Demonstration Experiment of Geothermal Reservoir Exploration Techniques: Three-Dimensional Seismic Survey in the Yamagawa Geothermal Field

Masato Fukuda[1], *NAOSHI AOKI[2], Takao Nibe[2], Kaoru Sato[2], Susumu Abe[2]

1.Japan Oil, Gas and Metals National Corporation, 2.JGI, Inc.

An experimental three-dimensional (3-D) seismic survey was conducted in the Yamagawa geothermal field, Kagoshima, Japan for verifying its efficiency for geothermal reservoir exploration. This demonstration experiment was conducted by Japan Oil, Gas and Metals National Corporation. JOGMEC is developing several geothermal exploration methods to locate geothermal reservoirs more accurately by applying recent technologies used in other sectors such as oil, gas, and metal mining. Reflection method is one of the most promising geophysical survey methods which delineate subsurface geology precisely. It is proven in the oil sector that seismic method, especially 3-D seismic, reduces geological risks and increases success rates in drilling. However, many of geothermal fields in Japan exist in mountainous area. Seismic surveys might suffer from a rough topography and complicated geological structure. Since effectiveness and cost of seismic survey in Japanese geothermal area are arguable, the Yamagawa 3-D survey had the following aims. First, high density 3-D data were collected to show proper images of the geothermal reservoir. Second, several subsets with different survey designs were extracted and their images were compared to determine the relative cost-effectiveness. Since the Yamagawa geothermal field has a smooth topography comparatively, it allowed us to collect high density 3-D seismic data. The area of the survey was about 32 sqkm (4.5 km in N-S and 8 km in E-W). Both wireline telemetry system having 3,134 channels and 1,855 wireless nodes were used for the receiver lines. Two types of vibrators (18 tonnes and 7.4 tonnes), a fleet of 4 vehicles for each type, were uses for seismic source. While the larger vibrators were used at 988 shot points, the smaller vibrators were used at 2,274 shot points. Maximum Displacement Sweep technique enriched the low frequency components of the source frequency band. Sweep frequencies of 3-60 Hz and 4-60 Hz were used, respectively. Sweep length was 16 seconds. Number of sweeps is defined shot-by-shot as follows: 3 or 4 sweeps for the standard shot points and 8 or12 sweeps for the high energy shot points. The high energy shot point was distributed at every 200 m or less so that refraction tomography could be analyzed more properly. Data processing is being conducted at the time of writing this report. The preliminary results have depicted complicated structure in the volcanic region and shown a consistency with geological information from the wells. We plan to conduct several decimation tests that evaluate 3D and 2D geometries. Full Waveform Inversion, attribute analysis, and an integrated study with gravity, magnet-telluric, and well data will also be applied in the next phase.

Keywords: Geothermal, Yamagawa, Fault, Fracture, 3D, Seismic