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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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論 文 名　：　Interpretation of Gravity Data to Delineate the Geothermal Reservoir Extent and Assess the Geothermal Resource in the Municipality of Isa, Southern Kyushu, Japan
（南九州伊佐地域における地熱貯留層の広がりと地熱資源の評価に資する重力データの解釈）

区　　分　：　甲

論 文 内 容 の 要 旨

The municipality of Isa is located in the southern part of Kyushu Island, and it is considered to be one of the wealthiest places in Japan because one of the most important gold mines, the Hishikari mine, is operated in this area. Additionally, there are many hydrothermal manifestations, e.g., Hishikari, Yunoo, Kawanami, and Kintaro hot springs, which can be exploited by the community for 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 the power potential density between 10 and 20 kW/km^2. To calibrate the previous value, this study attempts to analyze and interpret the gravity data for delineating the geothermal reservoir boundary and the assessment of geothermal resource.

This dissertation consists of 6 chapters as follows:

Chapter 1: This chapter describes the general background of the study as well as the global information about the geothermal status in Japan and also documented studies that were conducted by preceding researchers. The history and current state of geothermal development in Japan, with a particular focus on low enthalpy fluid, i.e., hot springs, are given. Likewise, a description of the purpose, the plan and the structure of the thesis are also made.

Chapter 2: This chapter presents a Python-based stochastic library for assessing geothermal power potential. The specific aims of this chapter are to use the volumetric method to estimate electrical energy production ability from a geothermal liquid-dominated reservoir, and to build a Python-based stochastic library with useful methods for running such simulations.

Chapter 3: This chapter focuses into detail on the various characteristics that define the Isa geothermal area. The chapter starts with a detailed review of the geology and structural setting of the area from both local and regional viewpoints. According to the Kagoshima geological map, volcanic and sedimentary rocks are the dominant type of rocks in this area. Cretaceous Shimanto Supergroup controls the fundamental structure of the deepest element. The arrangement of this area 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. Then a description of the methodology used in the study of lineaments from Landsat images is presented. The description includes the extraction of lineaments from the satellite image, their analysis, and interpretation, and presentation of the results using rose diagrams. The diagram shows azimuth direction of the local distribution of lineaments trending ENE-WSW. The angular tendency corresponds pretty well to

that of the faults, the general alignment from lineaments matched with the regional trend of Kagoshima Graben. The last section reviews the previous studies carried out by NEDO such as well loggings and conceptual model of the eastern part of the municipality of Isa, Kagoshima.

Chapter 4: This chapter describes the gravity study. Accordingly, the 2-D and 3-D gravity modeling were conducted 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 10×10 km was selected and analyzed considering a Bouguer Density of 2.458 g/cm^3. The Bouguer Anomaly result shows a high gravity value at the center, which extends 5.61 km^2 horizontally and could represent the inferred geothermal resource. In addition, integrating the previous research result, the inferred geothermal resource might be 24.5 km^2. 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/cm^3 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 possible geological faults. For a better understanding of the region, the 3-D gravity modeling was also carried out. The result shows an area which has density values below 2.4 g/cm^3 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/cm^3 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, the location of the probable geothermal reserve which has an area of 4.006 km^2 could be inferred.

Chapter 5: This chapter brings together the results from previous chapters and assessment of the geothermal power potential in the eastern part of Isa, Kagoshima which is one of the main aims of this dissertation. Two scenarios are simulated: inferred and probable geothermal resource. Integrating past research reports carried out by NEDO, using the volumetric method with the calculated geothermal reserve area, and the Monte Carlo method, which is coded on Python, a possible inference that the output that is greater than or equal to 4.27 MWe and 121.9 kWe is 90 % for the inferred and probable geothermal resource respectively was estimated. After that, the preliminary power potential assessment density was 174.1 kWe/km^2 and 30.4 kWe/km^2 for the inferred and probable geothermal resource respectively for 20 years.

Chapter 6: This chapter presents the conclusions of the study, and this includes a summary of the conclusions made in preceding chapters.