Paper Number: 3931

Detection of fractures acting as hydrothermal fluid path by lineament analysis and radon gas measurement

Koike, K.[1], Kubo, K.[1], Kashiwaya, K.[1], Tada, Y.[1], Sakurai, S.[2], Iskandar, I.[3], Saepuloh, A.[4], Heriawan, M.N.[3], Notosiswoyo, S.[3] and Masoud, A.A.[5]

[1]Graduate School of Engineering, Kyoto University, Kyoto, Japan; koike.katsuaki.5x@kyoto-u.ac.jp
[2]Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, Kyoto, Japan
[3]Faculty of Mining and Petroleum Engineering, Bandung Institute of Technology, Bandung, Indonesia
[4]Faculty of Faculty of Earth Sciences and Technology , Bandung Institute of Technology, Bandung, Indonesia
[5]Faculty of Science, Tanta University, Tanta, Egypt

Development of facture system is the most fundamental geological element for forming a geothermal reservoir in volcanic areas, because some fractures are highly permeable and act as paths of hydrothermal fluids that are originally heated groundwater by hot rocks. Fractures are different in origin, size, and permeability. Therefore, detection of fluid path fractures from many fractures is uppermost important for estimating reservoir distribution and identifying a suitable location of geothermal power plant. Drilling investigation is indispensable to this detection at a first stage of geothermal resource exploration, but drilling cost is the highest and many drillholes are necessary in case of complicated geologic structures. Accurate detection by remotely-sensed and ground-based methods can reduce number of drillholes and consequently, the initial exploration cost.

Based on the above background, this study aims to develop a method to detect the fluid path fractures by lineament analysis and soil-gas chemistry. Multi-shading of digital elevation model [1] and the segment tracing algorithm [2] and its improvement were used for lineament extraction. By grouping of the lineaments based on similarity of direction and distance between neighbourhoods, pseudo-fracture planes were constructed with estimation of their strikes and dips, lengths, and distribution pattern as Koike et al. [3]. After that, radon concentrations in soil gasses were measured at sites on continuous pseudo-fracture planes using an instrument RAD7 (Durridge). Gasses were pumped up from boreholes of 0.5 to 1 m depth. Concentrations of two radon isotopes, Rn-222 and Rn-220, were measured repeatedly at a site by setting the unit period as five minutes. The half-life of Rn-222 (3.58 d) is 6000 times longer than that of Rn-220 (53.4 s). Usefulness of radon was demonstrated as a tracer of temperature and pressure changes in geothermal reservoir [4].

Two geothermal areas, Appi in northern Japan and Wayang Windu in western Java, Indonesia, were selected for testing the lineament and radon combination. As the result, three characteristics were clarified as essential to detection of fluid path fractures: high concentration of long half-life Rn-222, large concentration ratio of Rn-222 to Rn-220, and small decrease in Rn-222 concentrations with the elapse time, which signifies large volume and high ascent velocity of radon carrier gases originated from the degassing of hydrothermal fluids. The estimated fluid path fractures were verified by a conceptual geological model constructed from the drillhole data in each geothermal area.

References:

[1] Masoud A and Koike K (2011) ISPRS Journal of Photogrammetry and Remote Sensing 66(6): 818-832
[2] Koike K et al. (1995) Computers & Geosciences 21(9): 1091-1104
[3] Koike K et al. (1998) Computers & Geosciences 24(6): 573-583
[4] Koike K et al. (2014) Journal of Volcanology and Geothermal Research 275: 85-102