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ECOGI, a New Deep EGS Project in Alsace, Rhine Graben, France

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ABSTRACT

The ECOGI deep EGS geothermal project was initiated in 2011. ECOGI is a joint venture between "Electricité de Strasbourg" Group, "Roquette Frères" industrial partner, and the "Caisse des Dépôts et Consignation" institute. The drilling site is located in Rittershoffen, 6 km east of Soultz-sous-Forêts, in Northern Alsace. It is designed to deliver a power of 24 MWth to the "Roquette Frères" bio-refinery located in Beinheim in order to cover around 25% of their industrial heat needs. The project is supported by "ADEME" with the "Fond Chaleur", "Conseil Régional d'Alsace" and "SAF Environnement", as guarantor in case of unproductive well. 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.

Vintage seismic profiles available in the vicinity of the project were reprocessed in 2012 using modern techniques leading to an updated geological interpretation of the Rittershoffen region. The drilling of the first well GRT-1, started in autumn 2012 and ended three months later when the well reached a depth of two and a half kilometers within the fractured granite basement. A reservoir development strategy was then designed in order to optimize and enhance the hydraulic properties of the well. The main operations were applied in two sequences, respectively in April 2013 and in June 2013. This strategy was successfully applied, as the hydraulic properties of the GRT-1 reached the target for an industrial development of the project. The reservoir temperature also reached the predictions, with temperatures above 160°C. An advanced seismological monitoring of the reservoir has been set up, allowing real-time location of induced seismic events, thus offering the best support for decision makers during operation. The seismic risk has been mitigated and no events were felt by the local populations despite a complex development of the seismicity in time.

Two new seismic profiles were acquired during summer 2013 in order to produce a better structural image of the reservoir for targeting the second well, GRT-2. Several post processing strategies were applied to this newly acquired seismic data which improved the geometrical understanding of the major local faults. Combined with the numerous logs and hydraulic tests performed in GRT-1 well, GRT-2 target has been identified and the trajectory designed. Drilling of GRT-2 started in March 2014.

1. INTRODUCTION

1.1 ECOGI Project

The ECOGI Project is located in Rittershoffen, a small village located in the Upper Rhine Valley (Northern Alsace, France). The location of the project is shown in Figure 1. The site is located 6 km east of Soultz-sous-Forêts, the well-known European EGS pilot site.

The project consists in 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.

1.2 Geological and geothermal conditions

The Upper Rhine Valley is a Tertiary graben. The shallow geology (0 to 1500 m – 2000 m depth) consists in sedimentary layers, overlaying the crystalline basement, which is made of altered and fractured granitic rocks which are older than 330 My. Temperature, structural and stress conditions of the underground of the region are very well characterized, thanks to numerous hydrocarbon exploration wells, vintage seismic profiles and to extensive investigations that have been performed in the neighboring geothermal site of Soultz-sous-Forêts.

During the 80's, several hydrocarbon exploration wells were drilled in this area, 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 stress state to be found in the basement in this area is well known from interpretation of borehole image logs (Valley, 2007). Orientation of SHmax is approximately 169°, and observation that focal mechanisms show a mix of normal and strike slip faulting suggests that SHmax is very closed to Sv.

Figure 1: Location of Rittershoffen, new EGS site in Northeastern France

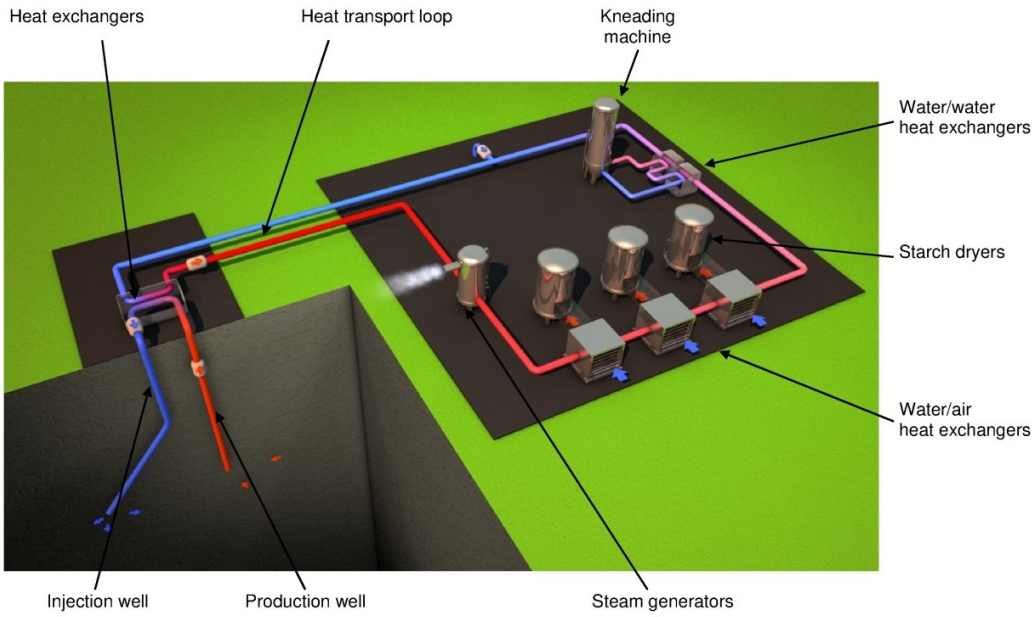

Figure 2: Schematic sketch of the global heat use for the ECOGI project (source ECOGI)

2. WELL GRT-1

2.1 Target definition

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 vintage seismic profiles were reprocessed using Pre-Stack Time Migration processing algorithm.

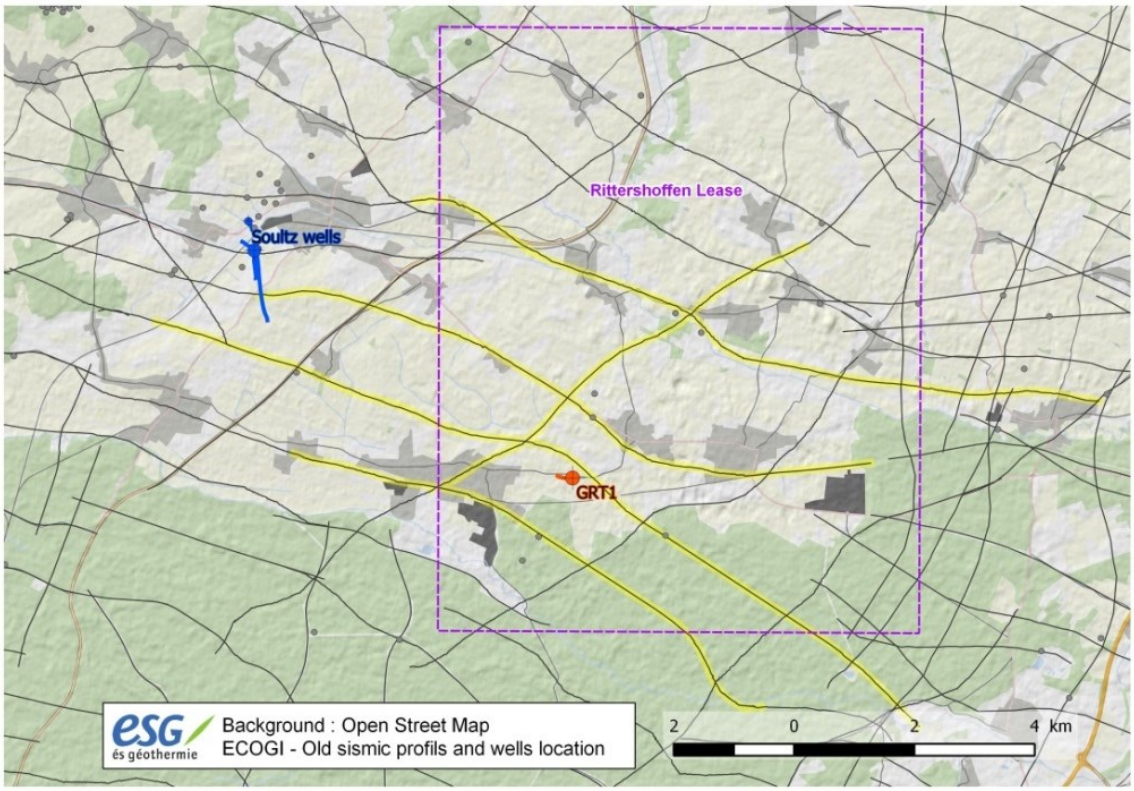

Figure 3: Vintage seismic profiles and wells available in the region

Results were interpreted and integrated in a 3D model in order to define the target of the first well GRT-1 (see figure 4). As a result, a well constrained structural image of the deep underground of the region could be obtained. A regional fault zone could be identified, approximately oriented in a North-south direction; dipping westward and located close to the transition between the Triassic sandstones (Buntsandstein) and the top basement. This local normal fault 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 favorable 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.

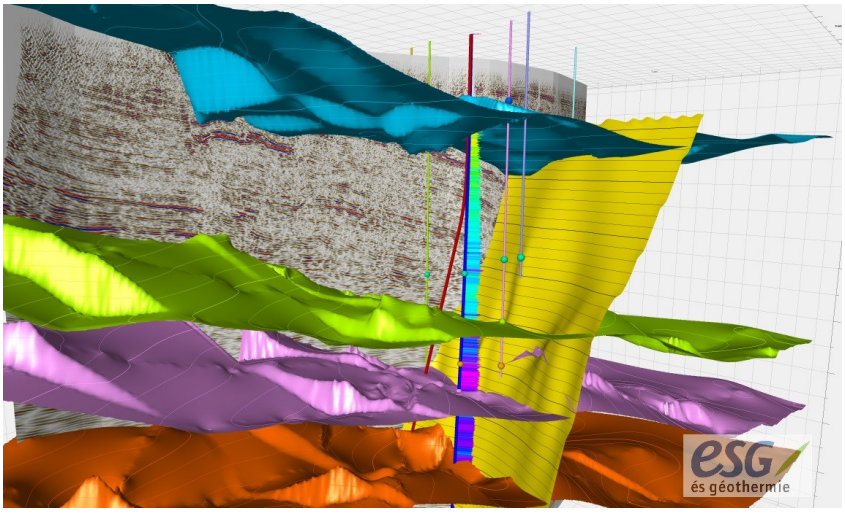

Figure 4: 3D geological model, showing GRT1-1 well, (in blue), planned GRT-2 trajectory (in red), pre-existing wells, the main fault structure and 4 geological horizons. From the top to the bottom of the 3D model, the main geological units derived from the seismic interpretation are: Schistes à Poissons from Rupelian (blue), Top Trias (green), Top Buntsandstein (pink) and top basement (orange).

2.2 GRT-1 Drilling

The first well was drilled by COFOR, using a MR8000 Rig (see figure 5), with a hook weight of 200 To. The target depth, located at the interface between sediments and crystalline basement (about 2.5 km TVD) was reached in December 2013.

Figure 5: Drilling GRT-1 (COFOR) using a MR8000 Rig.

Geological monitoring of GRT-1 and mud logging showed 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).

2.3 Testing and reservoir development strategy

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 applied in April 2013
- A targeted chemical stimulation of the well in June 2013. 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, using 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, also in June 2013. A flowrate of 80 l/s could be achieved.

A real-time seismic monitoring was achieved during the entire stimulation process in collaboration with the University of Strasbourg (Maurer et al., 2015). The maximum magnitude threshold set by ECOGI (1.7 Mlv) was never reached and no earthquake was felt by the local population. The largest induced earthquake reached a Mlv magnitude of 1.5.

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.

3. WELL GRT-2

3.1 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). 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.

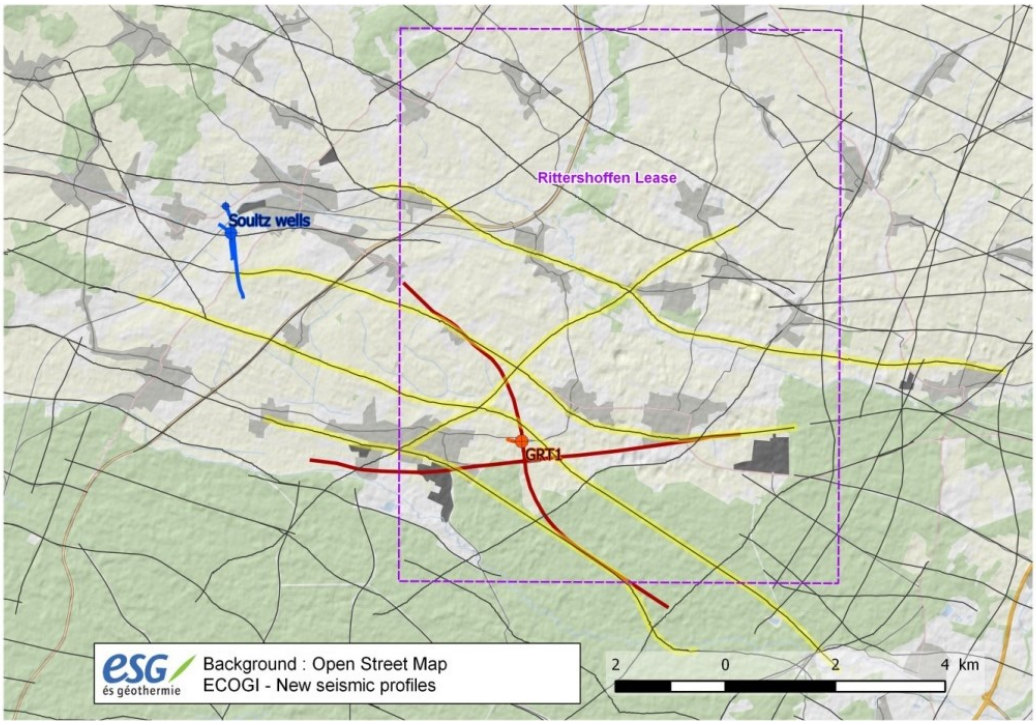

Figure 6: new seismic lines acquired after GRT-1 drilling in summer 2013

Figure 7: Drilling GRT-2 (COFOR) using a HH300 Rig.

3.2 GRT-2 target definition and drilling

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 drilling of the second well, realized 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 summer 2014.

CONCLUSION

The project ECOGI is now almost finished. The first well has been successful, and the second well is being drilled right now.

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.

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