T032-P001 Time: May 26 17:15-18:45

Applying hypocenter open-data and GIS to modeling and assessment of geothermal resources: A case study for the Oita area, Japan

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For the purpose of contributing to long-term progressive optimization of development and utilization of geothermal resources being rich in Japan, we have been conducting construction of assessment support system and case studies with the title of 'Study of Geothermal Resources Assessment using GIS' (Shigeno and Sakaguchi, 2002).

In the present study, electronic hypocenter data (1998-2000) that have been greatly improved for precision and detection limit, and openly supplied by Japan Meteorological Agency (2002) have been used. Processed hypocenter data have been overlaid on data sheets of active volcanoes, hot-spring and fumarole areas, active faults, and gravity anomalies among other published data for the 'Oita' area (1:200,000 quadrangle map by Geographical Survey Institute), using a simplified GIS. Applicability of the hypocenter data to regional modeling of geothermal systems and estimation of deep thermal structure has been examined (Shigeno, 2003). Study results have been summarized as follows:

(1) Hypocenters in the crust have been grouped along their accumulated frequency distribution curve to shallow (0-7.5 km, 765 cases), intermediate (7.5-15 km, 2011 cases) and deep (15-30 km, 57 cases) levels. They have tended to form swarms in time and space.

(2) The above hypocenters have been concentrated around three large active volcanoes in a large graben extending between the Beppu and Aso areas. Associations of the shallow and deep hypocenters with the intermediate ones have been characteristics of these areas. At Yufu-Tsurumi Volcanoes, a region of earthquake quiescence (ca. 10 km wide and deeper than 10 km depth) has been observed under the central part, associating with concentrated hypocenter regions (CHRs) at its shallow depth, and east and west sides. A distribution model of magma chambers or high-temperature (H-T) igneous bodies at the central depth, and stress-strain-rupture regions and/or reservoirs and passages of hydrothermal fluids at the surrounding regions has been delineated based on the above. Both at Kujyu and Aso Volcanoes where earthquakes have been less frequent, regions of earthquake quiescence at the central parts, and CHRs partly or semi-circularly at surrounding areas have also existed suggesting distributions of magma chambers or H-T igneous bodies.

(3) Distributional relationships between the hypocenters and hydrothermal systems have seemed to be more complicated and diverse. Concerning volcanic H-T fumarole areas, Tsurumi and Kujyu-Iwoyama have corresponded to CHRs, but Aso-Nakadake (more openly active) has not. Among H-T hot-spring and fumarole areas, Beppu-Yufuinn, and Sujiyu (NW to Kujyu Volcano) have been CHRs, but many other areas have not. Possible causes for these have been estimated to be differences of size and characteristics of the hydrothermal systems, additional effects of magmatic and volcanic activities, overlapped effects of regional stress-strain-rupture field, temporal changes of the above, and insufficient detection limit of earthquake observation among others.

(4) Long NW-SE alignments of hypocenters corresponding to slope distributions of gravity anomaly have been observed. These could be important in the relations to regional crustal and geothermal reservoir structures. Most of the active normal faults that are of E-W trend and abundant in the graben have not corresponded to CHRs. However, hypocenters of M-6 class earthquakes and swarms have been observed near some of the faults in past records. Regional stress-strain-rupture field functioning with longer cycles has been estimated to control the activity of the faults distributed in 'non-active-volcano-and-non-H-T-hydrothermal areas (lacked in local mass and energy supplies)' in the field.