REVISITING THE ANOMALOUSLY HIGH NATURAL HEAT DISCHARGE IN THE IZU PENINSULA, JAPAN

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ABSTRACT

There have been many interesting studies so far, geochemical and geophysical, on the nature of thermal discharge from the earth's deeper part, specifically referring to the Izu Peninsula, central part of Japan. The peninsula was formed by the collision of the Philippine Sea Plate to the thicker crust of the southwestern end of northeast Japan, therefore it is situated at a tectonically singular position. For example, Okubo et al. (1983) have compiled the data of underground temperatures measured in deep wells distributed over the whole area of Izu Peninsula, and they classified the area into three different types of geothermal regime: up-flow dominated, down-flow dominated, and thermal conduction dominated regimes. One remarkable fact is that the thermal conduction dominated area in the southernmost part of the peninsula, which contains the township of Minami-Izu, is characterized by very high heat flow value at about 120 - 150 mW/m^2 even though we can find no very young volcanic activity there. In view of other geoscience data obtained up to present time, a review is made of the observed heat discharge in the area, and some discussions are given on the possible mechanisms to explain its anomalous characteristics.

Keywords: heat discharge, conductive heat flow, hot springs, Izu Peninsula

1. INTRODUCTION

It has been well known to Japanese people since early time that there are many high temperature hot springs in the Izu Peninsula, central Japan. Occurrence of hot springs with generally high temperature of discharge, combined with the fact that Izu Peninsula is geographically located at a fairly short distance to Tokyo and other cities in Kanto plain, is making the area one of most popular resort areas having our traditional spas (we call them "onsen" in Japanese). We find here an interesting subject for geoscientific study, because we believe there should be some special mechanisms responsible for the occurrence of the natural phenomena, i.e., high temperature hot springs found in areas lacking in very young volcanic heat.

2. GEOPHYSICAL AND TECTONIC SETTING

First, looking at regional geophysical data covering the Izu Peninsula, in particular its gravity and magnetic maps, it is clear that this area belongs to the northernmost tip of the N-S trending volcanic belt sitting on the Philippine Sea Plate (abbreviated as "PSP" hereafter), instead of a part of the crustal block of northeast Japan (NEJ). Geological studies have confirmed the origin of all the territory forming the present day Izu Peninsula to be a long chain of subsea volcanic islands on top of the PSP which have come from the tropical zone in the south. The first collision of the volcanic islands onto NEJ may have been at about 0.6 Ma, and we can see pieces of evidence for gradual crustal uplifting in most of the peninsula area until present time (Koyama, 2010) and such kind of movement might have caused the subsurface isotherms pulled up to shallower levels than in the normal crust, generally speaking. Geochemical studies provided strong supporting evidence that a large part of the waters from those hot springs in Izu Peninsula have components which are derived from chemical interactions with rocks under very high temperature conditions. All those information can be incorporated to discuss about the thermal characteristics of the earth's crust in the area where we are interested from the practical point of view.

3. PREVIOUS WORKS ON HEAT DISCHARGE ESTIMATION

In a study by Yuhara (1973) so-called "heat flow value with consideration of convective heat due to hot springs" was estimated to be more than 100 m W/m^2 over the whole are of the Izu Peninsula. This estimation is also in line with the calculated results of areal total heat discharge by hot springs with their maximum surface temperature as high as 100 deg C, reported by other researchers (Oki and Hirano, 1972). Such results may be indicating a good correlation between conductive heat flow from deeper part of the earth and the amount of heat carried by the discharging hot water to the surface. Later than that, Okubo et al. (1983) have presented the data of temperatures measured at 238 deep boreholes in the Izu Peninsula, and have shown that there are three types of temperature vs. depth curve: One type is that representing upward flow of warm water, another is that representing downward flow of water, and third is that representing thermal conduction dominated heat transfer to the ground surface, without so much simple relationship with the geological age and/or type of rocks in respective areas. For the thermal conduction dominated area in the southwestern part of the peninsula, high heat flow value of about 120 - 150 mW/m^2 is estimated based on their temperature data (Fig.1) by giving an assumed value of thermal conductivity, even though we can not find any young volcanic activity there. Therefore, it is inferred that very high conductive heat flow all over the Peninsula is playing the critical role for the presence of many hot springs in the area.

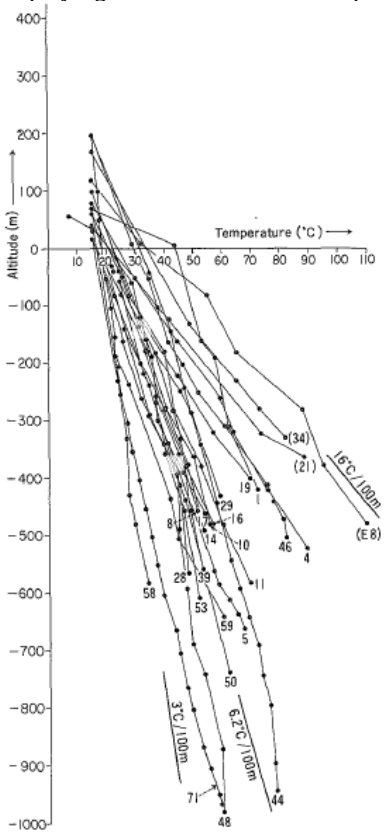

Fig.1 Temperature vs. depth curves of deep boreholes which show nearly linear increase of temperature with depth measured in the Izu Peninsula (reproduced from Okubo et al., 1983).

4. CONCLUDING REMARKS

The author would like to point out in this paper that certain hot springs having temperature values high enough for future utilization as a source of electric power could naturally occur due to very high conductive heat flow in the earth's crust, as observed in the Izu Peninsula. Also, geological history of the Izu Peninsula appears to be very unique, because collision of the oceanic plate to another plate has taken place there, and since that time the peninsula has been put in a very singular tectonic position which influences the geothermal characteristics as mentioned above.

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