An application of the heli-borne survey data to geothermal resource study

*Toshiyuki Tosha[1], Akihiko Chiba[2], Yoshiharu Kida[3], Gen Nakamoto[4]

1. Kumamoto University, 2. Sumiko Resources Exploration & Development Co. Ltd., 3. Japan Oil, Gas and Metals National Corporation, 4. Fugro Japan Co., Ltd.

Geothermal energy, which is abundant in Japan and , is one of environmentally harmonized resources with less CO_2 emissions. Electricity generated by geothermal resources can be supplied in a constant output for a long period and is not influenced by weather conditions. Geothermal resource can also be directly used as heat directly (e.g. Cultivating vegetables). After the 2011 Great East Japan Earthquake the demand actions for the development have been increasing to expect a base power supply instead of the nuclear power generation. To answer the request, the The survey is also required in a virgin wide area including natural parks where the deregulations are being conducted. The survey in the at a virgin field starts to conduct a wide area exploration in geological and geophysical methods. Gravity exploration has often been used to obtain the rough geological structure, but recently investigation of for a finer geological structure is planned by current geophysical measuring techniqueshe deviation of the gravity. In particular, the measurement of the gravity gradient in the air is suitable for the wide area exploration of mineral resources in vast exploration areas such as Australia because an air plane and a helicopter can explore a wide area with uniform research density.
Since FY2012 JOGMEC (Japan Oil, Gas and Metals National Corporation) has conducted the geothermal resource potential survey by gravity and electromagnetic measurements using the helicoptermethods in 12 areas. Last year in 2017, gravity gradient data were acquired around Mt. Waita located at Oguni, Kumamoto Prefecture, and at Kokonoe, Oita Prefecture in Kyushu. The data acquisition method used by JOGMEC is not a the Full Tensor Measurement method that can acquire all components of the gravity gradient tensor but a method of acquiring two independent components (the Partial Tensor Measurement method). Other shortfall components of the tensor are estimated using a model. Therefore, there is a possibility that tTherefore, the result may be changed depending on the model. In addition, the distance between the two survey lines is fundamentally the same as that of between helicopter tracks (about 250 m), but the measurement interval along a survey line depends on the sampling frequency (about 5 m in the current specification), resulting in that measurement interval is significantly different between directions along and perpendicular to the flight lines. Because of the avoidance of the model dependency and the heterogeneity of the spatial data density Wwe applied the variogram analysis only to the raw data along the survey (flight) lines in the Partial Tensor Measurement method.
Variogram is a statistical method that characterizes the spatial continuity or roughness of a data set and was developed as a method for estimating quality at a gold mine. If there are two data sets, even if their means and deviations are similar by the one-dimensional analysis and are determined that they are almost identical, the continuity of the space is quite possible to recognise. The variogram γ(h)is obtained by adding the square of the difference between observed values (Zi and Zj) at two points to all pairs (N(h)) where the distance between two points is less than a certain value (h) and divided by a factor of two as described in the equation (1). In addition, by approximating the number N(h) of pairs is sufficiently larger than h, we can get a relationship that the variogram takes zero or a minimum value where the similar event repeats at the distance (h) as shown in the equation (2). Faults often have the flower structures where parallel faults are exposed at the surface and they might converge to a single fault in deeper layer. We can estimate the faults by the analysis of the variogram where the faults are repeated to appear in the flower structure. We have also interpreted the data around Mt. Waita using the variogram analysis and the SI

index which is one of the spatial filters. Judging from the analysed data a new fluid flow model could be proposed. This research was carried out as a joint work between Kumamoto University and Sumiko Resources Exploration & Development Co. Ltd.

Keywords: gravity gradient, geothermal exploration, Oguni Kokonoe, variogram, fault, flower structure

$$\gamma(h) = \frac{1}{2|N(h)|} \sum_{N(h)} (Zi - Zj)^2 \quad (1)$$

$$\gamma(h) = V - C(h) = V\{1 - r(h)\} \quad (2)$$

Example of flower structure

