Geothermal Resources Council TRANSACTIONS, Vol. 17, October 1993

GEOTHERMAL RESOURCE ASSESSMENT FOR THE 15 MAJOR GEOTHERMAL FIELDS IN JAPAN BASED ON BORE HOLE TEMPERATURE LOGGING DATA

Shiro TAMANYU

Geological Survey of Japan

ABSTRACT

The target fields have been surveyed in detail with many drill holes, and subsurface isothermal contours have been constructed by the extrapolation of temperature logging data using the relaxation method. These fields are classified into shallow convective, shallow conductive, deep convective and deep conductive zones based on mapping of patterns of depth-temperature curve and gravity basement. The thermal energy of the shallow convective zone is the most promising resource at present, however, the thermal energy at the deep convective and conductive zones can be utilized indirectly as a heat source for the shallow convective system. The results indicate the resource in the Sengan field is by far the most extensive in Japan, and some exploited fields are underestimated by this assessment method.

INTRODUCTION

The geothermal resources are preliminary assessed as stored heat energy by a volumetric method using a subsurface temperature grid extrapolated from the bore hole temperature logging data. This assessment have been applied to 15 areas that have been extensively surveyed with many drill holes(Fig.1). These areas are roughly classified into caldera-related and non caldera-related areas. The former consists of Kurikoma, Dozangawa, Okiura, Western Teshikaga, Yuzawa-Ogachi, Oku-Aizu and Ikedako areas, and the latter consists of Sengan, Kurino-Tearai, Shimokita, Northern Azuma, Western Unzen, Minami-Kayabe, Toyoha and Hohi areas. These areas have been surveyed as Japanese national geothermal projects. In the Hohi area, the MITI project "Survey of large-scale deep geothermal development with regard to environmental conservation" was carried out(MITI, 1987). In the Sengan and Kurikoma areas, the Sunshine geothermal project "Confirmation study of the effectiveness of prospecting techniques for deep geothermal resources" was carried out(NEDO, 1989b). In the remaining 12 areas, the Agency of Natural Resources and Energy geothermal project "Geothermal development promotion survey project" has been carried out. NEDO has digitized these project data, with the exception of the Hohi area, for the purpose of correlation analysis among the many kinds of exploration data and geothermal structures as a part of the synthetic analysis of "Confirmation study of the effectiveness of prospecting techniques

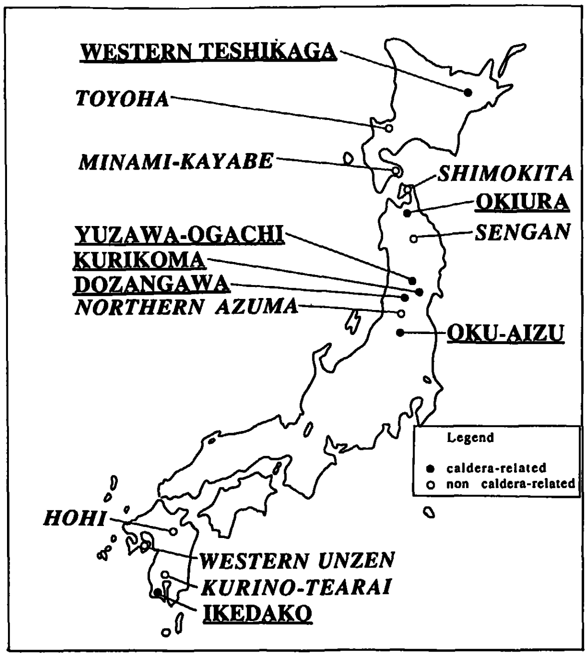


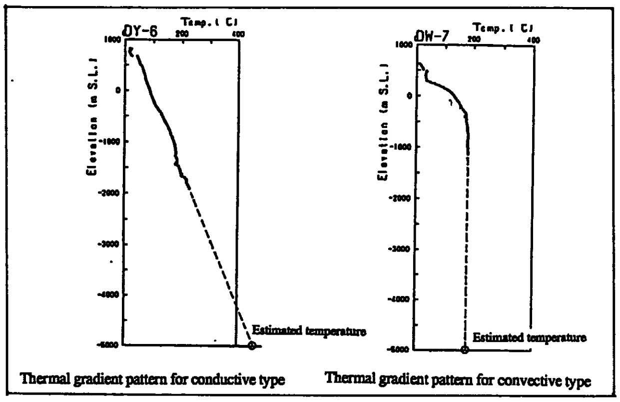
Fig. 1. Index map of studied areas.

for deep geothermal resources" (NEDO, 1988, 1989a). Suda and Yano(1991) digitized temperature logging data for the Hohi area with other many geothermal fields in Japan. The author used these digitized data for this resource assessment. The geothermal potentials for these areas except the Hohi area have been preliminary assessed by the comparison of the size of the high temperature area at -1 km and -2 km ASL(above sea level) extracted from subsurface isothermal contour maps for each surveyed field(Tamanyu,1992).

DATA PROCESSING

The flow chart of data processing is presented in Fig. 2. The subsurface equilibrium temperature, gridded at a 250 m interval was calculated by the relaxation method using the following three kinds of fixed initial grid data. The first is the grid data for surface temperature which are wholly assumed as 12°C. The second is the temperature at -5,000m ASL which is estimated from extrapolation of temperature-depth curve of drill hole based upon the assumption of either convective and conductive upflow(Fig.3). The third is the grid data close to drill hole which are assumed as the same as actual logging data.

The equilibrium temperature can be obtained by repeated calculation of relaxation. The most appropriate number of repetitions should be decided by good continuity between calculated grid data and actual logging data.



Thermal gradient pattern for conductive type Thermal gradient pattern for convective type

Fig. 2. Estimation of the temperature at -5.000m ASL by the exploration of thermal gradients.

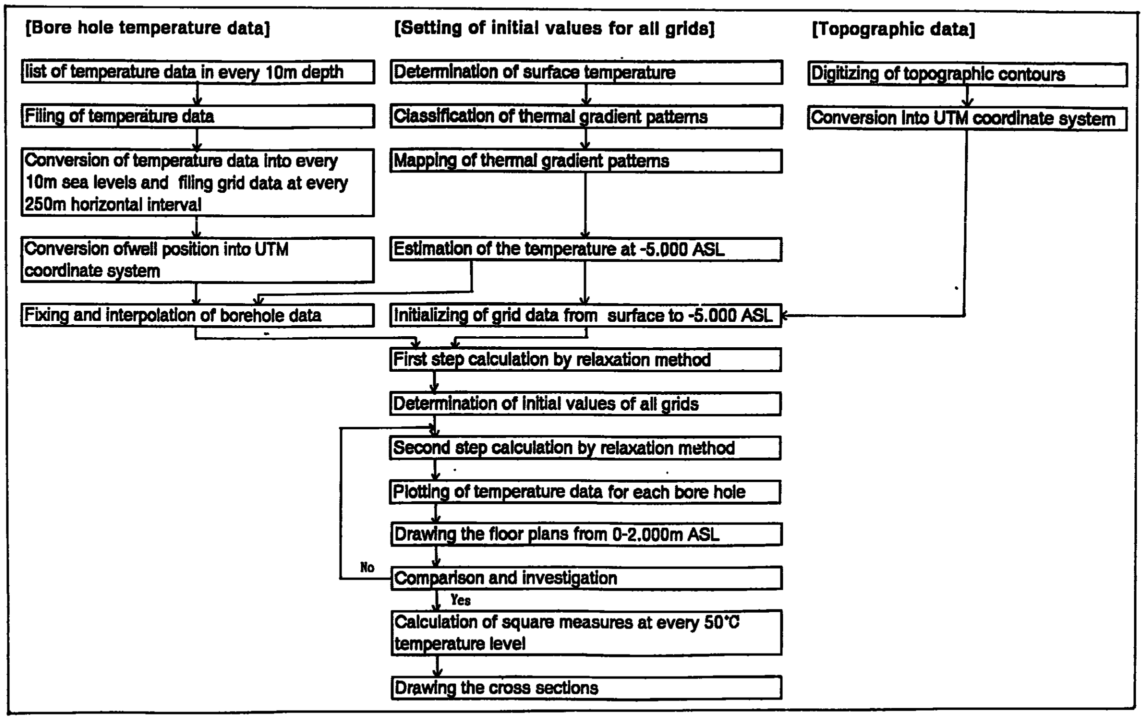


Fig. 3. Flow chart of data processing.

RESOURCE ASSESSMENT

The total thermal energy for each area can be calculated by the volumetric method as a summation of the four thermal energies from the shallow convective, deep convective, shallow conductive and deep convective zones where subsurface temperature is over 150°C. The distinction between conductive and convective zones are based on pattern recognition for depth-temperature curve. This classification is assumed to be applicable to not only shallow Cenozoic formations but also pre-Cenozoic basement. Recovery factors are assumed as 25% for convective zone, and 12.5% for conductive zone because porosity is generally lower in conductive zone than in convective zone. Both convective and conductive zones are further subclassified into shallow and deep parts respectively. The shallow part corresponds to the portion where temperature is over 150°C within Cenozoic formations. The deep part corresponds to the portion where temperature is over 150°C within pre-Cenozoic basement until -3 Km ASL. The geologic boundary between the Cenozoic and pre-Cenozoic formations can be estimated by gravity basement analysis. The estimated thermal energy for shallow convective part is the most promising resource at present(Fig. 4). However, the thermal energy for the deep convective and conductive zones can be treated as a kind of heat source for shallow convective zone. The result of resource assessment is shown in Table 1 and Fig. 5. According to these diagrams, the resource in the Sengan field is by far the most extensive in Japan. It must be interpreted that this high potentiality is derived from the special geothermal setting with many young Quaternary volcanoes and inferred young intrusive plutons in this area. Some exploited fields such as the Oku-Aizu, Yuzawa-Ogachi, Oku-Aizu and Hohi fields were underestimated because surveyed areas are restricted compared to actual exploited fields, and neglect of deep convection system within pre-Cenozoic basement.

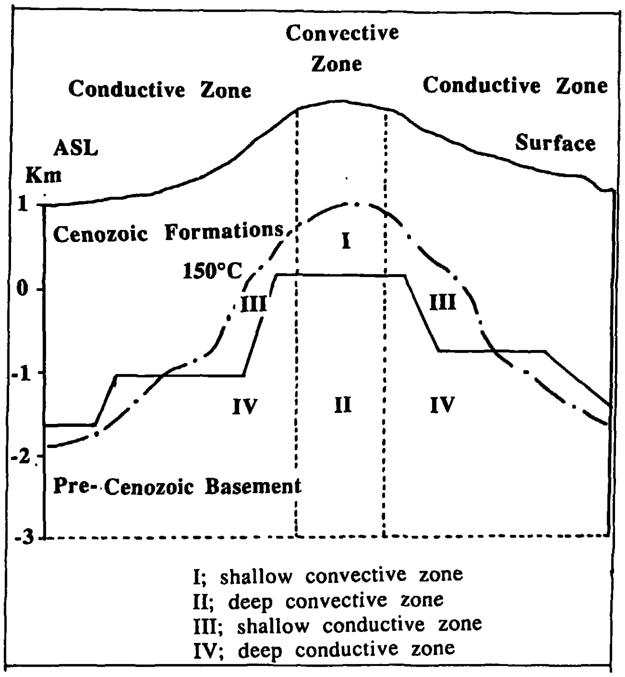


Fig. 4. Classification of shallow convective, deep convective, shallow conductive and deep conductive zones.

Table 1. Calculated thermal energies and their converted electric capacities for convected zones in studied areas.

	area	shallow conv.	shallow conv.	deep conv.	deep conv.
		10**17Joule	MWeX30y	10**17Joule	MWeX30y
Caldera-related	Ku	38.00	313.50	147.00	1212.75
	Do	0.00	0.00	32.00	264.00
	Ok	8.75	72.19	67.00	552.75
	Te	4.00	33.00	401.75	3314.44
	Yu	2.00	16.50	277.50	2289.38
	OA	16.50	136.13	20.50	169.13
	Ik	0.00	0.00	0.00	0.00
Non caldera-related	Se	144.00	1188.00	960.50	7924.13
	KT	51.00	420.75	247.30	2040.23
	Sh	32.25	266.06	16.75	138.19
	Az	0.00	0.00	16.25	134.06
	Un	1.00	8.25	64.50	532.13
	Ka	0.00	0.00	18.50	152.63
	To	6.00	49.50	159.25	1313.81
	Ho	18.75	154.69	231.50	1909.88

(Caldera-related type)
Ku; Kurikoma, Do; Dozangawa, Ok; Okiura, Te; Western Teshikaga, Yu; Yuzawa-Ogachi, OA; Oku-Aizu, Ik; Ikedako

(Non caldera-related type)
Se; Sengan, KT;Kurino-Tearai, Sh; Shimokita, Az; Northern Azuma, Un; Western Unzen, Ka; Minami-Kayabe, To; Toyoha, Ho; Hohi

CONCLUSION

1. There is essentially no difference in the estimated thermal energy between the caldera-related geothermal system and the non caldera-related geothermal system.
2. The estimation of the temperature at -5.000 m ASL have some uncertainties because extrapolation from thermal gradient of existing holes is limited to only shallow part. Therefore, the assumption of continuity of convection zone into pre-Cenezoic basement is not so certain.
3. The shallow convective thermal energy is the most promising geothermal resource, and the deep convective and conductive thermal energies can be treated as a kind of heat source of shallow convective zone.
4. The resource in the Sengan area is by far the most extensive because many young Quaternary volcanoes and young intrusive plutons exist in this area.
5. Some exploited fields were under estimated by this assessment.

ACKNOWLEDGEMENT

Y. Yano of Geological Survey of Japan prepared the temperature files in the Hohi area. NEDO offered the many kinds of digital data for all areas except the Hohi area. K. Nomura and M. Yoshizawa of Nikko Exploration & Development Co., LTD computed the subsurface temperature grid data by relaxation method. K. Youngman of Geological Survey of Japan read the draft critically. The author would like to express his sincere thanks to all of them for their help.

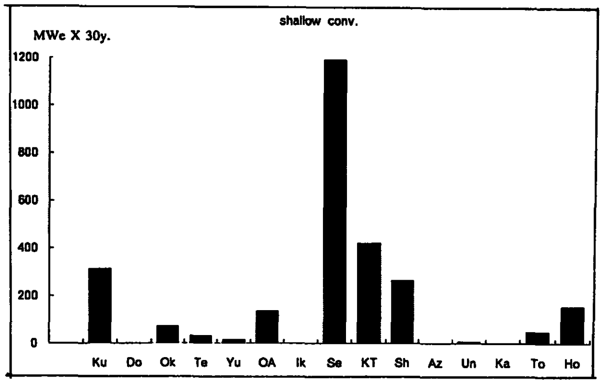


Fig. 5. Promising resources for studied areas. Abbreviation is same as Table 1.

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