Study of Fracture Analysis Based on Topographic Interpretation and Borehole Imaging in Otake Geothermal Field, Japan

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The Otake geothermal power plant has been operating since 1967 with an output capacity of 12.5 MW. It is the first hydrothermal single-flash geothermal power plant generation in Japan, situated at the Kokonoe, Oita Prefecture, 2 kilometers away from 110 MW Hatchobaru Power Plant. In 2018, renovation work of power plant has been started and successfully completed in 2020 with current output capacity to be 14.5 MW.
From Otake to Hatchobaru area, NW-SE faults are predominant, which are interpreted as strike-slip faults formed by the E-W compression field (Hayashi, et al., 1985). These NW-SE striking faults are assumed to be a major geologic structure controlling geothermal fluid flow in Otake field. However, Inuyama, et al. (2002) reported that other types of geologic structures are also considered to be associated to fluid flow. We have conducted tectonic geomorphic and geologic studies in the Otake geothermal field to reveal permeable geologic structures related with fluid flow in the Otake field. We first mapped fault traces by performing topographic interpretation using stereoscopic images prepared from 5 m DEM and aerial photographs. We then conducted field geologic observations along faults. In addition, we have analyzed fracture characteristics using BHTV logging data obtained from geothermal wells in Otake field. Temperature, pressure, and spinner (PTS logging) data measured in boreholes were also utilized to correlate fractures and permeable zones in the wells.
The faults at surface in the field are dominated by E-W striking. Tectonic geomorphic features such as fault scarp, alignment of saddles is observed along the fault trace. The down-to the south scarp is observed at the northern slope of the Okuenotsuji.
Fracture image logging was carried out to identify the subsurface fractures in the geothermal wells (named as ORS-8 and ORS-9) drilled in Otake field by Kyushu Electric Power Co., Inc. The wells are located in the same pad with drilling direction toward north and northwest. The lithology in the logging interval is volcanic rocks in Plistocene. In ORS-8 well, all of interpreted fractures is dominantly striking E-W (Mean direction N98.3^{o}E) with dip direction to the south range 80-90^{o} dipping angle. Meanwhile, in ORS-9 well, all of interpreted fractures is dominantly striking WSW-ENE (Mean direction N73.9^{o}E) with dip direction to the south range 60-80^{o}. Fractures with striking E-W and WSW-ENE dominates in the BHTV data near the permeable zones identified by PTS logging. These indicates permeable geologic structures are related with fractures striking E-W and WSW-ENE.
Fault mapping at the surface and fracture analysis using BHTV logging data infers E-W striking faults dominates in the Otake geothermal field. This study suggests fractures striking E-W and WSW-ENE is one of the major geologic structures for the pathway of geothermal fluid.
The Otake geothermal power plant has been operating for more than 50 years and dynamic data of fluid flow at the subsurface has been accumulated during field operation. In order to sustain stable field operation of Otake geothermal power plant, further integrated studies are desirable for better understanding of geologic structures and geothermal fluid flow.
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Keywords: Fracture, Geothermal, Topographic interpretation, Borehole imaging

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