1. GROUND WATER
2. DISTRIBUTION OF THERMAL SPRINGS

1. Ground Water

Ground water exists in the pores of strata and the fissures of rocks. The underground strata consist of the permeable layer which is made up of unconsolidated sand and gravel, the aquiclude which consists of silt and clay, and the aquifuge such as a rock bed. The aquiclude and aquifuge are called impermeable layer. Almost all underground water is produced in the permeable layer.

Ground water comes in two types—free surface water which exists in shallow places and confined water which is vertically sandwiched between impermeable layers. Confined water flows out in some instances, when an artesian well is drilled.

The aquifers in Japan which produce ground water consist exclusively of deposits and effusive rocks in the Pliocene and subsequent epochs. The lowlands, such as fans, flood plains, and deltas, are made up of the Recent deposits, such as sand and gravel, silt and clay, and their ground water is normally shallow and abundant. The quality of ground water is fine with the exception of that of areas close to the coastline. The tablelands and terraces consist mainly of the Pleistocene deposits, and ground water is produced from deep places in considerably large quantities. The ground water produced from the Pliocene deposits is not so great in quantity. Confined water sometimes exists in the bases of volcanoes, and water sometimes gushes out in great quantities from springs. The ground water which may be pumped up from mountains and put to use is small in quantity. It is difficult to exploit ground water in mountain areas.

Many of the springs, which are natural outcrops of ground water, are observed in the edges of fans, such as Matumoto Bonti (Basin); in the caves of limestone tablelands, such as Akiyosi Dai (Tableland), and in the bases of volcanoes, such as Huzi and Kirisima. Also observed are the submarine springs which have their outlets on the seabed.

The temperature of ground water in shallow places present diurnal and annual variations, and the range decreases in proportion to the depth. When the depth reaches certain levels (10–18 m), the temperature of ground water remains constant at values 1–2℃ higher than the annual mean air temperature. In further deeper places, the temperature goes up in proportion to the ratio of increase in the soil temperature.

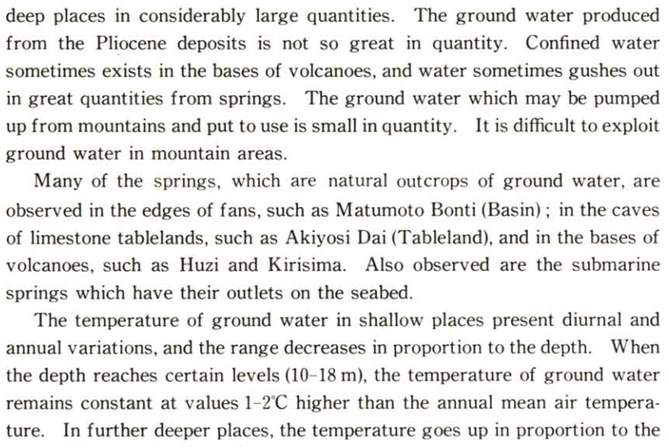
The fluctuations in the temperature of ground water are small, its quality is good, and it is easy to collect,so that its value as a water resource is great. However, the flow and recharge speeds of ground water are slow, so that the unplanned collection of ground water tends to result in an abnormal drop in the ground water level, pollution, such as with seawater, and land subsidence.

Salient Points of the Legend and Map Compilation

In this map, the quality of ground water is illustrated in the form of a diamond-shaped diagram. The portion in purple color represents the carbonate hardness type, to which most of normal ground water belongs. The portion in green color represents the carbonate alkali type, to which ground water in a stagnant environment often belongs. The section in blue color represents the noncarbonate hardness type, which is observed in thermal spring water,fossil water and others. The section in red color represents the noncarbonate alkali type, and seawater-polluted water and others belong to this type.

Sources

1. Geological Survey of Japan, 1 : 2,000,000 scale Hydrogeological Map of Japan, 1964.
2. Geological Survey of Japan, 1 : 25,000–100,000 scale Hydrogeological Maps of Japan, 1961–1969.
3. Geological Survey of Japan, Bulletin of the Geological Survey of Japan.
4. Geological Survey of Hokkaidō, 1 : 100,000 scale Hydrogeological Maps of Hokkaidō, 1963–1969.
5. Ministry of Agriculture and Forestry, Register of Facilities for Water Use on the Basis of Survey of Ground Water for Agriculture, 1963–1971.
6. Sōki YAMAMOTO, Ground Water Temperature of Japan, Chirigaku, Vol. 2, No. 3, 1953.



(YAMAMOTO, 1953)

2. Distribution of Thermal Springs

Many thermal springs exist in Japan. A check of the thermal spring registers of each prefectural government reveals that as of April 1, 1974, there were about 15,000 thermal springs where the water temperature was measured. Of these, the thermal springs with temperatures in excess of 42 ℃ containing aqueous vapor and gas were two-thirds. The total emission of thermal springs throughout the nation was about 1,400,000 ℓ/m. The number of watering places total about 2,600, of which about 1,400 watering places gush out more than 50 ℓ/m. The quantity of thermal spring water gushing out, as classified by watering place, is greatest in Beppu (Ōita Prefecture) was 80,000 ℓ/m, followed by Kusatu (Gunma Prefecture), Ibusuki (Kagosima Prefecture), Itō (Sizuoka Prefecture) and Yuhuin (Ōita Prefecture) each pouring forth more than 20,000 ℓ/m.

Most thermal springs are formed with the ground water heated by geothermy, and contain a wide variety of chemical components by interaction with outlying rocks. Thermal springs in Japan are generally distributed in conjunction with the Quaternary volcanoes and the Neogene volcanic rocks. There are some thermal springs which are associated with the Tertiary plutonic rocks and hypabyssal rocks or the Mesozoic granites. Many of the thermal springs associated with the Mesozoic granites are the chloride springs which feature strong radioactivity.

The drinking of thermal spring water and bathing in thermal springs are considered medically efficacious, and contraindications and indications for the use of thermal springs are determined, depending on the thermal spring quality. In Japan, however, the utilization of thermal springs for recuperation and rest are very popular, and well equipped watering places attract many tourists.

Salient Points of the Legend and Map Compilation

This map illustrates the quality, quantity and temperature of the thermal springs which gush forth more than 50 ℓ/m. However, there exist a number of springs at watering places, and they feature different thermal spring water qualities and temperatures in many instances. For this map, representative thermal spring water quality and the highest thermal spring water temperature are shown.

Sources

1. Data from the Environment Agency and prefectural governments.
2. Seiya UYEDA, Heat Flow, The Crust and Upper Mantle of the Japanese Area, Pt.1, 1972.

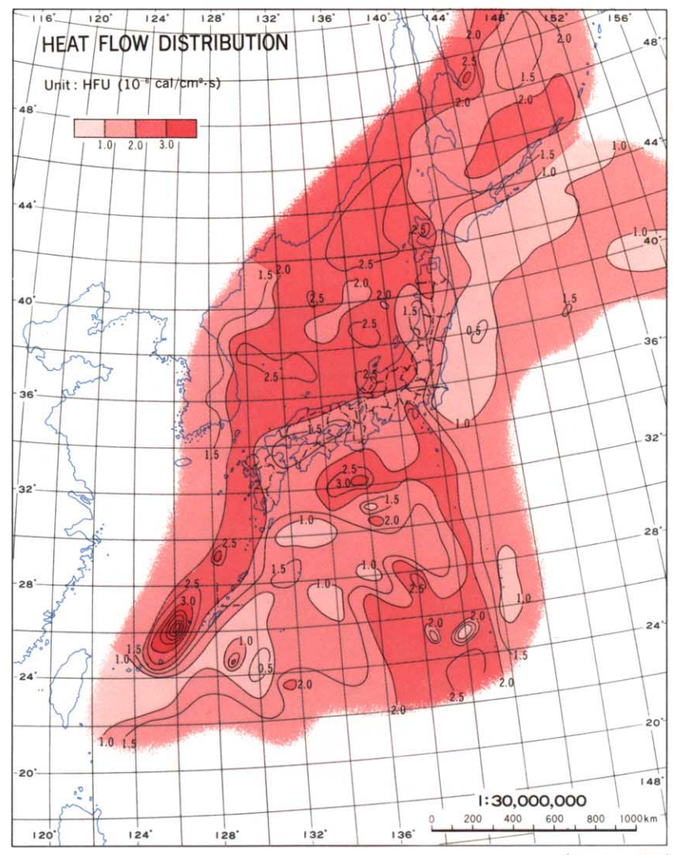
DEFINITION OF THERMAL SPRINGS BY THE THERMAL SPRING LAW

Of the thermal water, mineral water and aqueous vapor and other gases gushing out from the ground (excluding the natural gas the main component of which is hydrocarbon), those which have the following temperature or matter are regarded as thermal springs

1 Water temperature : higher than 25℃

2 Matter (any one of those enumerated below)

Matter	Content (Per 1kg)
Soluble matter (excluding gaseous matter)	Total 1.000mg and over
CO_2	250mg and over
Li^+	1mg and over
Sr^{2+}	10mg and over
Ba^{2+}	5mg and over
Fe^{2+}, Fe^{3+}	10mg and over
Mn^{2+}	10mg and over
H^+	1mg and over
Br^-	5mg and over
I^-	1mg and over
F^-	2mg and over
$HAsO_4^{2-}$	1.3mg and over
$HAsO_2$	1mg and over
Total sulfur corresponding to $HS^- + S_2O_3^{2-} + H_2S$	1mg and over
HBO_2	5mg and over
H_2SiO_3	50mg and over
$NaHCO_3$	340mg and over
Rn	2×10^{-9} curie and over
Ra	1×10^{-8}mg and over



(UYEDA, 1972)

7.1

GROUND WATER

GEOLOGY

Recent	Highly permeable. Specific capacities ranging from 1,000 to 3,000 m³/d/m. Contains generally free surface water
Pleistocene	Moderately to highly permeable Specific capacities ranging from 300 to 500 m³/d/m Contains generally confined water
Pliocene	Moderately permeable Specific capacities ranging as much as 100 m³/d/m
Quaternary effusive rock	At the foot of mountains, contains confined water

WATER QUALITY

(Result of analysis of ground water deeper than 30m
Each side represents e.p.m. ratio of ion)

- Carbonate hardness type
- Carbonate alkali type
- Noncarbonate hardness type
- Noncarbonate alkali type

SPRING

- 20,000m³/d and over but less than 100,000m³/d
- 100,000m³/d and over
- Submarine spring

DISTRIBUTION AREA OF ARTESIAN WELLS
(The figure represents the year of survey)

SEA WATER INTRUSION AREA

1:2,500,000

JAPAN SEA

NORTH PACIFIC OCEAN

Rebun Tō
Risiri Tō
Okusiri Tō
SADO
OKI
TUSIMA
IKI
GOTŌ RETTŌ
KOSIKIZIMA RETTŌ
ŌSUMI SYOTŌ
Yaku Sima
Tanega Sima
TOKARA RETTŌ
Yokoate Zima
Awazi Sima
Take Sima
Ō Sima
Miyake Zima
Hatizyō Zima
Etorohu Tō
Kunasiri Tō
HABOMAI SYOTŌ
Sikotan Tō
Yokoate Zima
Ō Sima
AMAMI SYOTŌ
Tokuno Sima
Okinoerabu Sima
OKINAWA SYOTŌ
Kume Zima
Okinawa Zima
RYŪKYŪ SYOTŌ
SENKAKU SYOTŌ
SAKISIMA SYOTŌ
Yonaguni Sima
Iriomote Zima
Isigaki Zima
Miyako Zima
DAITŌ SYOTŌ
Kita-Daitō Zima
Minami-Daitō Zima
KAZAN RETTŌ
Iō Zima
OGASAWARA GUNTŌ
Titi Zima
Haha Zima

DISTRIBUTION OF THERMAL SPRINGS

DISTRIBUTION OF THERMAL SPRINGS

(1974)

CHARACTERISTICS OF THERMAL SPRINGS

DISCHARGE (includes pumping)

	50～500	500～5,000	5,000 and over (ℓ/min)
Simple thermal spring	●	●	●
Bicarbonate spring	●	●	●
Sulphate spring	◆	◆	◆
Ferrous spring	▲	▲	▲
Chloride spring	■	■	■
Sulfur spring	◆	◆	◆
Acid spring	▼	▼	▼
Radioactive spring	*	*	*
Impossible to classify or indefinite	×	×	×

TEMPERATURE OF THERMAL SPRINGS

Under 25°C　25°C～42°C　42°C and above

Status as of April 1, 1974

1:4,000,000

50 0 50 100 150 200km

SEA OF OKHOTSK

JAPAN SEA

NORTH PACIFIC OCEAN

Etorohu Tō
Rebun Tō
Risiri Tō
Kunasiri Tō
Sikotan Tō
HABOMAI SYOTŌ
Okusiri Tō
SADO
OKI
Take Sima
TUSIMA
Awazi Sima
Miyake Zima
Hatizyō Zima
Aoga Sima
Ō Sima
IZU SYOTŌ
GOTŌ RETTŌ
KOSIKIZIMA RETTŌ
ŌSUMI SYOTŌ
Tanega Sima
Yaku Sima
TOKARA RETTŌ
AMAMI SYOTŌ
Tokuno Sima
Okinoerabu Sima
OKINAWA SYOTŌ
Okinawa Zima
Kume Zima
RYŪKYŪ SYOTŌ
SENKAKU SYOTŌ
SAKISIMA SYOTŌ
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