I-GET Report Summary

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Final Report Summary - I-GET (Integrated Geophysical Exploration Technologies for deep fractured geothermal systems)

Part of the project was to evaluate existing exploration methods, applied at representative sites throughout Europe. For this purpose, a database was compiled containing all available information on previous exploration efforts. The success or failure of these methods were discussed and recommendations have been derived from these experiences as well as from those gained in the field experiments performed within the project in a best practise guide for geothermal exploration.

The Travale test site was part of the extensive reservoir used since 1904 for energy production at Larderello. The productive zones of the deep reservoir occurred mainly within contact metamorphic carbonate rocks above a granite intrusion. Less productive fractured levels were also found inside deeper granitic bodies, where temperatures did not exceed 330 degrees Celsius. Deep wells did not meet productive levels where recorded temperatures exceed 350 degrees Celsius. The lowest boundary of this reservoir still represented an open question.

To better understand the extent of the reservoir at Travale and to predict the sustainability of the resource, extensive field operations were performed at the site prior to and within the I-GET project.

Existing seismic lines were reprocessed by partner UNIPI. In addition, magnetotelluric (MT) data were acquired by partner IGG parallel to some of the seismic profiles. Geophysical measurements were compared with information from well-logging, which was also performed within the project. The existing geophysical data were the basis for a final reservoir model at the regional scale, calculated and developed by I-GET partner ENEL. This numerical simulation granted a better understanding of the geothermal processes that are the basis of the continuous steam supply in the Travale system.

The volcanic site at Hengill, Iceland was expanded to increase energy output for the rapidly growing aluminium industry in Iceland. MT surveys at Hengill were performed by I-GET partner ÍSOR. At Hengill, an extensive MT survey was carried out. Joint one-dimensional (1D) inversion of all MT and TEM soundings in the Hengill area was performed and a three-dimensional (3D) reisistivity structure was compiled from the individual 1D models.

Finally, a full 3D inversion was done for the full MT tensor, corrected for static shifts by TEM. The 3D inversion revealed very interesting resistivity structure, showing deep conductors (3-9 km) under the geothermal system. The deep conductors were thought to be very hot intrusions and heat sources for the geothermal system(s) in the Hengill area.

In addition to electromagnetic measurements, a broad-band passive seismic survey was carried out.

At Gross Schoenebeck, seismic experiments included two parts: First a 40 km long profile to derive a regional two-dimensional (2D) seismic model of the potential reservoir layers and overlying sediments. Second, a star-like arrangement consisting of 4 profiles each of 6 km length was deployed and a low-fold (low budget) 3D seismic experiment was conducted to identify fractures around the geothermal well location.

In addition to the surface geophysical measurements, borehole geophysics was used to complement the set of field data.

Rock physics experiments at high pressure and temperature were performed at the high pressure laboratory at GFZ Potsdam, where conditions in the reservoirs could be simulated, with controlled pressure, temperature and pore pressure as well as pore fluid salinity.

To improve data quality, CSAMT measurements were performed to complement the MT data with a controlled source of electromagnetic signals. This procedure improved data quality in the upper section of the geological profile significantly. For the lower part, two options of robust data processing were applied to improve the quality of calculated parameters. First, the coherence between time series of magnetic field components recorded on survey and remote sites was applied. Then data were reprocessed without the use of the coherence function. The reprocessing results appeared to be a little better than results of the first applied option, but finally, the quality of obtained estimations of MT parameters was rather poor for low-frequency range and the results of interpretation could prove unreliable.

A joint interpretation of all available data included the newly acquired seismic and MT profiles as well as information from well-logging. Sets of resistivity maps and structural maps related to horizons interested for geothermal investigations were prepared. Zones of lower resistivities in central and southeastern parts of the area were probably connected with strong fracturing or high porosity forming ways for filtration of geothermal water. Vertical boundaries of resistivity more or less correspond to faults interpreted from seismic data.

These encouraging results gave a much clearer picture of the potential reservoir. The quality of the seismic data and the information compiled within the project provided a useful basis for an evaluation of the further development of the well.

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