographical factors. The low annual precipitation in Yamanashi Prefecture is because it is located inland, surrounded by 2,000-meter mountains, and is less susceptible to typhoons, low-pressure systems, and fronts. In fact, a comparison of annual precipitation distribution and elevation distribution shows this tendency. The southern part of Yamanashi Prefecture (south of the Kofu Basin) receives more than 1,500 to 2,000 mm/year of precipitation, while the area north of the Kofu Basin receives less than 1,500 mm/year.



Elevation distribution map

(Created by Hisada)

The reason why Yamanashi Prefecture is a "treasure trove of Sei-sui " is because of its characteristic topography. Although the amount of precipitation is low, the terrain around the Kofu Basin acts like a "funnel", gathering precipitation over a wide area in the central part.

Moreover, the specific height difference between the basin floor and the high mountains is more than 2,000m, allows for water collection even with a small amount of precipitation.

While some of these precipitations become surface river water, a significant portion of the

precipitation infiltrates as groundwater flow. Groundwater flow is influenced by rocks and sediments, resulting in "abundant Sei-sui".

[Geology]

In this report, we will clarify the sake brewing in Yamanashi Prefecture, which produces abundant Sei-sui, focusing on the geology of the plains of the Kofu Basin and the surrounding highlands.

The rocks that form the uplands surrounding the "funnel shape" are the Kofu Granite Body, the Misaka Group of the Koma Mountains-Misaka Mountains, and the Minami Yatsugatake-Kayagatake volcanoes.

The Kofu granitic body is characterized by the weathering of granite into “masa” (“masa” is weathered granites that have decomposed and become granular). In this study, we conducted a survey on Mt. Hinata-yama (1,660 m), which is northeast of Mt. Kai-Komagatake, and observed that it has undergone significant weathering and has become "masa".

Mt. Hinata-yama is in the northern part of the Kai-Komagatake rock body, which is a part of the Kofu Granite Body. The Kai-Komagatake rock body is composed of coarse-grained hornblende-biotite granodiorite (Sato et al., 1989). The top of Mt. Hinata is called "the shore of the sky," and is covered with white sand, or masa, reminiscent of white sand and green pine trees (Hisada’note; It refers to beautiful scenery such as the coast). The thickness of the masa is unknown, but it is estimated to be quite thick (tens to hundreds of meters), since the fact that the area around Mts. Hinata-yama and Kai-Komagatake is covered with “tectonic soil” (Quaternary Society of Japan, ed. 1987). Tectonic soil is a type of periglacial microtopography formed on the ground by repeated freezing and thawing. Therefore, even fresh solid granite is subject to microfracture, and water penetration from the surface layer to the deep underground is assumed to have progressed, resulting in a thickened weathering layer due to hydration and other factors. Chigira (2002) also states the following:

> In masa, CaO and Na_2O clearly decrease along with MgO and P_2O_5. CaO and Na_2O being lost by more than 50%. $H_2O(+)$ increases from 2x to 3x. Masa also loses 100% of its CaO and Na_2O when it reaches the core stone*. This corresponds to the disappearance of plagioclase.
>
> (*Core stone is a spherical granite rock mass left over from weathering.)

This means that the groundwater gains components that the ‘masa’ loses.

In other words, the minerals that make up the rock have been dissolved by the process of almost ingredient-free water seeping down through the bedrock. This suggests that plagioclase in the masa plays an important role in the formation of these constituents.

In Yamanashi Prefecture, there are volcanoes: Kurofuji-Kayagatake volcano, Minami-Yatsugatake volcano, and an active volcano, Mt. Fuji. Here, Kayagatake volcano - Minami Yatsugatake volcano is described.

Kurofuji and Kayagatake volcanoes erupted between 1.0-2.2 million years ago.

The dacite that makes up the majority of these volcanoes form a flattened volcanic body, mainly as pyroclastic flow deposits including pumice flows. Andesite erupts on the western flank of Kurofuji volcano, forming Kayagatake volcano, a small stratovolcano. Thus, Kurofuji volcano is formed of dacite lava and pyroclastic flow deposits, while Kayagatake volcano is formed of andesite lava and pyroclastic flow deposits, which may be slightly different from the Yatsugatake groundwater flow system.

The older eruption of Minami-Yatsugatake volcano lasted from 1.3 million years ago to 250,000 years ago, and the younger eruption lasted from 200,000 years ago to 23,000 years ago. Mt. Minami Yatsugatake erupted mainly andesite and basalt. Extensive fan-like high terraces developed at the foot of the mountain (Ozaki et al., 2002). These sediments are called the foothill gravel layer. The thickness of the sand and gravel layer is up to 20 m, and the grain size of the gravel is often 5-30 cm in diameter, and sometimes more than 1 m. The matrix is sometimes sandy, sometimes scoria or "loam" in texture, generally without stratigraphy or sorting, but sometimes roughly stratified (Kawachi, 1977). Yatsugatake Volcano is designated as an active volcano by the Japan Meteorological Agency. According to Oishi and Suzuki (2004), at least five Plinian eruptions (i.e., large-scale eruptions that form a caldera) have occurred during the younger-Yatsugatake stage in the last 200,000 years with intervals of about 10,000 to 105,000 years.

South of Mt. Gongendake of the Minami-Yatsugatake volcano in the ancient period, a huge collapse occurred during the Middle Pleistocene, which is said to be the largest in Japan.

The Nirasaki debris avalanche deposit, which has a maximum thickness of more than 200 m, a maximum run length of more than 40 km, and a maximum volume of about 9 km^3, was deposited from the southern part of Mt.Yatsugatake to the southern margin of the Kofu Basin (Ozaki et al., 2002). The sediments consist mainly of andesitic lava, tuff breccia and

volcanic breccia, and poorly sorted matrix with a mudflow-like appearance containing lava blocks, basement rock gravels, and river gravels (Ozaki et al., 2002). These debris avalanche deposits and fan-like high terrace deposits at the foot of the mountain have high permeability and are used as water channels for groundwater systems.

The Misaka Group (also called the Nishi-Yatsushiro Group) is a geological formation widely distributed in the Tanzawa, Misaka, and Koma mountain ranges. The formations are relatively highly consolidated and have poor permeability. The Miocene strata comprising the Misaka Group are as follows (Geological Map of Yamanashi Prefecture, 1970).

Upper Layers:

Kawaguchi Formation:
Mainly dacitic tuff and conglomerate

Onuma Formation:
Mainly dacite or tuff

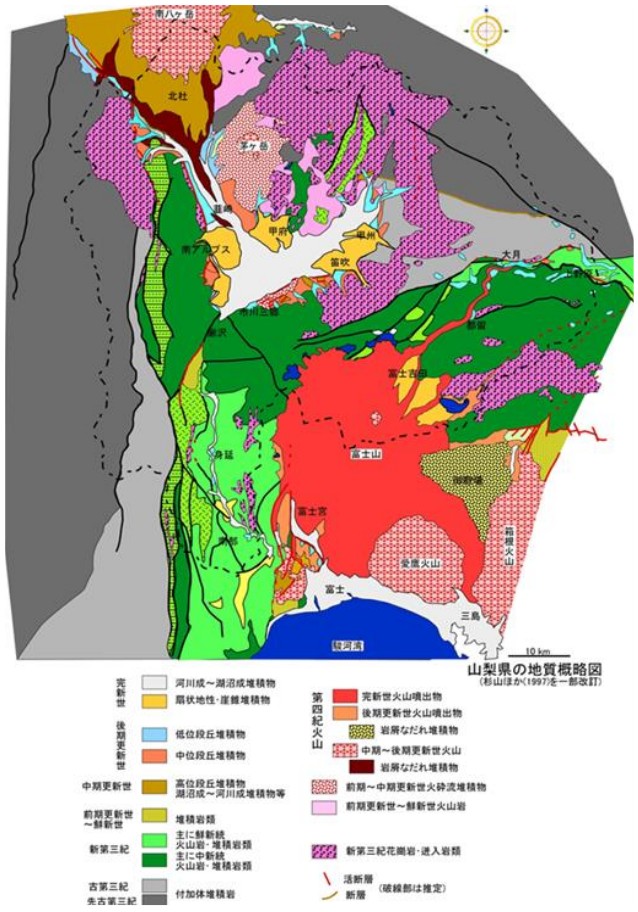
Takahagi Formation:
Mainly basaltic lava and volcanic breccia

Nishi-Yatsushiro Formation: Mainly andesitic pyroclastic rock

Momonoki Formation:
Mudstone

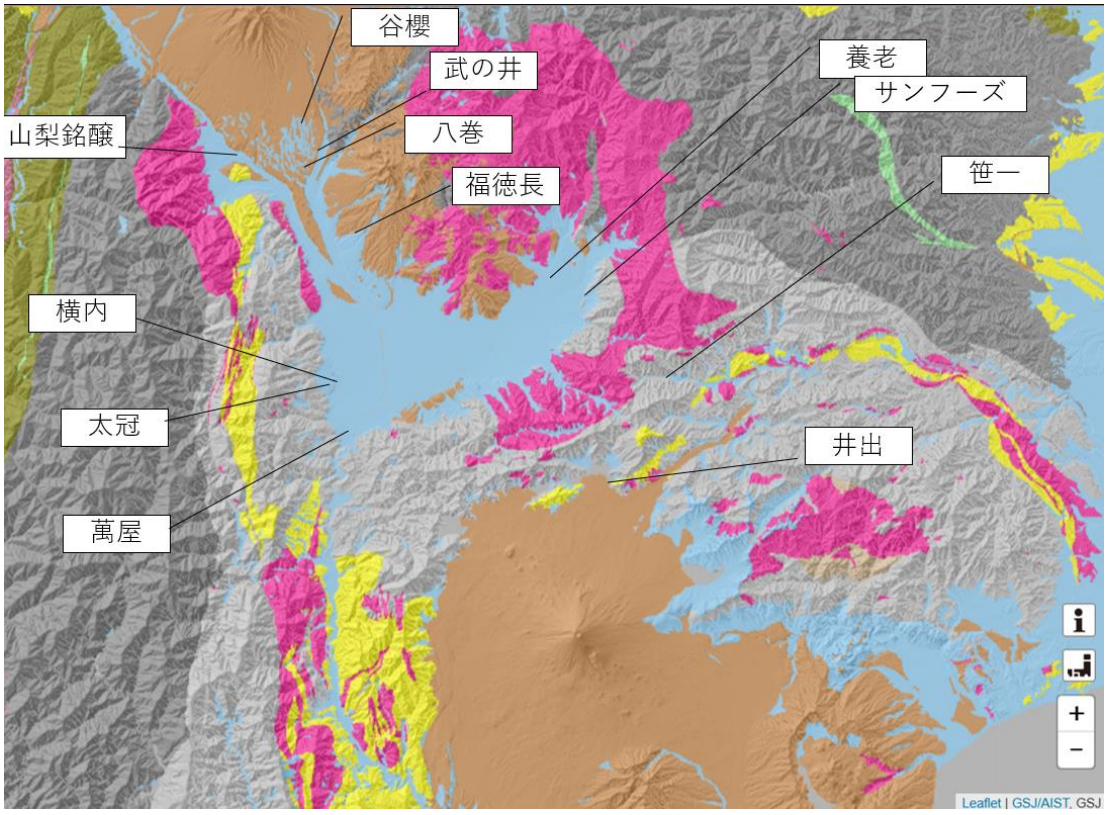
Kushigatayama Formation:
Mainly basaltic-andesitic lava and tuffaceous breccia

Lower Layers:



Geological Map of Yamanashi Prefecture (1970)

The rock types are various kinds. The rocks include dacite, andesite, basalt, conglomerate, sandstone, mudstone, and volcaniclastic rock, all of which are relatively highly consolidated. However, according to outcrop observations, the development of joints and small faults is remarkable. The degree of permeability is unknown, but it is unlikely to extend deep into the subsurface, and the residence time is likely to be short. In summary, the permeability is higher in the order of granite, the Misaka Group, Minami Yatsugatake-Kayagatake, and masa of granite. The characteristic of water in Yamanashi Prefecture is that it flows through shallow bedrock in a short period of time after precipitation, and the duration of the aquifer is relatively short.



Sake brewery in Yamanashi

(Created from the Japan Seamless Geological Map)

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Part Ⅱ Sake brewing water in Yamanashi －Water Quality Survey Report

KARATA,Yukihiko and YABUSAKI,Shiho

Field surveys were conducted on two separate occasions in November-December 2022 and October-November 2023.

During the survey conducted from November to December 2022, we visited several springs distributed in the survey area, sampled the main spring water in each area and brewing water from sake breweries, and explored the characteristics of the geology and water in these areas.

We also visited five sake breweries in the prefecture, where we heard about the local climate, culture, and history of sake brewing (especially sake brewing that takes advantage of water as a resource) and analyzed the brewing water provided by the breweries.

During the survey conducted from October to November 2023, we traced the topography of the Kofu Basin and the Southern Fossa Magna, which characterize the topography of Yamanashi, as well as traces of the Jomon culture.

In this study, water samples were analyzed in detail for ion concentrations, trace elements, stable isotopes, and other parameters. This report includes trilinear diagrams and Stiff diagrams to characterize the water quality and describe each site.

This report only describes the water quality survey and analysis conducted at each sake brewery and the surrounding area, as far as it is possible to discuss at this time. Please note that detailed water quality analysis data and discussions may be published separately in the form of research papers, etc., to the extent that they can be made public.

Survey area

In this survey, geological areas were set up as follows according to the geological features distributed in Yamanashi Prefecture and the distribution of sake breweries.

I. Accretionary prism area of the Outer Zone of SW Japan

II. Sedimentary rocks areas due to the collision of the Izu Peninsula

III. Plutonic rocks (granite) outcropping area in the southern Fossa Magna

IV. Volcanic rocks outcropping area in the southern Fossa Magna

The relationship between the geologic areas and the Fossa Magna formation history above is shown in the table below.

Geological Distribution Area	Corresponding Fossa Magna formation history	Main exposed places
Ⅰ. Accretionary prism area of the Outer Zone of SW Japan	Before Sagami-ko accretionary age	Southern Alps Kanto Mountains
Ⅱ. Sedimentary rocks area due to the collision of the Izu Peninsula	Sagami-ko accretionary age ～ Misaka Volcanic Island Period	Misaka Massif Koma Massif
Ⅲ. Plutonic rocks (granite) outcropping area in the southern Fossa Magna	Kofu granite magma intrusion age ～ Southern Fossa Magna Collision Era	Kai-Komagatake Granites Kofu Granites
Ⅳ. Volcanic rocks outcropping area in the southern Fossa Magna	Kofu Basin Period	Mt. Yatsugatake Mt. Amigasa Mt. Kayagatake Mt. Fui

Fossa Magna formation history and main exposed areas in the study area

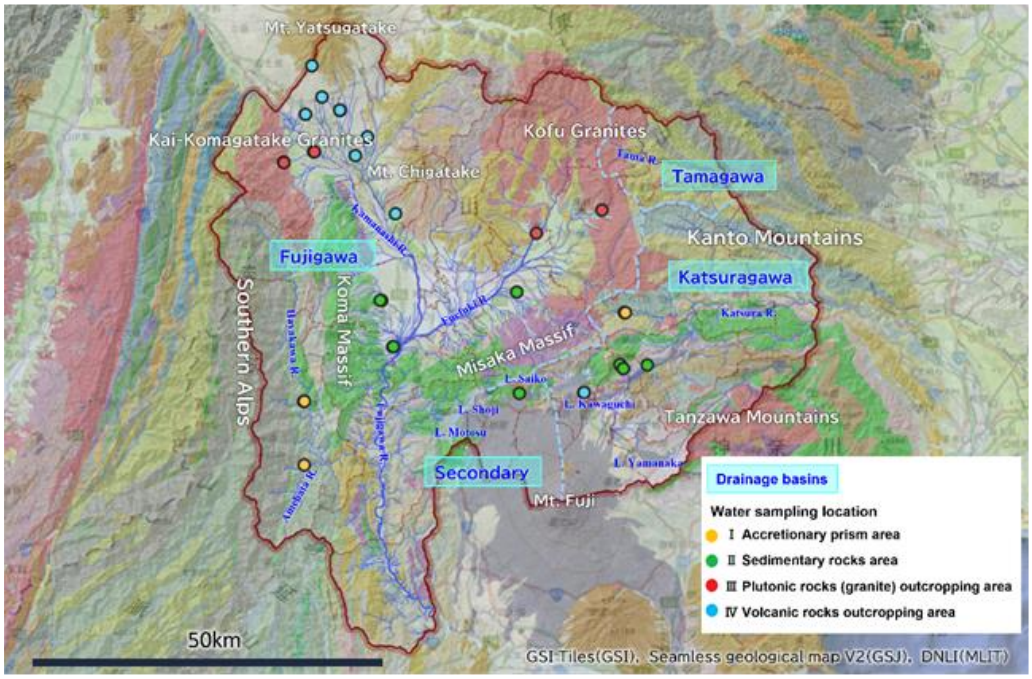
Drainage basins, groundwater flow systems, geology, and sake breweries in the study area

When discussing sake brewing water, it is generally classified by "water system (river basin)," but even water from the same water system differs in quality depending on its location.

In particular, in order to understand the characteristics of groundwater, it is important to know where its recharge area (water source) and flow area are, and what kind of environment there is. (Even tap water has different characteristics depending on where it comes from.)

In other words, for sake brewing water, which often uses water from wells or springs, it is more persuasive to talk about the water quality in terms of the geology of the water source or

recharge area rather than the water system.



Drainage basins and geological distribution in Yamanashi Prefecture

Therefore, in this survey, we will report the survey results not for each water system, but for each survey area set earlier.

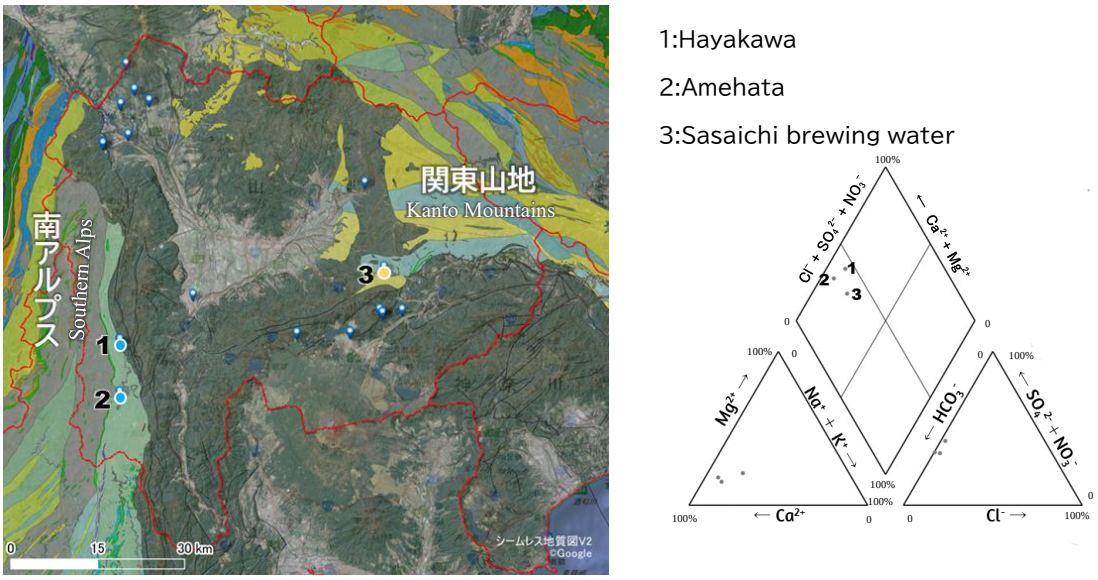
The relationship of each water system to the geologic areas and breweries surveyed in this study is shown in the table below.

Drainage basins		Geological Distribution Area	(GI YAMANASHI)	Sake brewery
Fuigawa	Hayakawa – Amehata Basin	Ⅰ. Accretionary prism area of the Outer Zone of SW Japan	(Southern Alps foothills)	—
	North side of Kamanashi Revier basin	Ⅳ. Volcanic rocks outcropping area in the southern Fossa Magna	(Yatsugatake foothills)	Tanizakura Yamaki Takenoi Fukutokucho
	South side of Kamanashi River Basin	Ⅰ. Accretionary prism area of the Outer Zone of SW Japan ～Ⅲ. Plutonic rocks (granite) outcropping area in the southern Fossa Magna	(Southern Alps foothills)	Yamanashi-meijo
	Fuefuki River Basin	Ⅲ. Plutonic rocks (granite) outcropping area in the southern Fossa Magna	(Chichibu foothills)	Yoro
	Fujigawa River Basin south of the Kofu Basin	Ⅱ. Sedimentary rocks area due to the collision of the Izu Peninsula	(Southern Alps foothills)	Yorozu-ya Taikan Yokouchi San foods
Katsuragawa	North side of Katsuragawa River	Ⅰ. Accretionary prism area of the Outer Zone of SW Japan ～Ⅱ. Sedimentary rocks area due to the collision of the Izu Peninsula	(Fuji・Misaka)	Sasaichi
	South side of Katsuragawa River (include Lake Yamanaka-ko and Lake Kawaguchi-ko)	Ⅱ. Sedimentary rocks area due to the collision of the Izu Peninsula	(Fuji・Misaka)	—
Tamagawa		Ⅰ. Accretionary prism area of the Outer Zone of SW Japan	—	—
Secondary		Ⅳ. Volcanic rocks outcropping area in the southern Fossa Magna	(Northern foothills of Mt. Fuji)	Ide

Contrast between drainage basins and geological areas and breweries.

I. Accretionary prism area of the Outer Zone of SW Japan

In Yamanashi Prefecture, there are some pre-Sagami-ko Accretionary Era formations in the Southern Alps and the Kanto Mountains, and these formations are called the Shimanto Belt. The Shimanto Belt accretionary complex was mainly deposited during the Cretaceous to Paleogene periods, and consists mainly of alternately layered sedimentary rocks such as sandstone mudstone and conglomerate.



Water sampling points and trilinear diagrams

This time, we visited the Amehata and Hayakawa River basins in the Southern Alps and the Sasaichi sake brewery in the Kanto Mountains to conduct research and analysis (see figure below).

Southern Alps, Hayakawa River tributary and near Amehata Dam

Hayakawa Town in Yamanashi Prefecture is located in the southwest of the prefecture on the border with Shizuoka Prefecture and is known as "the least populated town in Japan" with almost no flat land.

The Itoigawa-Shizuoka Tectonic Line (the western edge of Fossa Magna) runs along the Hayakawa River, which flows north and south, and its outcrop (Arakura Fault) is designated as

a National Natural Monument. The west side of the Itoigawa-Shizuoka Tectonic Line is the "I. Accretionary prism area of the Outer Zone of SW Japan" and the east side is "II. Sedimentary rocks area due to the collision of the Izu Peninsula ". Even in the outcrop, you can observe that the rock quality is different between the east and west sides.

Here, water samples were collected from the tributaries of the Hayakawa River and the river near the Amehata Dam, and water quality was measured.

Arakura fault (Explanation board)

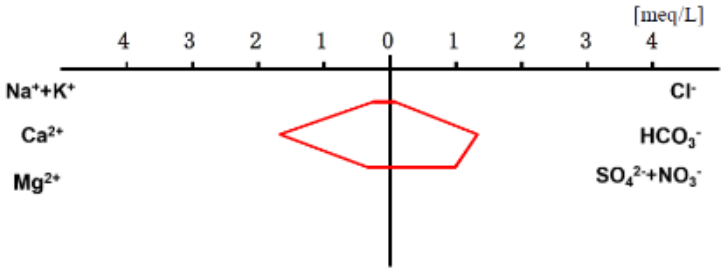
Outcrop of Arakura fault

Both sites 1 and 2 show Ca-HCO_3 types, with a relatively high proportion of sulfate ion (SO_4^{2-}) concentrations. The water quality at the above two sites has the highest amount of dissolved constituents among the surveyed sites, and the concentrations are higher than those of other river waters in areas not affected by anthropogenic influences (e.g., drainage and agriculture), such as in urban areas.

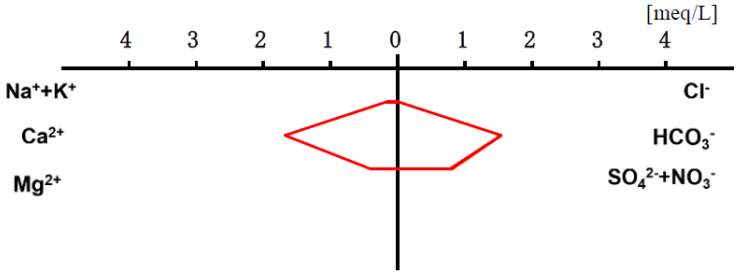
Hayakawa（site1）

Amehata（site2）

We considered the possibility of the influence of hot spring water located in the upstream, however, water quality of these river water samples are different from that of the Nishiyama hot spring located along the upstream of this watershed, so it is expected that factor of water quality formation is not hot spring water mixing but influence of the geology.



1 Hayakawa



2 Amehata

Stiff diagram of sample water in the Southern Alps

Boundary between Kanto Mountains and Misaka Mountains

On the Koshu-Kaido Road from Otsuki to Kofu, you will find Sasago-syuku post town before the Sasago Pass. Sasago-syuku was a combination of Shirano-syuku, Amida Kaido-syuku, and Kuronota-syuku, and a culture developed to entertain travelers crossing the Sasago Pass, which was a difficult pass.

The Shimanto Belt accretionary complex of the Kanto Mountains is distributed along this road and up to the Sasago Pass, while the surrounding mountains are intruded by granitoids of the Kofu granite body and the Misaka Massif. Therefore, to understand the geological influence on the groundwater flowing in this area, it is important to estimate the water source and recharge area by conducting water analysis in the surrounding area.

Sasaichi Sake Brewery

In this study, we visited the Sasaichi Sake Brewery near the boundary between the Kanto and Misaka mountain ranges, where we were provided with brewing water and interviewed with Mr. Amano, the president of the company.

Sasaichi Sake Brewery was founded in 1661 (Kanbun 1). This area has long been famous for

its pure water, and it is said that the storehouse was built here. As it is a post town on the Koshu -Kaido Road and close to Edo, it has long had strong connections with Edo (Tokyo) and central Japan, such as by transporting water to tea parties at Edo Castle, and has actively worked to foster local industry.

In 1953, they started making wine with grapes grown in our own vineyards, and at the “New Brew Festival”, we offer Japan sake that goes well with game meet (gibier), Chinese and French cuisine as "the only event where you can drink both Japan sake and wine.

The source of the brewing water is a deep well at a depth of 35 to 40 meters. The water quality of the brewing water was Ca-HCO_3 type. The identification of the recharge area is important because this area is located near the boundary between the Kanto Mountains and the Misaka massif, and various geological features are distributed in this area.

The survey revealed that the abundant groundwater recharged near the boundary between the Misaka massif and the Kofu granite body is used as brewing water as it contains moderate mineral content and is delicious.

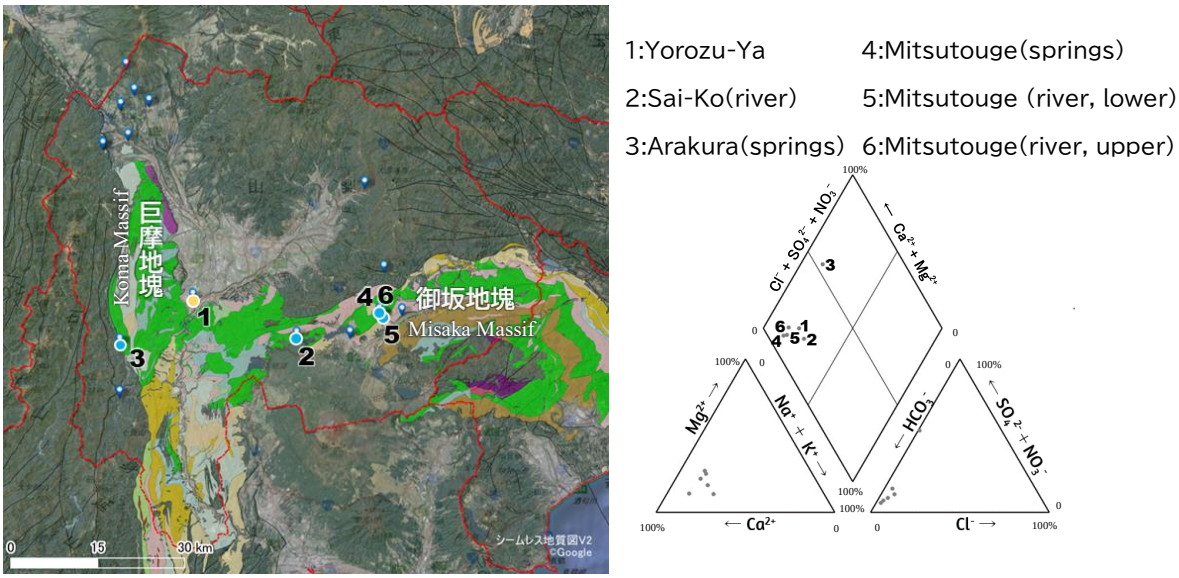
Sasaichi ShuYu Kan (Shop)

The mountain behind brewery

II. Sedimentary rocks area due to the collision of the Izu Peninsula

The Misaka Group was formed during the Neogene Miocene (approximately 16 to 10 million years ago) by the collision of the Koma Massif (Kushigata-yama Massif) in the west and the Misaka Massif in the east, and is composed mainly of green tuff. The Fujikawa Group in the Kyounan area(southern part of the Yamanashi) consists mainly of mudstones, sandstones, and conglomerates that were deposited during the Miocene to Pliocene of the Neogene periods of the Cenozoic Era.

This time, we visited foothill of Mitsutoge and the north shore of Lake Saiko in the Misaka massif, Arakura in the Koma Massif, and the Yorozu-ya Brewery in Fujikawa Town to conduct research and analysis (see figure below).



Water sampling points and trilinear diagrams

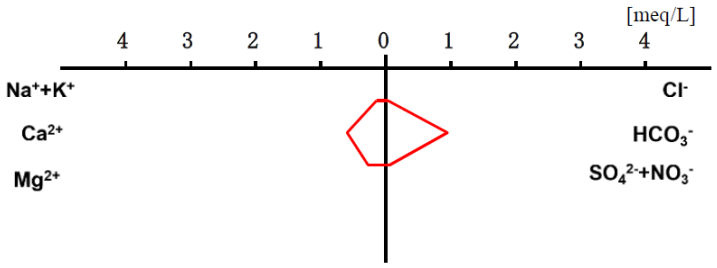
Misaka Massif / Foothill of Mt. Mitsutouge

Mt. Mitsutoge is a mountain with an altitude of 1,785 m on the border among Tsuru City, Nishikatsura Town, and Fuji-Kawaguchiko Town in Yamanashi Prefecture, and sedimentary rocks such as conglomerate can be seen at the foot and summit, and igneous rocks can be seen in the middle. These geological formations resulted from the conversion of volcanoes and sediments from the Miocene of the Neogene period to land by arc-arc collisions.

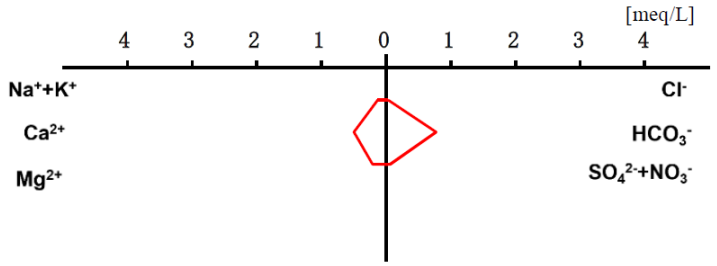
Water samples were collected at three sites (points 4, 5, and 6) and water quality was measured.

Mitsutouge（point 4）

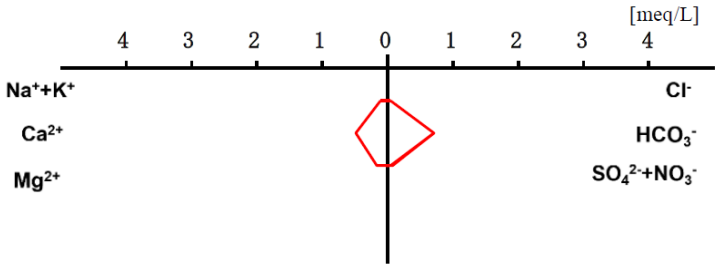
Mitsutouge（point 5）



4 Misutouge



5 Mitsutouge (river, lower)



6 Mitsutouge (river, upper)

Stiff diagram of sample water in Mitsutouge

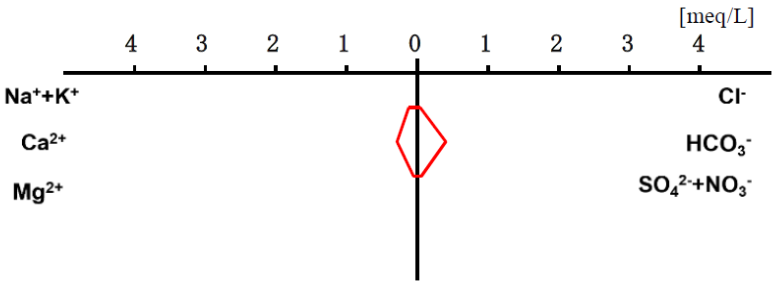
The water at these three sites is Ca-HCO_3 type, but the dissolved constituents in the spring

water are slightly higher than those of the other two river waters, and the $\delta^{18}O$ (oxygen stable isotope ratio) and $\delta^{2}H$ (hydrogen stable isotope ratio) values are slightly lower, therefore, it is suggested that the spring water is different from the river water, and the spring water flowed through the near the soil surface. Additionally, the low concentration of V (vanadium) and P (phosphorus) of spring water suggested that the source the spring water was not Mt. Fuji.

In addition, igneous rocks of the Misaka massif are distributed on the northern shore of the Sai-ko Lake. Water samples were taken from the river flowing into the Sai-ko Lake, and water quality was measured.

Mitsutouge（point 6）

North shore of Sai-ko（point 2）



2 Sai-ko

Stiff diagram of sample water in north shore of Sai-ko

This river water has a Ca-HCO_3 type water composition, with low V (vanadium) and P (phosphorus) concentrations, clearly indicating that the source of river water is not Mt. Fuji but from the Misaka Massif.

Koma Massif / East side of Arakura spring

This Arakura spring is located on the east side of the Itoigawa-Shizuoka Tectonic Line, and

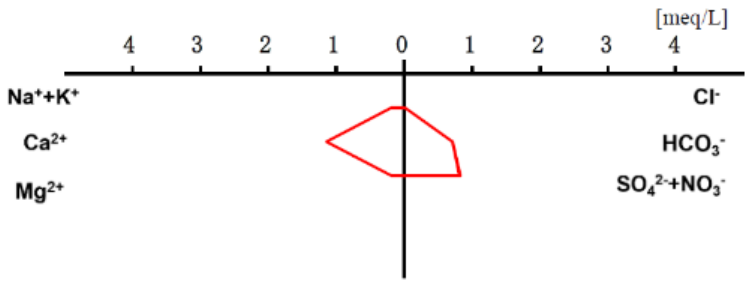
the surrounding rocks are considered to be igneous rocks of the Neogene Miocene

Because the tectonic line runs very close to the site, it is not certain which rocks the water sampled here came from.

Arakura spring water shows the Ca-SO_4 type, and the sulfate ion concentration is relatively high same as the Hayakawa and Amehata rivers located in the Southern Alps.

Arakura springs

Arakura springs（point 3）



3 Arakura springs

Stiff diagram of sample water in Arakura spring

Yorozu-ya Brewery

We visited Yorozu-ya Brewery near the confluence of the Fuji and Fuefuki-gawa Rivers, where they provided us with brewing water and interviewed with Mr. Tamagawa, president of the company.

The Yorozu-ya Brewery Company was founded in 1790. This area is a post town that prospered from the "Fuji River Boat Transport", and the brewery was originally involved in the brewing of miso and soy sauce, and also brewed sake served there.

This area, which prospered through the transportation of boats, was also aplace of cultural exchange. The brand name "Syunnouten" was named after a tanka poem written by Akiko Yosano, who was in contact with the sixth-generation owner of the brewery. All of the buildings on the premises, including the Rokusai Sake Brewery Gallery, were built in the Meiji period (1868-1912) and still retain the atmosphere of that era.

Mr. Tamagawa epressed his desire to create a sake that pairs well with food and that people can enjoy while eating, and that will impress them with its good taste.

For brewing, Fujikawa-machi's tap water is used, which is drawn from four deep wells located within a 10-minute walk from the brewery and distributed as tap water.

As a general image, it is often thought that tap water is not delicious, but if groundwater in the same area is used as a water source, tap water quality is almost the same as groundwater, so tap water can be said to be sufficient (good water). In other words, in this case, there is almost no difference in sake production between using tap water and groundwater.

In this sense, using tap water is the same as using groundwater or spring water if the water source is groundwater (or spring water), which can be proven by comparing the dissolved matter content with that of actual groundwater.

Mr. Tamagawa mentioned that 100% of the sake rice is grown in the prefecture and 90% is locally grown, and he wanted to know the truth about where this water originated.

The composition of the supplied brewing water was of the Ca-HCO_3 type, with high dissolved concentration. Since this area is located in alluvial fan area, it is thought hat the groundwater quality influenced by the geology of alluvial fan.

Yorozu-ya Brewery

Brewery Gallery Rokusai

III. Plutonic rocks (granite) outcropping area in the southern Fossa Magna

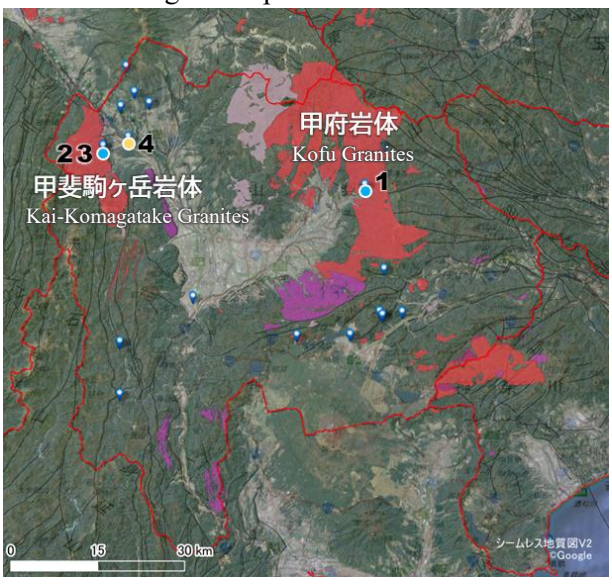
The intrusive plutonic rocks that were intruded during plate subduction in the Neogene are exposed as the Kofu Rock Body in the central to northern part of the prefecture and the Kai-Komagatake Rock Body in the western part.

This time, we visited a spring at a mountain pass in Kofu Rock Body, Komagatake Shrine and Ojira River in Kai-Komagatake Rock Body, and Yamanashi-Meijo in Hokuto City to investigate and analyze the water.

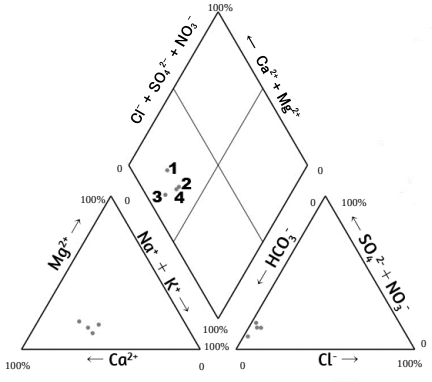
Kofu Rock Body / Spring water(Touge no Yu-sui)

Granites of the Kofu Rock Body are distributed in the area from Enzan to the Sakeishi Onsen(hot spring) area on National Route 411 toward Ome, Tokyo. The name "Sakeishi" comes from a boulder called "Sakeishi" located at the site of the Hagiwara Kuchitomebanjo (guard station) on the side of an old road in the area. This boulder has a shape of a giant stone split from the center, and has been an object of worship because of its mysterious shape.

This flat cracking feature is characteristic of granitic rocks, and such megaliths with straight cracks, as if cut with a knife from the middle of the rounded core stone, can be found in granite areas throughout Japan.



1:Touge no Yusui
2:Ojira River
3:Komagatake Shrine
4:Yamanashi Meijo

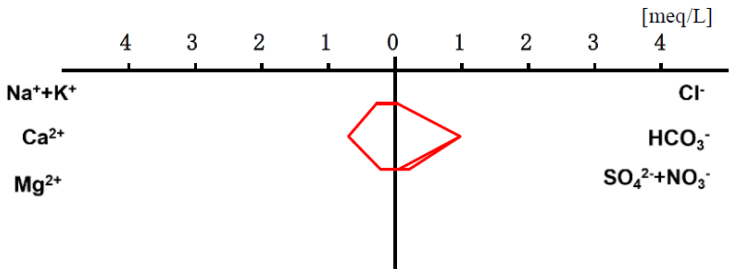


Water sampling points and trilinear diagrams

This time, water samples were taken from a spring at a mountain pass near this crack stone, and water quality was measured.

Touge no Yusui

Water Sampling



1 Touge no Yusui

Stiff diagram of sample water in Touge no Yusui

The Ca-HCO_3 type water quality composition of the spring water at the pass, which has a relatively high amount of dissolved constituents for a spring water, and it is assumed that the residence time of the spring water is relatively long.

Kai-Komagatake Rock Body, Komagatake shrine and Ojira river

On the eastern slope of Mt. Kai-Komagatake, granitoids of the Kai-Komagatake Rock Body are distributed. The Ojira River flows along this slope, and many whitish giant rocks lie on the riverbank.

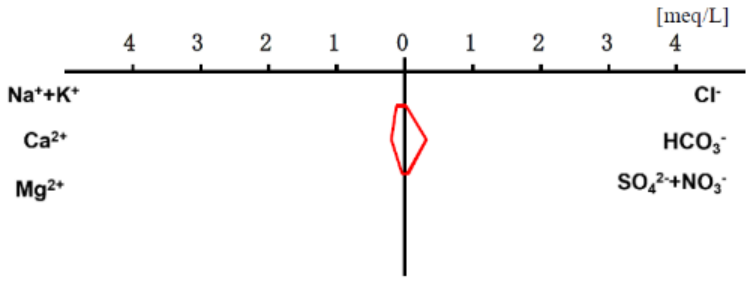
Mt. Kai-Komagatake is the highest mountain (2967m) among the many “Komagatake” mountains in Japan, and a mountain worship called "Komagatake Kou" has flourished since

ancient times, with various stone monuments and stone Buddhas erected in the mountains. Komagatake Shrine was built at the foot of the mountain by the Komagatake Kou followers.

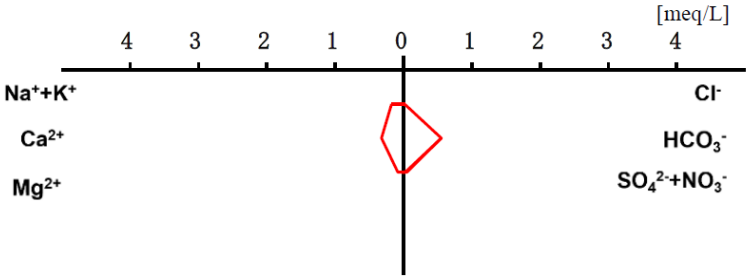
This time, river water from the Ojira River and spring water from Komagatake Shrine were collected and measured for water quality.

Ojira River

Springs at Komagatake Shrine



2 Ojira River



3 Komagatake Shrine

Stiff diagram of sample water in Ojira-gawa and Komagatake Shrine

Both two sites show Ca-HCO_3 type. In general, the water in the Hakushu area shows a Ca-

HCO_3 type, and although the dissolved constituents are slightly higher in the spring water than in the Ojira River, the concentration of the Komagatake Shrine spring water is lower than that of the other springs, suggesting that the residence time of the spring water is likely relatively short.

Beach in the Sky - Mt.Hinata

Mt. Hinata is a 1,660-meter-high mountain located to the north of Mt. Kai-Komagatake, which is also composed of granite from the Kai-Komagatake Rock Body. At Gangahara, located to the west of the summit, a sand dune like a beach stretches across the entire area, and below, across the Fossa Magna rift valley, there is a panoramic view of the Yatsugatake Mountains and other mountain ranges. The view of Mt. Kai-Komagatake looming in the background is a sight that is hard to believe that you are near the summit.

View of Yatsugatake from Hinata-yama

Granite becomes sand(“masa”) when weathered, and the groundwater in the Ojira River basin is recharged with moderate mineral content that has passed through such weathered granite.

Although a bit strenuous as a hike, “Hakushu and the Ojira River” are selected as one of the 100 best watersheds and can be reached in a day trip, so it is worth a visit.

Yamanashi Meijo brewery

We visited Yamanashi Meijo brewery and interviewed with Mr. Kitahara, the managing

director and head brewer, as well as being offered a bottle of brewing water.

Yamanashi Meijo was originally a sake brewery in Takato, Nagano Prefecture, but the seventh generation of the family built a brewery here in 1835 as a branch of the family. They chose this area because they fell in love with the water and because it was located along a road where people used to come and go at inns.

In pursuit of "how much can we express the texture of water," he has made various attempts, embodying the fact that even if the same raw materials (rice and yeast) are used, the same product will not be made with different water.

Even in the Kamanashi River basin, the water is different between the Kai-Koma side and the Yatsugatake side (soft on the Kai-Koma side and sharp on the Yatsugatake side), so by understanding the relationship between the water and yeast, we can make different sake for each region. He also said that he looks at water not in terms of hardness but in terms of balance.

Yamanashi Meijo

Sampling of brewing water

The water used for brewing is pumped up from a shallow well, and the well depth is approximately 10 meters. The deeper you dig, the higher the iron content.

According to the measurement of the brewing water, the Ca-HCO_3 type and the Na^+ ratio were also high. Since the water quality is slightly different from that of the Ojira River and Komagatake Shrine, it is considered that the groundwater is not directly infiltrated from the Ojira River.

Because the well is 10 m deep, it is likely that mountain spring water percolates into the ground and contributes components from the geology. Since $\delta^{18}O$ and $\delta^{2}H$ are generally the same as those of the Komagatake Shrine spring, it is assumed that the recharge area (recharge

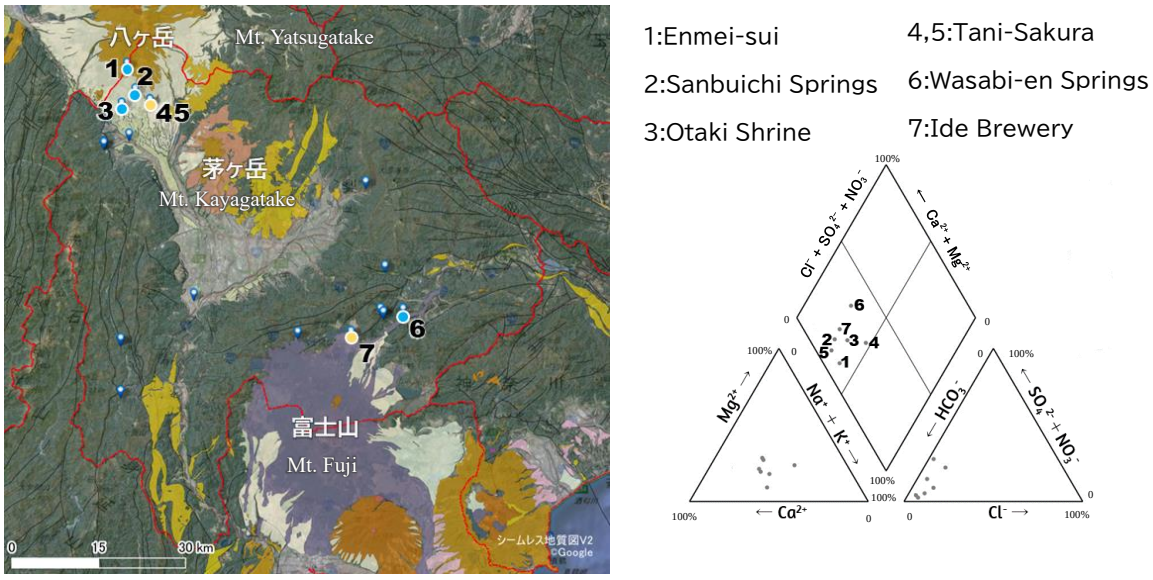
elevation) is similar, or that the recharge elevation is slightly lower for the groundwater from the Yamanashi Meijo than for the Komagatake Shrine spring.

IV. Volcanic rocks outcropping area in the southern Fossa Magna

Mt. Yatsugatake, Mt. Chigatake, and Mt. Fuji form a volcanic front aligned north-northwest to south-southeast. There are a huge accumulation of lava, volcanic debris, and volcanic mudflows at the foot of these mountains, and complex groun dwater flow zones have been formed.

The sediments in the Kofu Basin are characterized by a predominance of sand and gravel layers and a paucity of clay layers, probably due to the relative vertical movement of subsidence in the Kofu Basin and uplift in the surrounding mountains. The people of the region have been able to survive by increasing the area under cultivation through the development of flood control technology and by producing products that are suited to the climate.

Fuji lava flow, and visited the Tani Sakura Sake Brewery in Hokuto City and the Ide Brewery in Fujikawaguchiko Town to conduct research and analysis (see figure below).



Water sampling points and trilinear diagrams

We also visited each site and museum of the Japanese Heritage "*Obsidian and the Prehistoric Dwellers of the Chubu Highlands*" to experience the activities of the Jomon people and the

landscape of the Fossa Magna.

Southern foothill of Mt. Yatsugatake

There are many springs at the southern foot of Mt. Yatsugatake, and the Sanbuichi Spring Museum, located near the Sanbuichi Spring, provides easy-to-understand exhibits about the spring water system (groundwater flow) and the history of spring water use at the southern foot of Mt. Yatsugatake. It is recommended to first stop by the museum to gain some knowledge before touring the springs, as it will enhance your eperience.

This time, we visited Enmei-sui, Sanbuichi Spring, and Otaki Spring (Otaki Shrine), which are located at different elevations, to collect water samples and measure the water quality.

Enmei-sui（point 1）

Enmei-sui

Sanbuichi springs（point2）

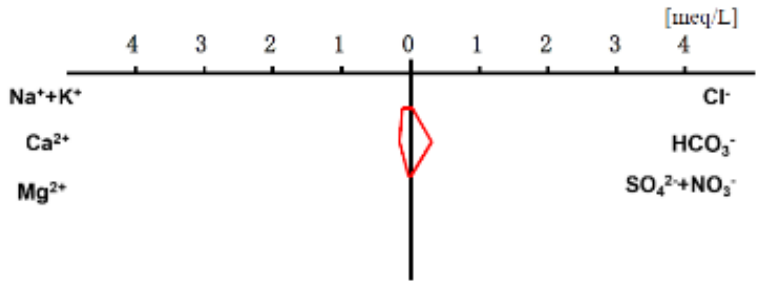
Water sampling at Sanbuichi

The water composition of the three springs recharging the Yatsugatake area is all of the Ca-HCO_3 type, but the amount of dissolved constituents differs slightly.

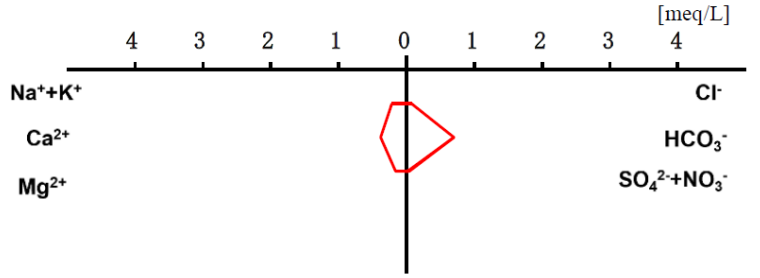
The concentration of Enmei-sui spring water at high altitudes is low, while the concentration is high in lower-altitude places such as spring water in Sanbuichi and Otaki Shrine, suggesting that it is related to residence time.

Otaki Shrine

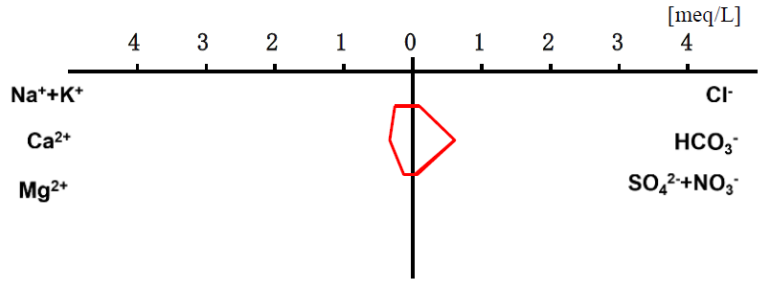
Otaki springs（point3）



1 Enmei-sui springs



2 Sanbuichi springs



3 Otaki Shrine

Stiff diagram of sample water in southern foothill of Yatsugatake

Since the amount of dissolved components is low in the Enmei-sui spring water at the highest altitude (point 1), the distance from the recharge area to the seep point is short.

The discharge site and groundwater flow system of these spring water are different, however, the $\delta^{18}O$ and $\delta^{2}H$ are similarly, so the recharge area (recharge altitude) of these spring water are likely same.

Japanese Heritage " Obsidian and the Prehistoric Dwellers of the Chubu Highlands "

The Yatsugatake Mountains and surrounding areas were the most densely populated area in the Japanese Islands during the middle Jomon period (around 5,000 years ago).

Many Jomon ruins have been discovered in the area, and many legacies of the Jomon people's lifestyle, interaction, and culture have been uncovered. In particular, there is a theory that the "perforated flange type earthenware" characteristic of this region may have been used for sake brewing, and further research is desirable.

Mt. Kai-Komagatake

Perforated flange type earthenware

Tani-Sakura Brewery / Yamaki Brewery

The brewing water was provided by Tani Sakura Sake Brewery and Yamaki Sake Brewery. We also visited Tani Sakura Sake Brewery and interviewed with Mr. Komiyama, the managing director.

Tani-Sakura Sake Brewery was founded in 1848 (the first year of Kaei) as a omiki(sacred sake) store that makes offerings to the gods and sake to be drunk by locals and people around them.

This area is close to the residence of Minamoto Kiyomitsu, who is said to be the ancestor of the Kai-Genji clan, Yato Castle, and the Hemi Shrine, and has been called "Machiya" in the center of the village for a long time.

It is characterized by the scenery of rice paddies developed in a stepped pattern on the slope at the foot of Mt. Yatsugatake, offering a place where you can see the magnificent scenery of the foothills of Mt. Yatsugatake. The label of the main brand, Tani Sakura, also uses an illustration of Yatsugatake, which appeals to the fact that it is a local sake at the foot of Mt. Yatsugatake. In addition, since the president is a former French cook, he aims to make a slightly dry and firm sake that can be paired with Western food, which is said to be highly regarded by people overseas.

Water from a deep well (30 m deep, 18 m intake depth) is used for brewing. The water used to come from a water tap (the source is from a large spring), but they have recently switched back to using wells.

The water in this area, both well and tap, is characterized by a slight bitterness, but the reason for this is not known.

This time, we were provided with water from both wells (groundwater) and the water supply.

Groundwater has a Na-HCO_3 type and is characterized by a long residence time. On the other hand, the tap water (source: Dai-Yusui) is of the Ca-HCO_3 type and has a water quality composition similar to other springs in Yatsugatake (Enmei-sui, Sanbuichi, and Otaki springs), which is different from that of the ground water (brewing water).

On the other hand, both are characterized by high P (phosphorus) concentrations of 100 μg/L or more (the reason for the high P concentrations is currently unknown).

Tani-Sakura Brewery（point4,5）

The old name was “Kosen-ya”

Yato Castle

Hemi Shrine

Fuji Lava Flow

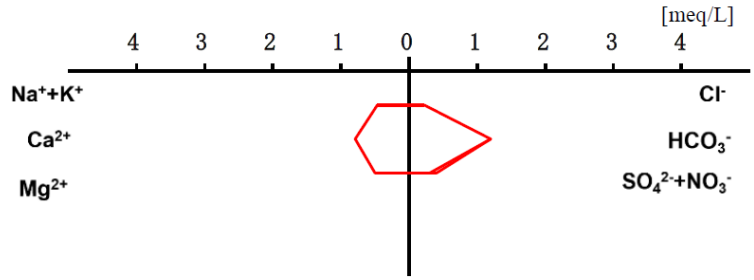
Mt. Fuji erupted about 9,000 years ago, and its lava flow filled the valley of the Katsura River and reached Saruhashi in Ohtsuki City. The valley of the Katsura River is covered with layers and layers of lava and ejecta deposited by the repeated eruptions of Mt. Fuji.

This time, we collected spring water seeping from a cliff near the Wasabi Garden in Natsukari, Tsuru City, and measured its water quality.

The Wasabi Garden spring water shows the Ca-HCO_3 type, with high concentrations of vanadium (V) and phosphorus (P), and the source of the spring water is likely Mt. Fuji. Compared to springs in Oshino Village and Fuji-Kawaguchiko Town located in the upper reaches of the river, this water is expected to have a longer residence time due to its higher dissolved constituents.

Springs near Wasabi-en（point 6）

Water sampling



6 Wasabi-en

Stiff diagram of sample water in Wasabi-en

Ide Brewery

We visited the Ide Brewery, where we were provided with brewing water and interviewed with the brewery's representative, Mr. Ide Yogoemon.

Ide Brewery was established around 1700 (mid-Edo period). The brewery was originally producing soy sauce and miso, but around the end of the Edo period, rice began to be delivered to the brewery, and when the Princess Kazunomiya was sent to Edo, the brewery learned that other breweries were making sake as well as soy sauce, and began producing sake.

This area has long been a place of heavy human traffic because Kawaguchi Station on the ancient government road Misaka-michi was established here, and the Funatsuguchi trail is one of the bases of the Fuji trail. The high altitude of the region has allowed sake brewing to take advantage of the clean, germ-free environment in the cold winter and the labor force during the off-season.

Until the 1960s, a shallow well of about 12 meters was used for brewing water, but this was changed to tap water in 1975 (the water source is a well-managed by the town).

The water provided to us also contained high levels of vanadium, indicating that the water originated from Mt. Fuji.

The composition of the brewing water provided to us is of the Ca-HCO_3 type, with a slightly higher percentage of Na+ and Mg^{2+} . The concentrations of P (phosphorus) and V (vanadium) are high, and are almost identical to those of spring water and groundwater collected in Fuji-Kawaguchiko Town. The public water source of Fuji-Kawaguchiko is groundwater (well water), but there are several water source wells with different characteristics depending on the location. Therefore it is necessary to trace the information of the source wells from which the water supply used by the Ide Brewery is derived.

Ide Brewery（point 7）

Shop “Sakaboushi”