

## Image Database of Geothermal Drill Core Samples in Japan

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### ABSTRACT

Drill core samples from about 50 surveyed areas in Japan have been reserved in the depository of Geological Survey of Japan. Total length of the core samples reach up to 26.6 km. Core image database is the best way to preserve these images forever and open to public. The database is temporarily uploaded on the website: <http://riodb02.ibase.aist.go.jp/drillcore/>. The locations of surveyed areas for core samples are shown on the geothermal resources map in the scale of 1:1,000,000. Most surveyed areas are located around volcanic front, and farther areas behind volcanic front show generally lower potential with several exceptions. The thermal features based on maximum temperatures are compared each other by projection on the same diagram. The comparison indicates that potential reservoirs are expected around 250 ~350°C at 500~2,500 m in depth. The thermal features are also shown as cross-sections of geologic and thermal structures. Important characteristic core samples are chosen from Kyushu, Tohoku and Hokkaido and briefly explained.

### 1. INTRODUCTION

Well data for Japanese nation-wide geothermal surveys were compiled by Yano, *et al.* (1989) and Suda and Yano (1991). Drill core samples of 26.6 km in total length, are reserved in the depository of Geological Survey of Japan. The inventory of these core samples was published with index tables as an open-file report of Geological Survey of Japan (Tamanyu and Arakawa, 1995). However, all of these core samples cannot be preserved forever. A core digital image database is the best way to preserve these images forever and opened to public parties interested in subsurface geology. Therefore, the image database of drill core samples is completed and is temporarily open to the public.

The camera-type high definition scanner system (CTHDSS) was introduced to digitize the images of core samples. The system provides very high resolution with maximum shooting resolution of 20 million pixels (Tamanyu, *et al.*, 2002).

The database is temporarily uploaded on the website: <http://riodb02.ibase.aist.go.jp/drillcore/>. The core image database will be combined with the borehole-logging database and geothermal resources database to be a uniformed geothermal database in future.

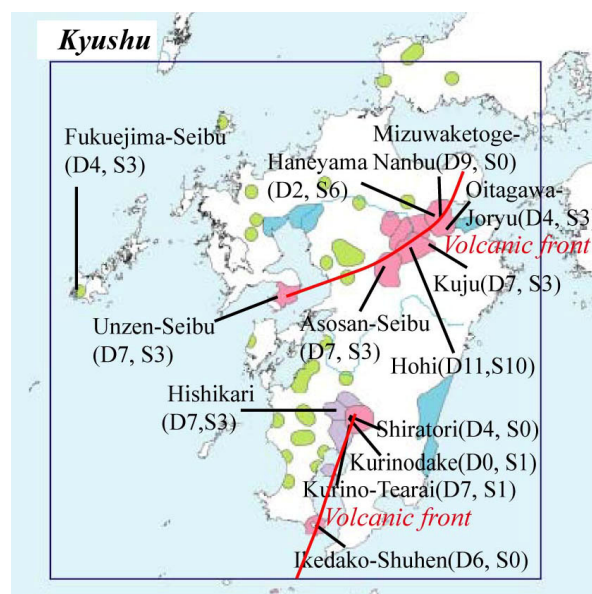
### 2. LOCATIONS OF SURVEYED AREAS ON GEOTHERMAL RESOURCES

The geothermal resources map of Japan was published on a scale of 1:1,000,000 by Yamaguchi *et al.* (1992). The digitized resources map of Tohoku and Kyushu was

published based on a scale of 1:500,000 by Sakaguchi and Takahashi (2002). Locations of surveyed areas are shown separately by following three districts: Kyushu, Tohoku and Hokkaido (Fig. 1, 2 and 3). The geothermal resource areas are classified into three categories: Geothermal resource areas related to Quaternary volcanoes (colored red and purple), geothermal resources areas not related to Quaternary volcanoes (colored light green and yellow), and deep-seated hot water resource areas (colored light blue). The former two categories are subdivided into rank A and rank B according to degree of potentialities. Each surveyed area is plotted on the map and numbers of drill holes are shown as D (drill holes deeper than 1,000 m) and S (drill holes shallower than 1,000 m) in parentheses. The surveyed areas where only a few drill holes have been carried out, and the exploration areas by private companies are excluded in this paper.

#### 2.1 Kyushu

Surveyed areas in Kyushu district are shown with geothermal potential areas and volcanic fronts in Fig. 1. Most surveyed areas are located on and near the geothermal potential areas related to Quaternary volcanoes, and only Fukuejima-Seibu area is relatively far from volcanic front. Main geothermal areas in Kyushu are grouped into Hohi area (including Kuju, Mizuwaketoge-Nanbu, Asosan-Seibu, Haneyama and Oitagawa-Joryu), Kirishima area (including Kurino-Tearai, Kurinodake, Shiratori, and Hishikari) and Satsunan area (including Ikedako-Shuhen).



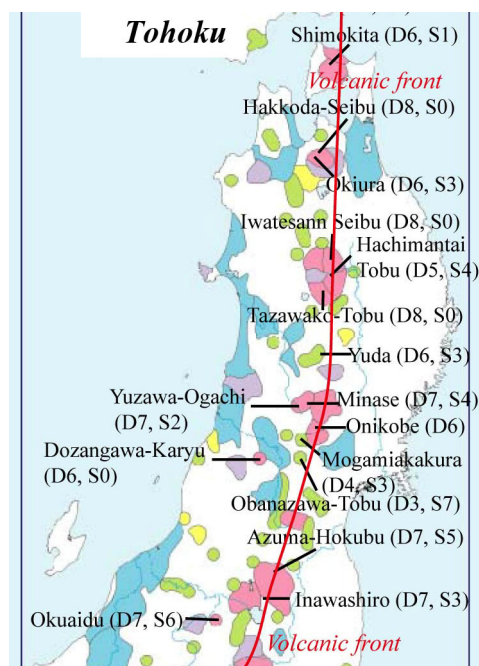
**Figure 1: Surveyed areas in Kyushu district are shown with geothermal potential areas and volcanic fronts.**

Hohi areas have been exploited as four geothermal power stations: Hattchobaru power station of 110 MW, Otake

power station of 12.5 MW, Takigami power station of 25 MW and Suginoi power station of 3MW. Kirishima areas has been exploited as Ogiri power station of 110 MW and Satsunan area as Yamakawa power station of 30 MW.

## 2.2 Tohoku

Surveyed areas in Tohoku district are shown with geothermal potential areas and volcanic front in Fig. 2. Most surveyed areas for core samples are located in the geothermal potential areas related to Quaternary volcanoes on and near volcanic front, and two areas are pretty far behind from volcanic front. Main geothermal areas in Tohoku are grouped into Sengan (including Iwatesan-Seibu, Hachimantai-Tobu and Tazawako-Tobu), Kurikoma (including Yuzawa-Ogachi, Minase and Onikobe), Bandai-Azuma (including Azuma-Hokubu and Inawashiro) and Hakkoda-Osoresan (including Hakkoda-Seibu, Okiura and Shimokita). Although Okuaidu and Dozangawa-Karyu are relatively far from volcanic front, both areas have reasonably high geothermal potential. Okuaidu has been exploited as the Yanaidu-Nishiyama power station of 65 MW, and Dozangawa-Karyu has been used as the Hijiori hot dry test site. Sengan area has been exploited as following four power stations: the Matsukawa power station of 23.5 MW, the Kakkonda power station of 80 MW, the Sumikawa power station of 50 MW and the Ohnuma power station of 9.5 MW. Kurikoma area has been exploited with the following two power stations: the Onikobe power station of 12.5 MW and the Uenotai power station of 28.8 MW.

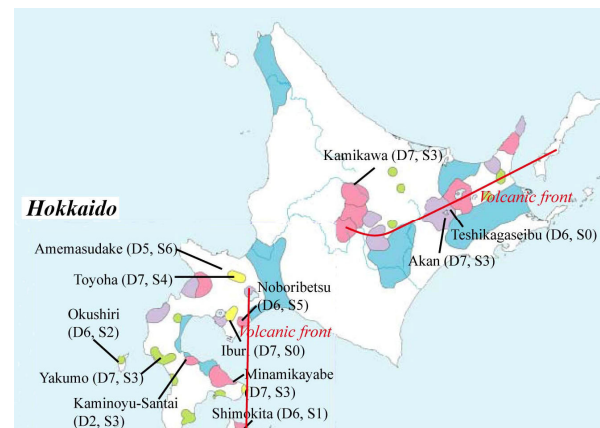


**Figure 2:** Surveyed areas in Tohoku district are shown with geothermal potential areas and volcanic front.

## 2.3 Hokkaido

Surveyed areas in Hokkaido district are shown with geothermal potential areas and volcanic front in Fig. 3. Some surveyed areas for core samples are located in the geothermal potential areas related to Quaternary volcanoes on and near volcanic front, and other areas are scattered behind volcanic front. Main geothermal areas in Hokkaido are grouped into Donan (including Minamikayabe, Kaminoyu-Santai, Yakumo and Okushiri), Doo (Toyoha, Amemasudake, Iburi and Noboribetsu) and Doto

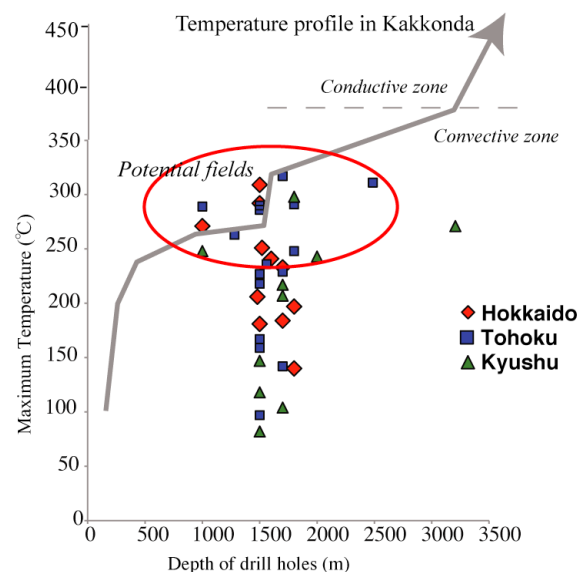
(Kamikawa, Akan and Teshikaga). Only one power station has been exploited in Donan with the Mori power station of 50 MW.



**Figure 3:** Surveyed areas in Hokkaido district are shown with geothermal potential areas and volcanic fronts.

## 3. THERMAL AND TECTONIC FEATURES OF KYUSHU, TOHOKU AND HOKKAIDO

In order to grade the thermal features for each area, the drill hole recording maximum temperature in the surveyed area is chosen, and compared each other by grouping of Kyushu, Tohoku and Hokkaido (Fig. 4). The temperature profile of Kakkonda WD-1a is shown as reference data because the boundary between convection zone and conduction zone is clearly identified (Ikeuchi et al., 1998). The profile also indicates that shallow and deep reservoirs occur with separation of less permeable horizon around 1500 m in depth. Potential fields for geothermal electric power generation using conventional hydrothermal system are chosen as the zone delineated by red colored oval. About one half of surveyed areas contain the drill holes that proved potential fields, and another half did not show adequate temperatures.



**Figure 4:** Comparison of maximum temperatures and their depths of drill holes for each surveyed area in Kyushu, Tohoku and Hokkaido. The temperature profile of Kakkonda WD-1a is shown as reference for high potential areas.

### 3.1 Kyushu

Geothermal features in Kyushu are related with thick Quaternary volcanic deposits within extensional depression such as Hohi graben and Kagoshima graben. The potential fields in Hohi and Kirishima areas occur within clear fault zones near the bases of active Quaternary volcanoes. The cross-section of geologic and thermal structures in Hohi is shown in Fig. 5 (Tamanyu and Wood, 2003).

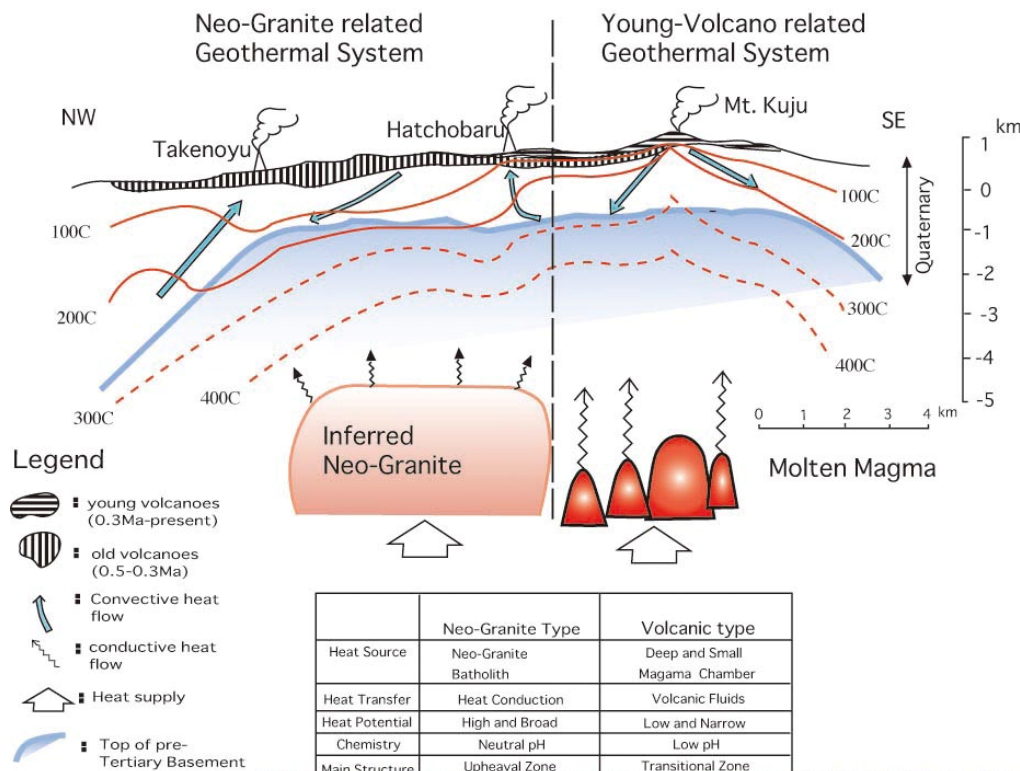


Figure 5: Cross-section of geologic and thermal structures in the Hohi graben which corresponds with western half of Kuju-Bepu graben (Tamanyu and Wood, 2003).

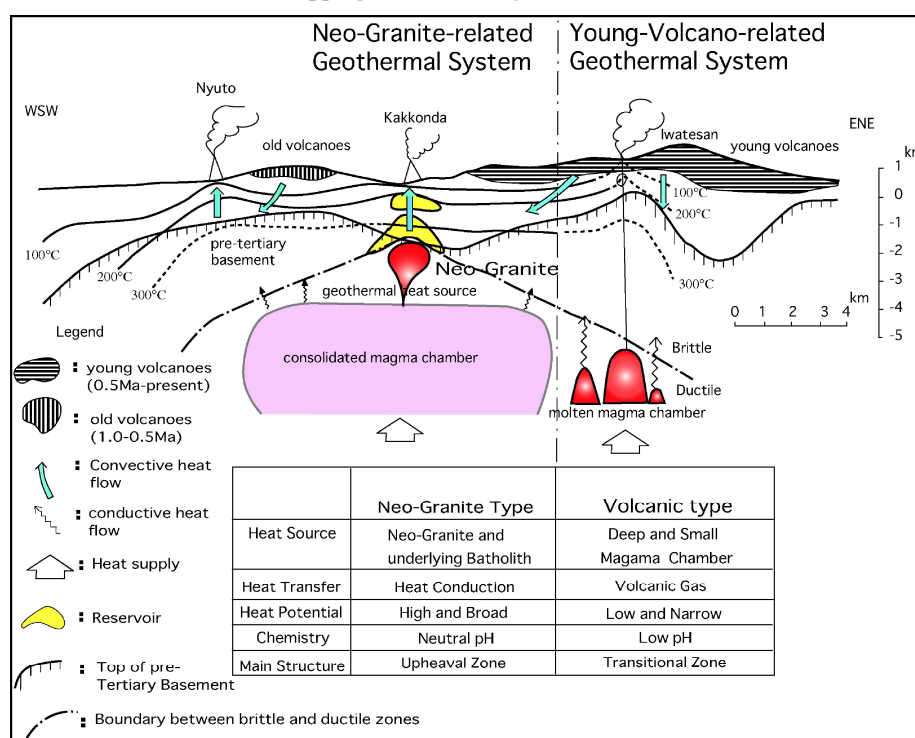


Figure 6: Cross-section of geologic and thermal structures in Sengan (Tamanyu, 2000).



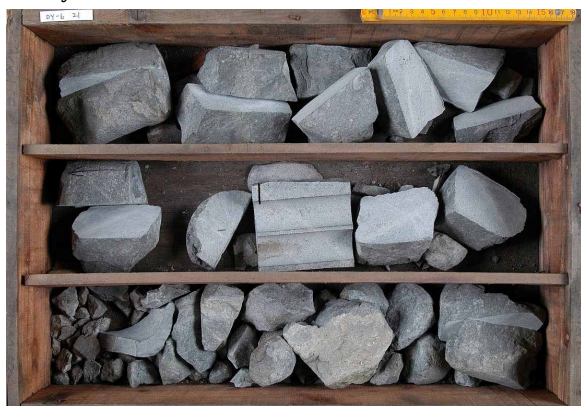
### 3.3 Hokkaido

Geothermal features in Hokkaido are same as Tohoku district. Donan and Doo are regarded as northern extension from Tohoku. Doto is related with Chishima island arc system. Most geothermal areas are located on and behind the volcanic front. Toyoha area used be exploited as silver mine, and closed at present. This area is expected as potential geothermal area. However, geothermal exploration has been opposed by local hot spring owners.

## 4. IMPORTANT CORE SAMPLES FOR FUTURE EXPLORATION

The most significant core samples are chosen from Kyushu, Tohoku and Hokkaido respectively, and explained with some comments as follows.

### 4.1 Kyushu



**Figure 7: A spot core sample from 3,000 m depth of DY-6, Sugawara in Hoho geothermal area, Kyushu.**

This is a spot core sample from 3,000 m depth of DY-6, Sugawara in Hoho geothermal area, Kyushu. The temperature of this depth reached 266°C. The drill hole was aimed to encounter the deep-seated reservoir along geologic fault inferred from gravity anomaly gap. The drilling result indicates the deep reservoir does not have enough fluids for electric power generation. On the otherhand, exploited Ohtake and Hacchobaru areas occurred on the upheaval zone of pre-Quaternary basement.

### 4.2 Tohoku



**Figure 8: A spot core sample from 2,842-2,844 m depth of WD-1a, the Kakkonda geothermal field in Sengan, Tohoku.**

Figure 8 illustrates a spot core sample from 2,842-2,844 m depth of WD-1a, the Kakkonda geothermal field in Sengan, Tohoku. The temperature of this depth is around 380°C that is assumed as the boundary between brittle and plastic deformation, and corresponds also to the boundary between heat convective and conductive zones. Above photo

indicates the irregular intrusive boundary between Quaternary Kakkonda granite (right side) and pre-Tertiary sedimentary rocks (left side). Kakkonda granite is regarded as the heat source of the present Kakkonda geothermal system.

### 4.3 Hokkaido



**Figure 9: A spot core sample around 600 m depth of TH-6, Toyoha geothermal area, Hokkaido.**

Figure 9 shows a spot core sample around 600 m depth of TH-6 in Toyoha geothermal area, Hokkaido. The discharge test of this hole provided steam of 1.4 t/h and hot water of 17.3 t/h. The vertical dyke shown in above figure might serve as a conduit for discharging fluids.

## 5. CONCLUSION

The image database for stored core samples is temporarily uploaded on the website: <http://riodb02.ibase.aist.go.jp/drillcore/>. The locations of surveyed areas for core samples are marked on the geothermal resources map in the scale of 1:1,000,000. Most surveyed areas are located around the volcanic front, and the areas farther behind the volcanic front have generally less potential with several exceptions. The exceptions are Okuaidu and Dozangawa-Karyu in Tohoku. The thermal features for surveyed areas are investigated based on maximum temperatures and their depths with reference to the temperature profile of Kakkonda deep hole, WD-1a. The comparison of thermal features among surveyed areas indicates that potential reservoirs are expected around 250 ~ 350°C at 500 ~ 2,500 m in depth. The representative thermal features are also shown as cross-sections of geologic and thermal structures for Hoho area in Kyushu and Sengan area in Tohoku. The important characteristic core samples chosen from Kyushu, Tohoku and Hokkaido and were explained briefly.

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