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GEOLOGICAL STRUCTURE AND SUBSURFACE TEMPERATURE DISTRIBUTION IN THE WASABIZAWA AREA, AKITA PREFECTURE, JAPAN

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ABSTRACT

The subsurface data obtained from more than 60 wells mainly drilled by New Energy Development and Industrial Technology Development Organization (NEDO) and Dowa Mining Co., Ltd. since 1974 indicates that the geology of the Oyasu-Doroyu hot spring area have four major structural features. The Kijiyama-and Kawarage-basins are characterized by very thick Miocene acidic pyroclastics and the Oyasudake-and Okumaemori-uplifts have very shallow Pre-Tertiary metamorphic and granitic basement rocks intruded by Tertiary intrusives. A very extensive exploration program (recently undertaken in the Wasabizawa area by NEDO under the new survey program "C" of the "Geothermal Development Promotion Survey") revealed that the area, which had been considered simply as part of the southeastern extension of the Okumaemori uplift, is separated into a horst-and-graben structure defined by NE- and NW-trending faults. Maps showing subsurface temperature contours at 100-m intervals ranging from +400 to –800 m (elevation) have been presented based on data including static temperature profiles obtained from new wells drilled during the recent exploration project. All maps show a similar pattern, with high temperature in the Uenotai and Wasabizawa areas, separated by a low-temperature trough extending along the Doroyu fault. In the Wasabizawa area, it is suggested that, at 500 m below sea level, all areas are within temperature contours of 220ºC or higher, and all maps show the contours are open to the SE, toward Yamabushidake and Takamatsudake mountains, indicating that the source of geothermal fluid and the heat source lie in that direction. Two separate high-temperature trends distinguished in the maps at elevations from +400 to –200 m (elevation) suggest that the flow pattern of geothermal fluid is strongly controlled by the NW-trending fault system.

1. INTRODUCTION

From 1993 to 1997, the New Energy and Industrial Development Organization (NEDO) carried out a new exploration program, "Survey C" of its Geothermal Development and Promotion Survey in the Wasabizawa project area located in Akita Prefecture, Japan (Fig. 1). The area had been considered to have a very promising geothermal potential as indicated by the regional survey previously conducted by NEDO, including the successful flow test of well N57-YO-3. The major objective of "Survey C" is to conduct a very extensive field investigation and an integrated evaluation of the area which is considered to have a promising high-temperature reservoir, in order to substantially reduce risks for private geothermal companies. The Wasabizawa project included the surface geothermal, geochemical and geophysical exploration, drilling nine new wells (Table 1), well testing, and an evaluation that includes numerical simulation of the reservoir. Dowa Mining Co., Ltd. was assigned to conduct the field work and the evaluation.

2. GEOLOGICAL STRUCTURE

2.1 Surface Geology

Figure 2 is the geological map of the Wasabizawa area and the Uenotai geothermal field. Table 2 shows the stratigraphic sequence of the area in more detail based on the surface geology and the subsurface geological data obtained from the wells. Robertson-Tait et al. (1990) discussed a regional geological structure of the area covering Wasabizawa, Uenotai and Oyasu districts.

Takamatsudake Volcanics, consisting of dacitic to andesitic lavas and pyroclastics, covers most of the Wasabizawa project area in the center of the map. Kabutoyama Formation covers most of the area north of the Doroyu fault, which controls southern margin of the Kijiyama basin (Minase basin by Robertson-Tait et al., 1990). Sanzugawa Formation, which underlies the Kabutoyama Formation consists of water-lain tuff and siltstone interbeds. It crops out in small areas north of the Doroyu fault in the figure. Minasegawa Formation (comprised of massive acidic tuff) crops out extensively in the area west of the Wasabizawa area and in the Kawarage area south of the Doroyu fault. Both the Sanzugawa and the Minasegawa Formations were penetrated by most of the wells drilled in the Uenotai area. Ohtoriyazawa Formation is seen only in a very limited area at the surface, located south of Shinyu hot spring. Doroyu Formation, the oldest Tertiary unit, is characterized by andesitic lavas and pyroclastics. It crops out in the area northwest of the Wasabizawa project area between the Doroyu and Wasabizawa faults and also in the area where Doroyu and Shinyu hot springs are located. Doroyu Formation also was encountered by most of the Uenotai wells. Pre-Tertiary granitic rocks crop out only in a small area north of Wasabizawa fault.

2.2 Geology in Wasabizawa Wells

Figure 3 is a stratigraphic correlation of the wells drilled in the Wasabizawa area and its vicinity. The depth of each deviated hole was corrected to vertical depth. Two wells, KU-2 and N57-YO-2, were drilled north of the Doroyu fault, and N57-YO-4 is south of the project area.

In the Wasabizawa area, Minasegawa Formation directly underlies Takamatsudake Volcanics, completely missing the Sanzugawa Formation. Ohtoriyazawa Formation was found in four Wasabizawa wells, and it is nearly one thousand meters thick in N5-WZ-1 and N7-WZ-5. Doroyu Formation is completely absent in the wells drilled in the southwestern half of the project area, where the top of Pre-Tertiary basement was found at very shallow depths above sea level. The Pre-Tertiary

basement is divided into two major lithologic units: metamorphic schist and granitic rocks. It has been found that the thickness of the schist unit increases significantly from N6-WZ-4 toward N8-WZ-9, and possibly to N5-WZ-2.

Flow tests were successfully conducted for seven Wasabizawa wells, including N57-YO-3. It was found that the major production zones are located in Pre-Tertiary basement rocks which also provide the major fractures in the Uenotai field.

2.3 Geological Structure

Figure 4 shows the geological structure based on the surface geology, interpretation of the geophysical data and the well geology. It is suggested that the geology in the area has four major structural features, mainly controlled by NE-SW and NW-SE trending fault systems. The Kijiyama and Kawarage basins are characterized by very thick Miocene acidic pyroclastics (Minasegawa and/or Ohtoriyazawa Formations) and the Oyasudake and Okumaemori uplifts have relatively shallow Pre-Tertiary basement. The southwestern half of the Wasabizawa area is still considered to be the southeastern extension of Okumaemori uplift, but Kawarage basin extends into western corner of the project area as suggested by the subsurface geology encountered by N5-WZ-1 and N7-WZ-5.

3. SUBSURFACE TEMPERATURE DISTRIBUTION

Maps showing subsurface temperature contours at 100 m intervals ranging from +400 to –800 m (elevation) were presented during the Wasabizawa project, and it is indicated that all areas at 500m below sea level are within temperature contours of 220ºC or higher. Figures 5 and 6 are maps showing the subsurface temperature distribution at sea level and –600 m (elevation), respectively. The temperature contours in both maps are open to the SE, toward Mt. Oyasu and Mt. Takamatsu, indicating the source of geothermal fluid and the heat source in that direction. The high-temperature zone which widely covers the Wasabizawa area is separated from the NW-SE trending temperature high in the Uenotai area north of the Doroyu fault by the low-temperature trough extending from Kawarage toward Shinyu hot springs. In Figure 5 (at sea level), two separated high-temperature trends are identified within the Wasabizawa project area, suggesting that the flow pattern of geothermal fluid in the area is strongly controlled by the NW trending fault system.

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REFERENCE

Robertson-Tait, A., Klein,C.W., McNitt,J.R., Naka,T., Takeuchi,R., Iwata,S., Saeki,Y. and Inoue,T. (1990). Heat source and fluid migration concepts at the Uenotai geothermal field, Akita Prefecture, Japan. Geothermal Resources Council TRANSACTIONS, Vol.14, Part II.

Table 1. Wells drilled in the Wasabizawa area

Well	Year drilled	Total depth, measured(m)	Others
N5-WZ-1	1993 ~1994	1501.5	Slim hole, Deviated Short term flow test
N5-WZ-2	1993 ~1994	1407.0	Slim hole, Deviated Short term flow test
N6-WZ-3	1994 ~1995	1505.0	Slim hole, Vertical
N6-WZ-4	1995	1556.0	Slim hole, Vertical
N7-WZ-5	1995	1501.7	Slim hole, Deviated Short term flow test
N7-WZ-6	1996	1345.0	Slim hole, Deviated Short term flow test
N7-WZ-7	1996	1701.5	8 1/2”hole, Deviated Long term flow test
N7-WZ-8	1996	1069.1	Slim hole, Deviated Reinjection well
N8-WZ-9	1996	1561.0	8 1/2”hole, Deviated Long term flow test
N57-YO-3	1982 ~1983	1200.0	Slim hole, Vertical Long term flow test

Table 2. Stratigraphic sequences of the Wasabizawa area

	FORMATION	LITHOLOGY
QUATERNARY	Takamatu dake volcanics	Dacitic to andesitic lava and pyroclastics
	Kabutoyama Formation	Dacitic welded tuff
TERTIARY	Sanzugawa Formation	Interbedded dacitic tuff and siltstone
	Minasegawa Formation	Dacitic pumice tuff and lappilli tuff
	Ohtoriyazawa Formation	Basaltic tuff,mudstone dacitic pyroclastics
	Doroyu Formation	Andesitic lava, pyroclastics, and mudstone
Pre-Tertiary Basement		Granitic rocks and schists

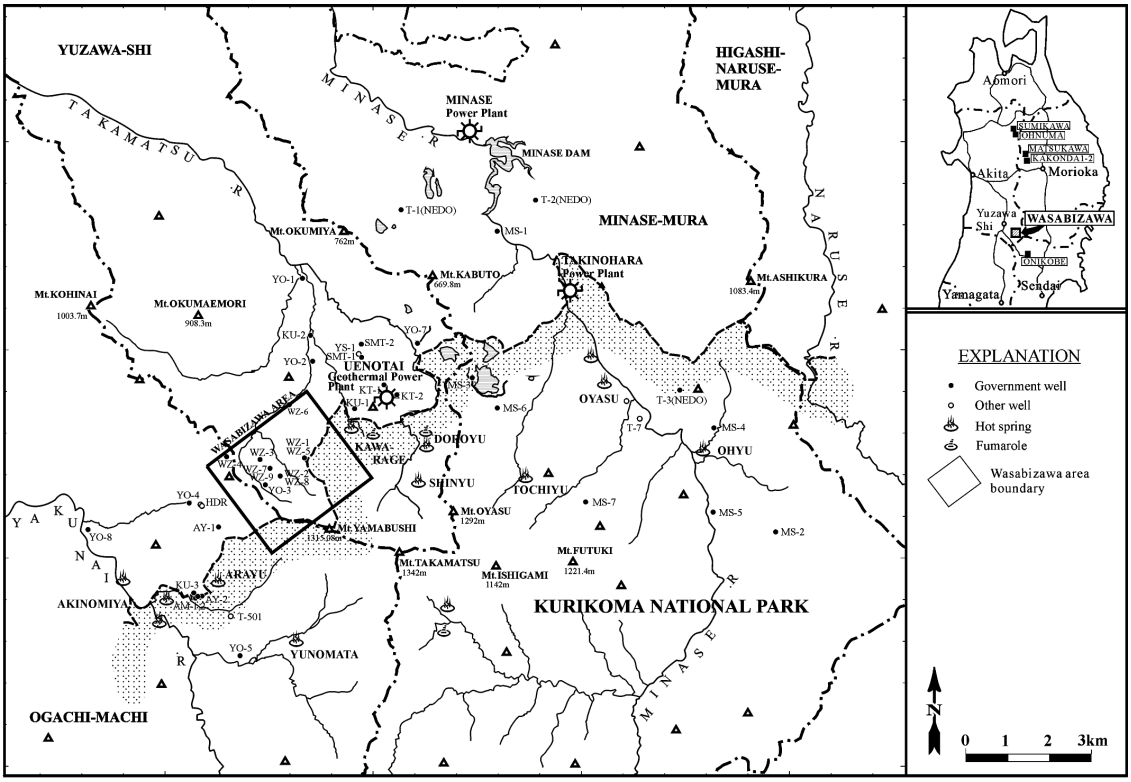

Figure 1. Map showing the Wasabizawa area and surroundings

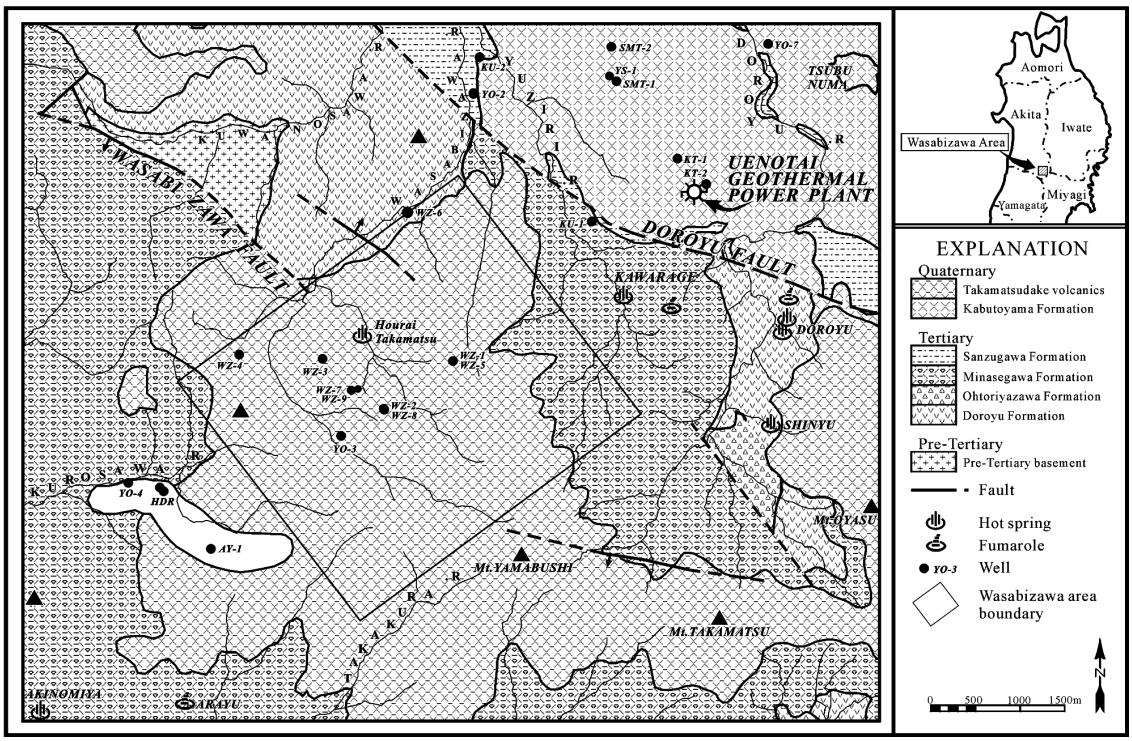

Figure 2. Geological Map of the Wasabizawa area and the Uenotai geothermal field

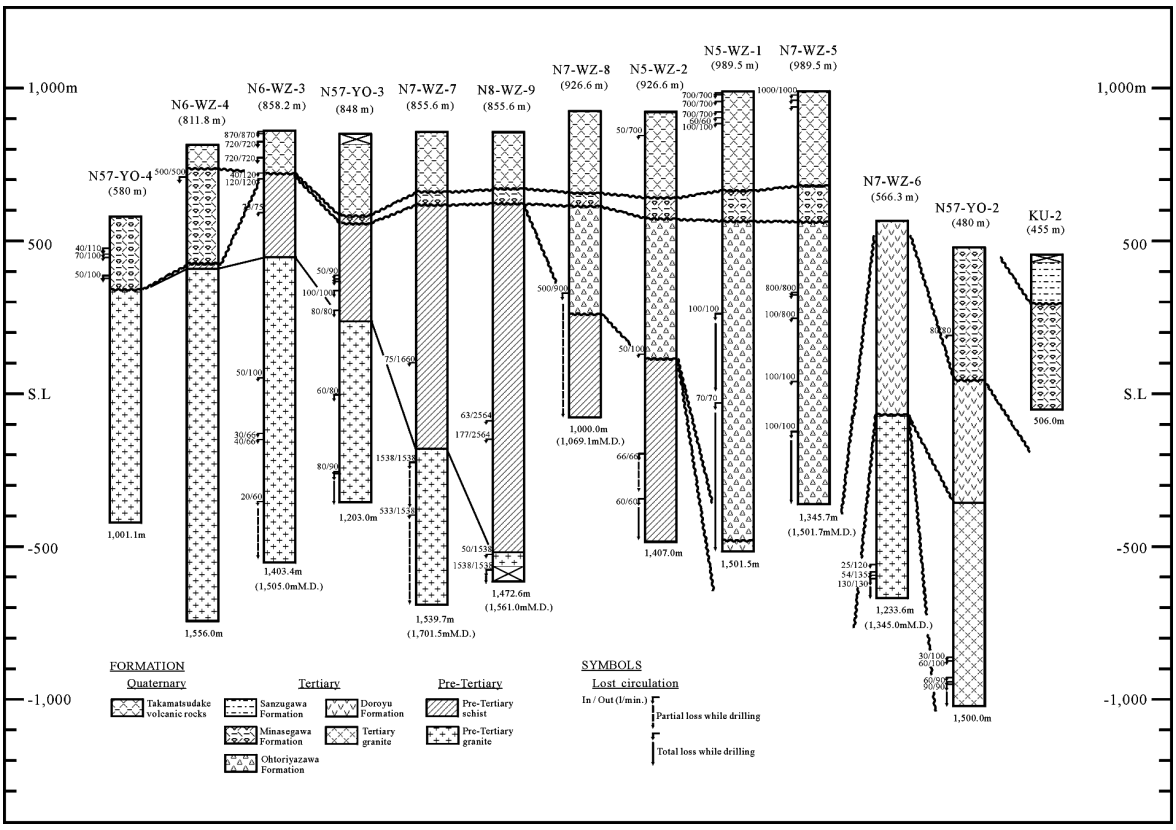

Figure 3. Stratigraphic correlation of wells drilled in the Wasabizawa and nearby areas

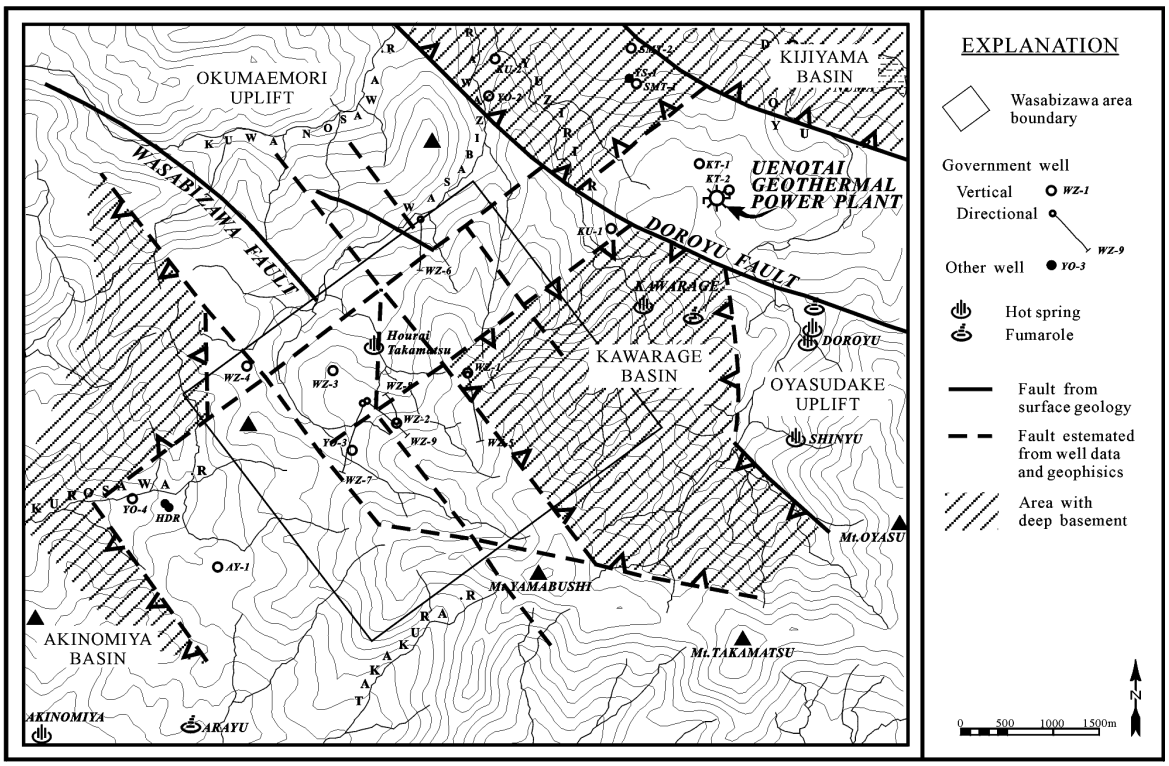

Figure 4. Structural map of the Wasabizawa area and the Uenotai geothermal filed

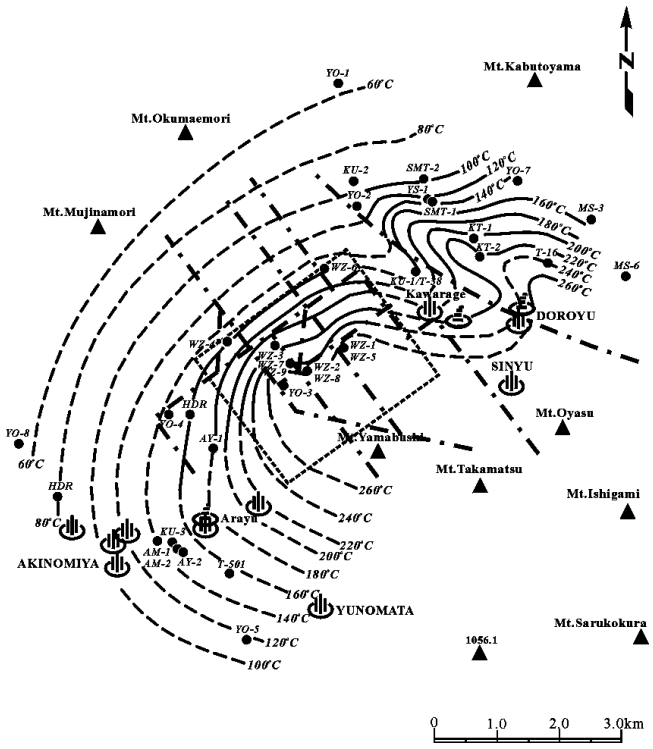

Figure 5. Subsurface temperature contours at sea level in the Wasabizawa area

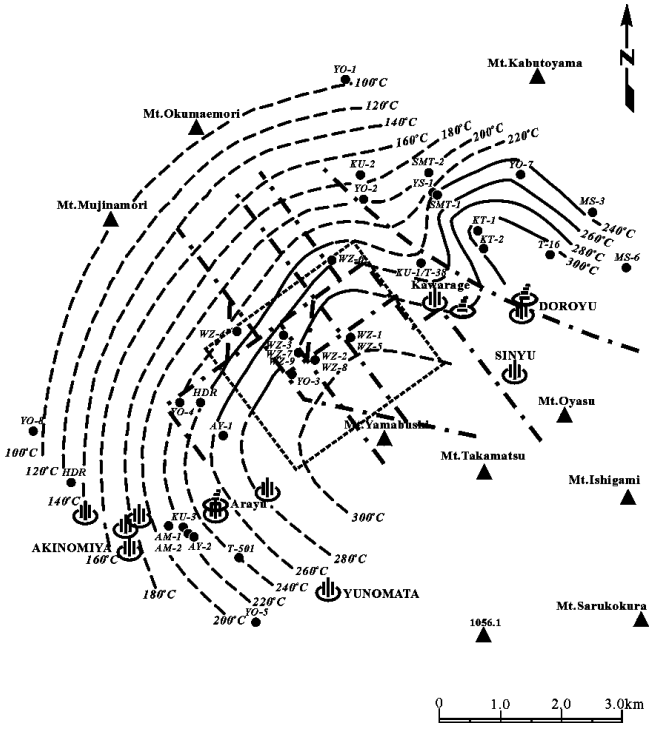

Figure 6. Subsurface temperature contours 600m below sea level