

Interpretation of Gravity Data to Delineate the Geothermal Reservoir Extent and Assess the Geothermal Resource in the Municipality of Isa, Southern Kyushu, Japan

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The municipality of Isa is located in the southern part of Kyushu Island, and it is considered one of the wealthiest places in Japan because one of the most important gold mines is found in this area, Hishikari mine. Additionally, there are many hydrothermal manifestations, e.g., Hishikari, Yunoo, Kawanami, and Kintaro hot springs, which can be exploited by the community as an electric power source. Until now, the geothermal resource has not been used for power generation purpose although Geological Survey of Japan had carried out some preliminary geothermal assessments, which show that the power potential density is between 10 and 20 kW/km². To calibrate the previous value, first, this study attempts to analyze and interpret the gravity data for delineating the geothermal reservoir boundary and the assessment of geothermal resource. Accordingly, the corresponding researchers conducted 2-D and 3-D gravity modeling in the current research. This modeling is an essential stage of the complete gravity analysis in the region, because the filtering gravity methods, i.e., Horizontal-Derivative and Tilt-Derivative, can quickly detect steep gradients and indicate the location of faults or geological boundaries, however, they cannot estimate geological structure depth and shape. For this purpose, an area of 10 x 10 km was selected and analyzed considering a Bouguer Density of 2.45 g/cm³. The Bouguer Anomaly result shows a high value at the center, which extends 5.61 km² wide and could represent the probable geothermal resource. According to the Kagoshima geological map, volcanic and sedimentary rocks are the dominant type of rocks in this area. Cretaceous Shimanto group controls the fundamental structure of the deepest element. This arrangement is typically composed of sandstone, shale, acidic tuff with subordinate conglomerates, and their alterations, also Pliocene volcanic rocks and alluvial deposits. Similarly, Kakuto and Okuchi Basin, which are located at east and west respectively, control the region. The 2-D gravity modeling was carried out requiring a density contrast between the two assumed layers, i.e., the basement and the low-density deposit, and thus a value of 0.4 g/cm³ was assigned. Likewise, the horizontal size of the cells was set at 100 m. The profile trending NW- SE shows a significant depression 400 m to 700 m deep located next to Hishikari hot spring. In this way, the hydrothermal fluids might be flowing up to the surface forming altered rocks and hot springs by using a possible geological fault. For a better understanding of the region, the authors also carried out 3-D gravity modeling. The result shows an area which has density values below 2.4 g/cm³ and the zone NE-SW direction that starts at the Uonogoe area and ends at the Yamada area. Besides, a large anomaly located in the central area that has density values above 2.5 g/cm³ is evident. This anomaly represents the hydrothermal alteration zone that hosts the propylitic altered rocks having precious minerals such as gold and silver. Between these evidenced zones, we could infer the location of the geothermal reserve which has an area of 4.06 km². Integrating past research reports carried out by NEDO, using the Volumetric method with the calculated geothermal reserve area, and a Monte Carlo simulation, we estimated a geothermal power potential of 90 kW (22.5 kW/km²) for 20 years. Nevertheless, this result needs to be corrected by further geoscientific investigations including inversion modelings.

Keywords: Isa region, gravity data, propylitic alteration, hot springs, gravity modeling, geothermal power assessment

