Recent geothermal research and development techniques for evaluation of geothermal reservoir in Japan

Hideaki HASE[1], Tatsuya SATO[1], Takashi OKABE[1], and Kazumi OSATO[1],
[1]Geothermal Energy Research & Development Co., LTD., 1-22-4 Shinkawa, Chuo-ku, Tokyo 104-0033, Japan
e-mail: hase@gerd.co.jp

ABSTRACT

Geothermal Energy Research & Development Co., Ltd. was established in November 1975 under the auspices of the former Ministry of International Trade and Industry (MITI). It began as a joint venture launched by geothermal development-related private enterprises in Japan with the aim of in order to promoting the research and development of geothermal energy as part of in the Sunshine Program that MITI initiated began in 1974. We have participated in the research and development of geothermal technologies conducted through the Sunshine Program, and have strived to introduce foreign cutting-edge geothermal technologies and to offer consulting services and information. At the present time, we have nearly reached the point where are also actively approaching application of our geothermal technologies we have developed can be applied so far to other fields. Examples of them include oil, gas, methane hydrate, metallic deposits, civil engineering, groundwater, protection against earthquakes, under-sea crustal structure study, the geological sequestration of carbon dioxide, and the underground disposal of a high level of nuclear wastes. With the recent trend in increasing human economic and social activities, global warning and other environmental problems have become apparent. Regarded as environment-friendly, clean, and renewable, the geothermal energy is expected to develop still further. Therefore, we will make our utmost efforts not only to contribute to the progress of the geothermal development but also to expand our new consulting business. We will present our recent and cutting-edge development techniques for evaluation of geothermal reservoir in this symposium.

Keywords: Geothermal reservoir, geothermal development technique

1. Exploration technology

We are the first company that has introduced and implemented a commercial magnetotelluric (MT) survey in Japan. We recently used the MT method to explore an area under the sea floor at a depth of 5,000 meters or more. At any desired depth from a few meters to tens of kilometers, we can use electromagnetic waves (such as MT, CSAMT, and TEM) or elastic waves (such as seismic reflection method, VSP, and cross-hole tomography) to investigate the geophysical structure and properties of the surface and borehole. We have electromagnetic methods based on 2D and 3D analyzing by using WSINV3DMT (Siripunvaraporn et al., 2005a; Siripunvaraporn et al., 2005b) technologies and offer exploratory services (such as exploration, data processing and analysis) for a wide range of applications. Examples of our services include groundwater and environment surveys at depths from several meters to tens of meters, the prospecting of hot springs or metallic deposits at about 1,000 meters deep, the exploration of geothermal energy and oil at several kilometers, and scientific or under-sea floor investigation at 10 kilometer or deeper. We are now involved in the development of CSEM (Controlled Source EM) for shallow areas

under the sea floor.

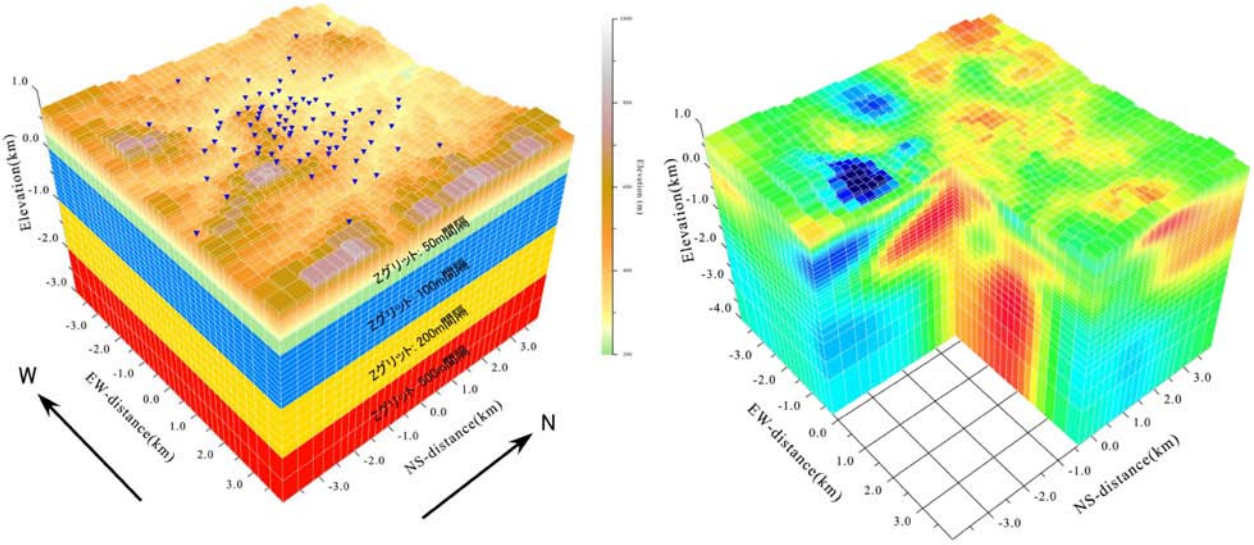

Fig.1 A result of MT3D inversion analysis. The left figure shows 3D grid image and the right figure shows 3D resistivity image.

2. Drilling and logging technology

For drilling applications, such as geothermal wells, hot springs, oil, gas, and scientific drilling, we offer cutting-edge technologies that allow accurate drilling control to a target point. Our technologies can control the drilling direction in real time by using any of cables, electromagnetic waves, or mud pulses to send back the drilling information, such as the direction and position of the bottom of a borehole, to the surface. SDI, one of our partners, has the top-level control-drilling and gyro survey technology that can be used at high temperatures. We also provide technical services, such as well completion after drilling, work over (removing scale), and scale control.

When a geothermal or hot spring well is drilled, a production test is conducted after drilling, or a power plant is inspected regularly, it is very important to characterize not only the production and injection capabilities of the well but also the properties (such as pressure, temperature, and permeability) of the strata around the well. We offer wire-line technologies and memory-based PTS logging methods, depending on the particular requirements and various applications. Moreover, understanding of the direction, distribution of underground fractures and formation stresses is very important in dealing effectively for treating underground fluids (for using geothermal energy, oil, groundwater, etc.) and formation rocks (for civil engineering). We offer logging services (BHTV and BTV), which generated the image of a borehole wall by scanning with ultrasonic beam or optically, core photographic tools (CORESCAN) and technologies for analyzing the borehole image (BHTV, FMI, and BTV). DHV (made by Expro) that is able to visually monitor a borehole at high temperatures can be used for variety of

applications, such as casing inspections, scale checks, and borehole work over jobs.

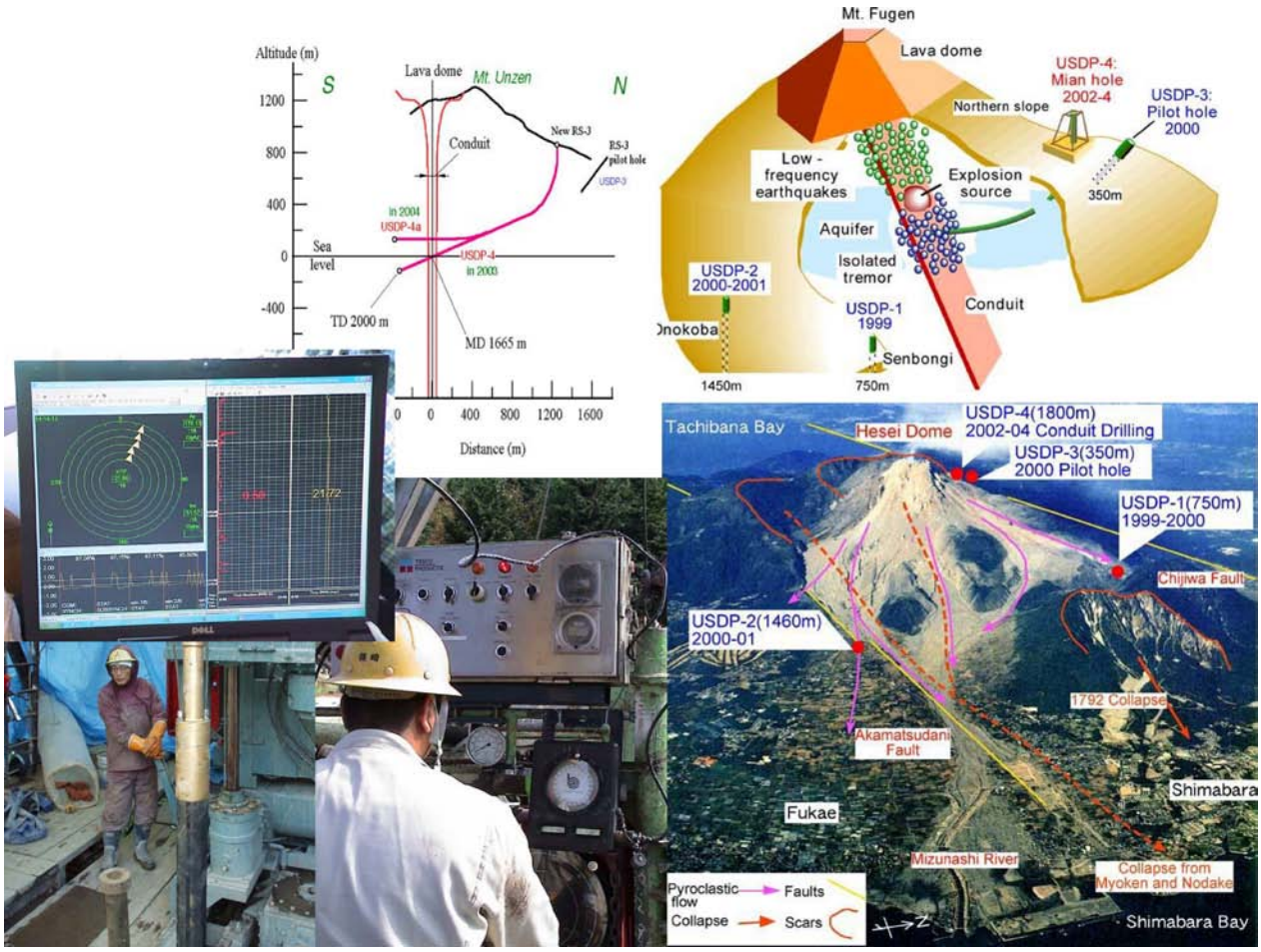

Fig.2 International cooperative research with scientific drilling for understanding eruption mechanisms and magmatic activity by using EM-MWD (electromagnetic-transmitting measurement-while-drilling)

3. Reservoir control and monitoring technology

Estimating how and where underground fluids are flowing now and will flow in the future is an important technology for controlling the underground fluid resources and to preserving the environment. For this purpose above, we offer a variety of hardware and software that is needed for necessary to instrumentation technologies (pressure and temperature monitoring, tracer-dilution 2-phase flow measurement, and general-purpose visualized underground information database "G★BASE", which we have developed by ourselved, is being used for geothermal energy, the disposal of a high level nuclear wasted, and in the earth sciences, Regarding 3D underground multi-phase thermal fluid simulator-TOUGH2 (Pruess et al., 1996), and also STAR (Ishido and Pritchett, 1999; Pritchett, 1995) after conducting a log of field tests for around 10 and several years, we are now in a position to offer take a total consulting service, action not

only for analyzing services but also for introduction into and training in a variety of fields, such as evaluating geothermal reservoirs.

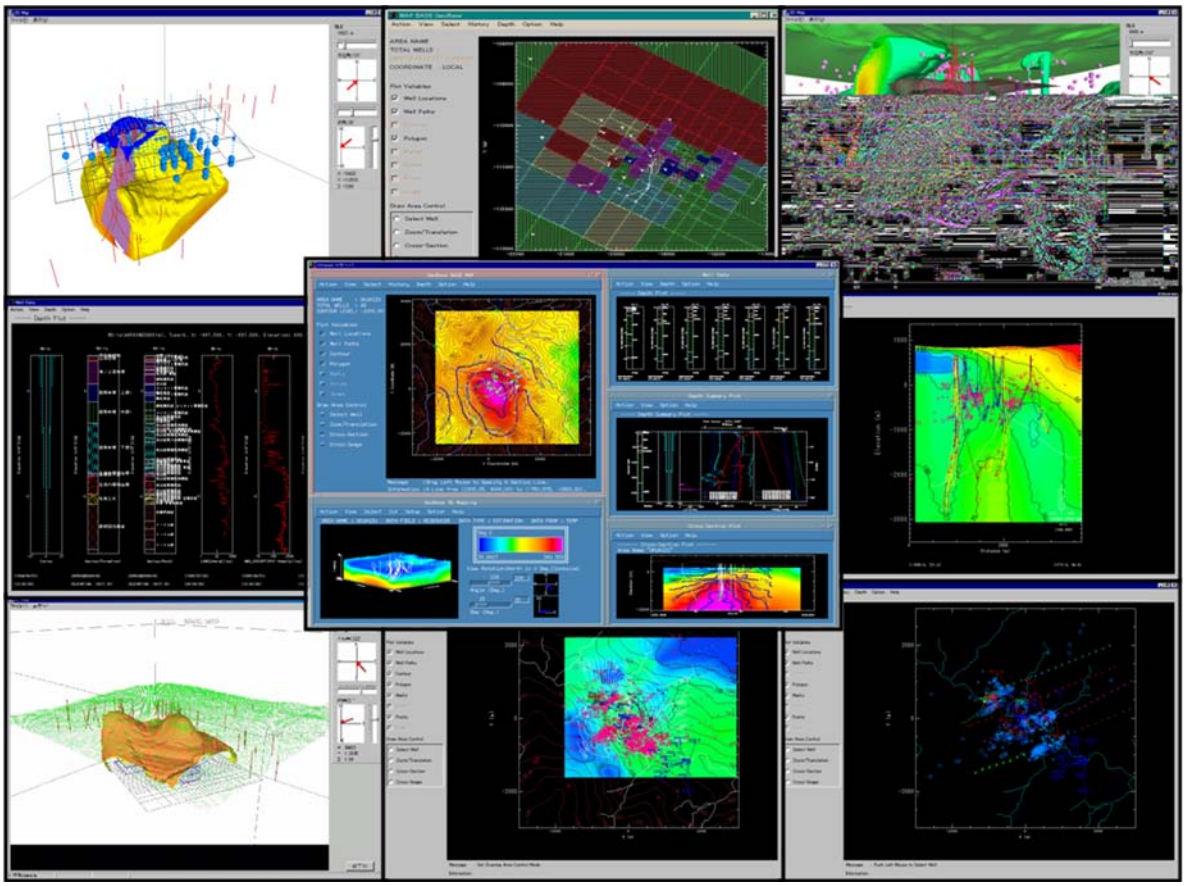

Fig.3 Using images of G★BASE

References

Ishido, T. and Pritchett, J. W. (1999): Numerical simulation of electrokinetic potentials associated with subsurface fluid flow. *J. Geophys. Res.*, Vol. 104, pp. 15,247-15,259.

Pruess, K., A. Simmons, Y. S. Wu and G. Moridis. (19969: TOUGH2 Soufware Qualification, Lawrence Berkeley National Laboratory Report LBL-38383, Berkeley, CA.

Pritchett, J. W. (1995): STAR: a geothermal reservoir simulation system, In: *Proc. World Geothermal Congress '95*, Florence, pp.2959-2963.

Siripunvaraporn W., G. Egbert, Y. Lenbury and M. Uyeshima (2005a): Three-dimensional magnetotelluric: Data space method, *Physics of the Earth and Planetary Interiors*, 150, 3-14.

Siripunvaraporn W., G. Egbert and M. Uyeshima (2005b): Interpretation of 2D magnetotelluric profile data with 3-D inversion: Synthetic examples, *Geophys. Jour. Inter.*, 160, 804-814.