Hydrogen isotopic distribution of fluid inclusions in the Kakkonda geothermal reservoir, northeast Japan

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The Kakkonda liquid-dominated geothermal field is located in the south part of Towada-Hachimantai national park and the Sengan geothermal area, in which Kakkonda geothermal power plant (unit 1: 50 MWe; unit 2: 30 MWe) is operating. The most striking characteristic of the field is that a very young (ca. 1 Ma) pluton (Kakkonda granite: Kato and Doi, 1993; Kanisawa et al., 1994) is the heat source. NEDO drilled a deep survey well WD-1a (3,729 m depth) and the thermal structure was studied (Ikeuchi et al., 1998; Komatsu et al., 1998). The thermal structure indicated that the reservoir was divided into three part, (1) shallow reservoir (0 to 1,400m depth), (2) deep reservoir (1,400 to 3,100 m depth) and (3) heat conduction zone (more than3,100 m depth). It is suggested that meteoric water infiltrates down to 3,100 m depth, since the bulk of the geothermal fluid is of meteoric origin.

Although WD-1a did not produce geothermal fluid, water samples were collected from near the well bottom and their chemical and isotopic compositions were measured (Kasai et al., 1998). The sample had extremely high salinity (ca. 40 wt% of total chloride salts) and the hydrogen isotopic ratio enriched in deuterium (delD -33 permil) relative to stream waters and well discharges in the field. These waters seems to be magmatic fluid and kept in the heat conduction zone.

The depth of the reservoir is the important key for evaluation of the geothermal resources. We studied hydrogen isotopic distribution of fluid inclusions in the reservoir, since it was expected that the origin and the distribution of the geothermal fluid offered new information about the depth of the reservoir.

We collected quartz grains containing fluid inclusions from various altitude (630 to -3,016 m asl for WD-1a) and rocks (tuff, tuff breccia, shale and Kakkonda granite) of WD-1a and other deep wells. We employed sieving, heavy liquid separation, magnetic separation, acid treatment and hand picking in order to separate pure quartz grains. Fluids were extracted from the fluid inclusions with a decrepitation. Hydrogen isotopic ratios were measured through the ordinary uranium-reduction method.

The extracted fluids were divided into three groups based on their hydrogen isotopic ratios and the altitude (rock) of samples. Group A: delD -99 to -46 permil, 630 to -2,145 m asl (shallow and deep reservoir: tuff, tuff breccia, shale). The delD values are similar to those of well discharges and stream waters or lower by 10 to 20 permil. Group A seems to represent the geothermal fluid which is of meteoric origin. Group B: delD -110 to -95 permil, -2,520 to -2,739 m asl (heat conduction zone: Kakkonda granite). The correlation of the depth and delD suggests that the origin of group B is meteoric. The depth of group B indicates that meteoric water infiltration is proceeding at the top of the heat conduction zone. Group C: delD -61 to +16 permil, -2,230 to -3,016 m asl (heat conduction zone: Kakkonda granite). The delD values are higher than those of the well discharges and stream waters, and similar to those of the high temperature volcanic gas (Giggenbach, 1992; Kusakabe and Matsubaya, 1986) and WD-1a fluid, which indicates that the origin of group C is magmatic.