The ECOGI EGS Project in Rittershoffen, France

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ABSTRACT

The ECOGI geothermal project, located in the Upper Rhine Graben, was initiated in 2011. It is designed is to deliver a power of 25 MW_{th} at the "Roquette Frères" bio-refinery in Beinheim in order to cover around 25% of the process heat needed by this industrial site. The drilling site is located in Rittershoffen, 6 km east of Soultz-sous-Forêts, in Northern Alsace, France. The project is supported by the "ADEME", the "Conseil Régional d'Alsace" and "SAF Environnement". ECOGI is a joint venture; the shareholders are "Electricité de Strasbourg" Group, "Roquette Frères" and a public institution "Caisse des Dépôts et Consignation."

Old petroleum seismic profiles available in the vicinity of the project were reprocessed using modern techniques and an updated geological interpretation of the Rittershoffen horst structure was proposed in 2011. The drilling of the first vertical well GRT-1 started in autumn 2012. The well reached a final depth of two and a half kilometre end of 2012 within the fractured crystalline basement. A reservoir development strategy was then designed in order to optimize and enhance the hydraulic properties of the well. These operations were applied in two sequences, respectively in April 2013 and June 2013 for the main operations. This strategy was successful, as the hydraulic properties of the GRT-1 reached the target for industrial development of the project. The reservoir temperature also reaches the predictions, with temperatures above 160°C. An advanced seismological monitoring of the reservoir has been set up, allowing real-time location of the induced seismic events, thus offering the best support for decision makers during operation to avoid events that could be felt by population. The drilling of the second well started in March 2014.

Introduction

Rittershoffen is located in Upper Rhine Valley (Northern Alsace, France). The location of the project is shown in Figure 1. This region has a long history of hydrocarbon exploitation, as several oil production wells are still active in the region. The site is located 6 km east of Soultz-sous-Forêts, the well-known European EGS pilot site.

The project is based on a geothermal doublet (see figure 2). The produced heat is delivered through a transport loop to the bio-refinery located in Beinheim, 15 km from the drill site. The heat is then used for industrial processes.

Figure 1. Location of Rittershoffen.

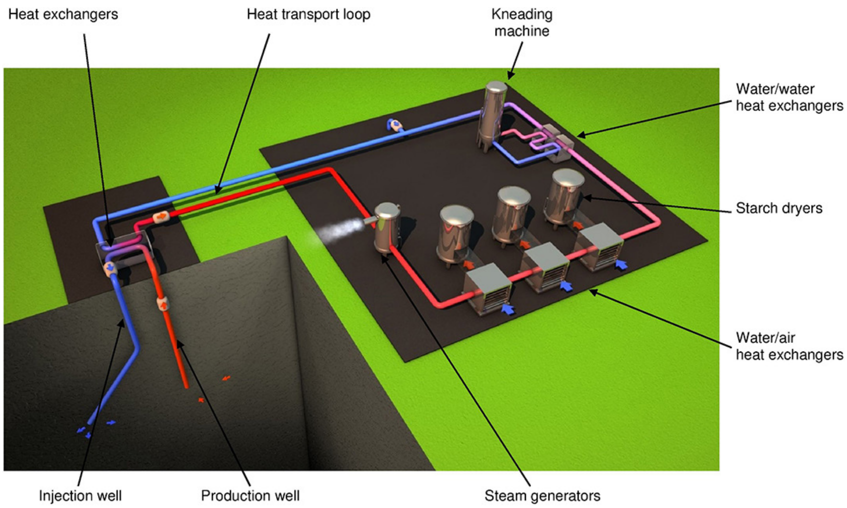

Figure 2. Global heat use concept (source ECOGI).

Geothermal and Geological Context

During the 80's, several oil wells were drilled in the area of Soultz-sous-Forêts, targeting deep-seated Triassic sedimentary layers. Most of these wells were unproductive. However the deepest bottom-hole temperature measurements show 140°C at 1600 m in the Muschelkalk (Middle Trias) and 158°C at 1780 m in the Buntsandstein (lower Trias). The Rittershoffen area is located on the eastern side of the Soultz-sous-Forêts where the geothermal gradient is one of the largest described so far in the Upper Rhine Valley. The first vertical well GRT-1 has been drilled within the post-Paleozoic sediments and the Paleozoic fractured crystalline basement of the Upper Rhine Valley.

Based on 2D seismic profile, the geothermal target was a fractured/faulted zone dipping westward and located close to the transition between the Triassic sandstones (Buntsandstein) and the top basement. This local normal fault, which is roughly oriented N-S, shows an apparent vertical off-set of 200 m and limits the western part of the Rittershoffen horst structure. Based on old oil wells but also on the experience of the Soultz-sous-Forêts results, it was assumed that this local fault could present favourable permeability conditions. Thus, it was decided to drill vertically within this local fault in order to reach an operational flow rate of 70 l/s.

A geological monitoring of GRT-1 as well as mud logging operations show two main zones of mud losses, corresponding to fracture zones, in both the Secondary sediments and in the crystalline basement. The deepest zone in the basement is a huge hydrothermally altered and fractured zone having a severe negative thermal impact on the temperature log. Those results are very similar to those observed within the Soultz-sous-Forêts geothermal wells (Genter et al., 2000; Vidal et al., 2014).

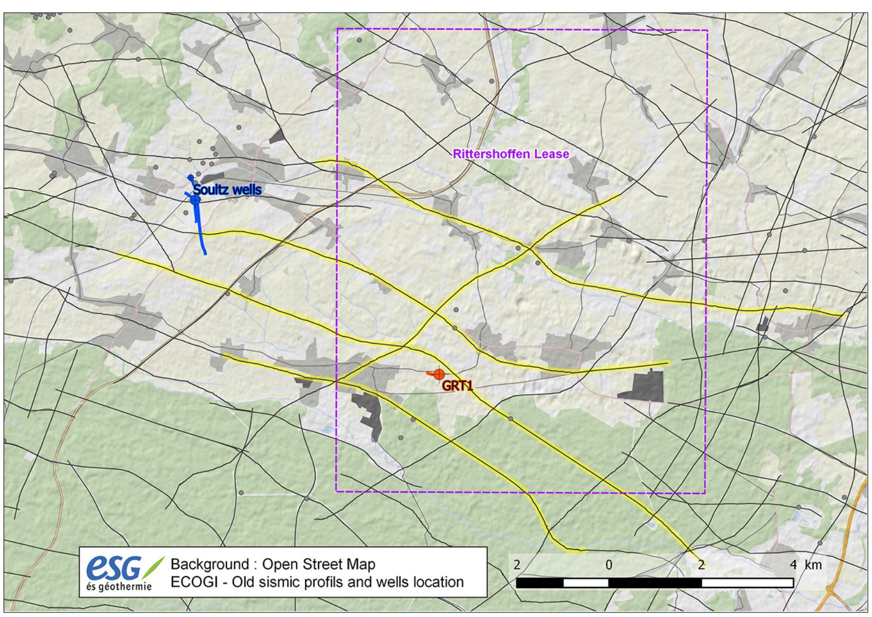

Figure 3. Vintage seismic profiles and wells available in the region.

Site Screening and Preliminary Data

The region has a long history of hydrocarbon exploration and production. Thus, numerous seismic profiles and wells were available in the area (see figure 3). Six existing wells were located in the direct vicinity of the project, showing extremely high temperature gradients (up to more than 150°C at 1800 m depth). Five seismic profiles were reprocessed using Pre-Stack Time Migration processing algorithms. Results were interpreted allowing to define the target of the first well GRT-1.

First Well GRT-1 and Reservoir Development Strategy

The first well was drilled by COFOR, using a MR800 Rig. The target depth, located at the interface between sediments and crystalline basement (about 2.5 km TVD) was reached in December 2013.

An extensive logging program was implemented in the different open-hole sections to the first well GRT-1, including:

- Caliper and spectral Gamma Ray;
- Sonic DT, neutron porosity and bulk density;
- UBI (acoustic imaging tool);
- Temperature and spinner logs.

The first hydraulic tests performed showed encouraging results. A reservoir development strategy was developed and applied (Baujard et al., 2014). It consisted in 3 steps:

- A thermal stimulation of the well, with low-rate cold fluid injections
- A targeted chemical stimulation of the well. To that purpose, environmentally friendly acids were specifically designed using drilling cuttings for laboratory testing. The chemical injections were applied to specific zones of the well, us-

ing open-hole packers. This technique limits the quantity of chemicals to be injected.

– A hydraulic stimulation of the well, with stepwise high rate fluid injections. A flowrate of 80 l/s could be achieved.

A real-time seismic monitoring was achieved during the entire stimulation process (Maurer et al., 2013). The development strategy was a great success, as the initial injectivity of the well could be multiplied by a factor 5 and reached the economical threshold defined by shareholders.

Real-time Seismic Monitoring

As required by the French authorities, since 2012, the micro-seismicity of both Rittershoffen and Soultz-sous-Forêts geothermal fields is monitored by a permanent network composed of 12 surface "short period" stations (1 Hz) (see figure 4):

- The Soultz seismic network, composed of 8 stations, one or three components sampling at 150 Hz (blue squares on figure 4).
- The Rittershoffen seismic network, composed of 4 three components stations sampling at 100 Hz (red squares on figure 4).

In addition, in the framework a cross-border collaboration between the industrial ECOGI, the service company ES-Géothermie and academics (KIT, EOST and EEIG "Heat Mining"), the ECOGI management decided to deploy a temporary seismic network (white triangles on the map)composed of 16 additional real-time telemetered surface stations. The seismological units, loaned by the GIPP-GFZ to the KIT, are composed of three-component seismometers (Sercel L4C-3D) and EarthData loggers (PR6-24, old generation) sampling at 300 Hz.

Waveforms from all stations are currently acquired in real-time and processed and archived by a SeisComp3 server. In order to locate micro-seismic events, a first 1D velocity model was build according to previous local studies based on the Soultz-sous-Forêts project (Cuenot et al, 2008). Moreover, a second 1D velocity model was build based on the sonic logs and the chrono-stratigraphic log performed in the GRT-1 well (Duringer and Orciani, 2013).

The maximum magnitude threshold set by ECOGI (1.7 Mlv) was never reached and no earthquake was felt by the local population neither in April nor in June. About a hundred induced earthquakes were manually picked and located in April 2013, and, based on the automatic detection procedure, a total of 174 events were detected, manually picked and located in June 2013 (see figure 5). A crisis of 37 detected induced earthquakes occurred 95 h after the water injection ended. The largest induced earthquake reached a Mlv magnitude of 1.5 during that crisis.

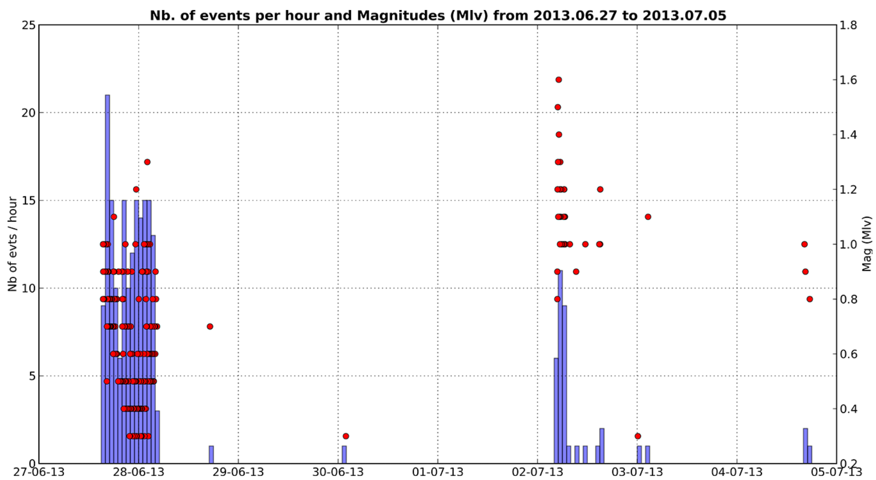

Figure 5. Seismic events rates and magnitudes during reservoir development in June 2013.

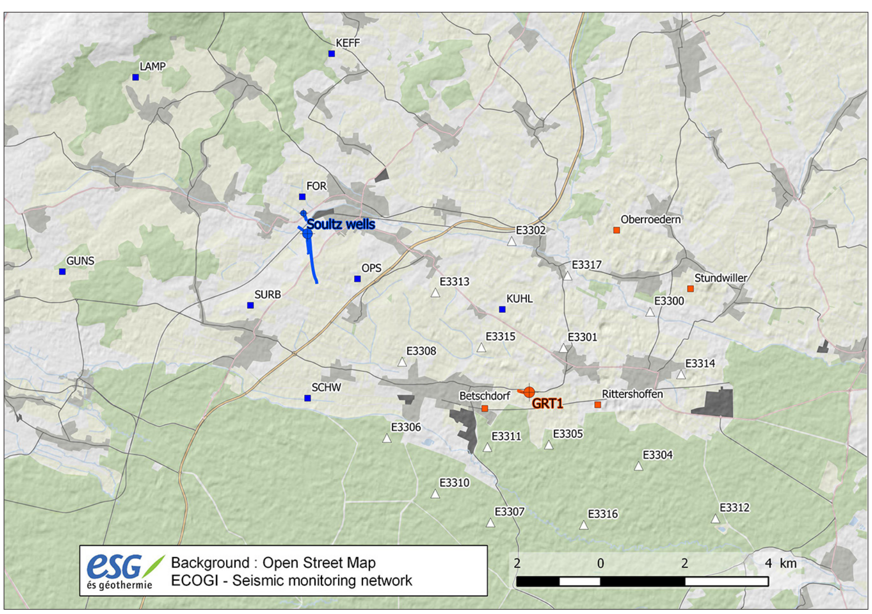

Figure 4. Seismic monitoring network (blue squares: Soultz network; red squares: ECOGI network; white triangles: KIT temporary network).

Seismic Data Acquisition

After validation of the GRT-1 results, two new seismic profiles were acquired during summer 2013 by Gallego Technic Geophysics (see figure 6, next page). Several post processing strategies, supervised by CDP Consulting were applied to this newly acquired seismic data (Pre-Stack Time Migration (PSTM) and also Pre-Stack Depth Migration (PSDM)). Previously used seismic profiles were also reprocessed using PSDM algorithms. Careful interpretations of the results lead to a much better structural image of this complex zone.

Second Well GRT-2

Based on the results of the new seismic profiles, the target of the second well GRT-2 has been defined, and the well trajectory and completion designed. The

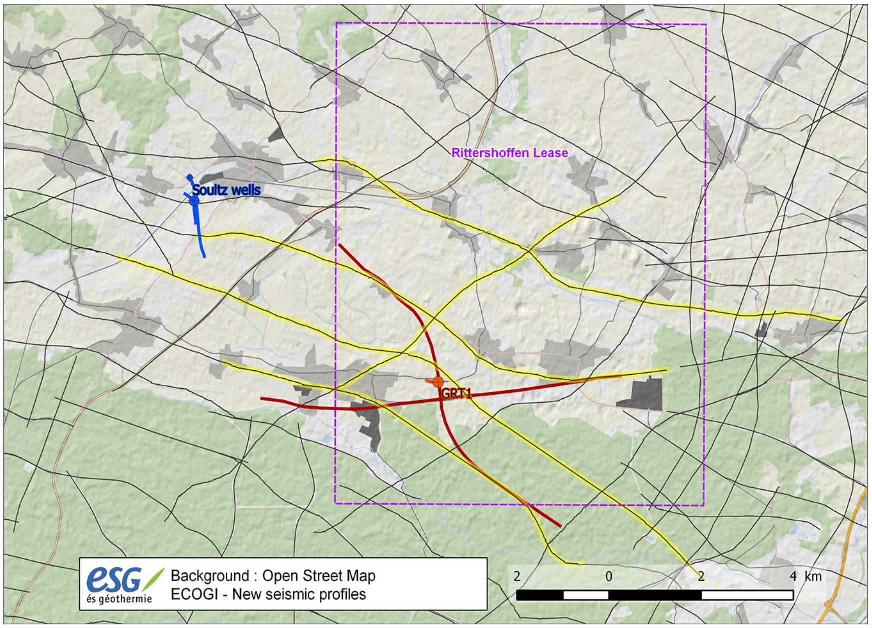

Figure 6. New seismic lines acquired after GRT-1.

drilling of the second well, realised by COFOR, using a 270 t Rig HH300 started end of March 2014. The well target is located in the same fault structure, more than 1 km away from the first well. Therefore, this second well is strongly deviated. The target depth should be reached in June 2014.

Conclusion

Taking advantage of the experience acquired in the framework of the Soultz-sous-Forêts project, “Electricité de Strasbourg” Group decided to strongly develop geothermal energy in Alsace. ES-Géothermie, a subsidiary created in 2008, aims at taking advantage of this experience into industrial projects such as ECOGI. The group also ties a strong partnership with academic research through the creation of an industrial Chair dedicated to deep geothermal energy in Strasbourg University.

The ECOGI project is the first project of a long-term strategy of this major energy player in Alsace. Results of the second borehole are expected during summer 2014.

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