



**EAGE**

**3D SEISMIC HIGH PRODUCTIVITY APPLICATION FOR GEOTHERMAL  
DEVELOPMENT**

**Case study in suburban environment (Munich Germany)**

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## Introduction

Exploration in the geothermal industry in Europe is commonly based on geological surveys and potential methods coupled with vintage O&G reflexion seismic reprocessing, mostly in 2D. The issues of structural mapping and fluid content of the “reservoir” to de-risk the drilling are often addressed by small new 2D seismic surveys and rarely 3D surveys, except in Germany, main reason being mainly economical.

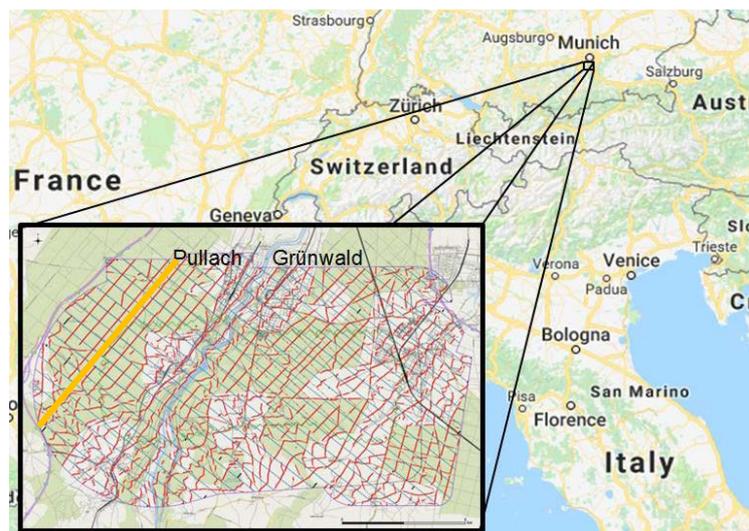
Recent development in wireless recording technology together with a dramatic increase in the productivity derived from the Middle East O&G industry such as blended vibroseis acquisitions made the seismic surveys more attractive and in accordance with geothermal budgets.

In parallel, the increased quality due to a higher vertical resolution and definition linked to a broadband acquisition make a huge difference even with the most recent surveys.

This paper presents the acquisition of the first 3D survey recorded in Europe with such technology and for geothermal object.

## Method

The survey located south of Munich City comprised 103km<sup>2</sup> (9,700 VPs – Figure 1) of 3D seismic, with a line interval of 424m, VP Interval of 17,67m and RP interval of 26,5m. Recording spread is one patch of 9,195 Sercel UNITE RAUex with a single SG5 geophone.



**Figure 1** Location map of the 3D survey in Bavaria (orange line is the XL2278 presented Figure 2).

The area comprises a mixture of urban, suburban, agriculture and forest. The forestry is generally well managed with a substantial network of “forestry” roads. There are many sensitive ecological areas: animals (birds, bats...) and water protection areas.

The valley of the Isar river runs through the project from South to North. The area is covered by a railway network, a main road going through the area from Pullach to Schäftlarn. One motorway goes along the West border of the prospect and another one crosses the North East corner of the prospect. The seismic survey was preceded and supported by an intensive public relations campaign. All district administrations concerned by the survey were informed far in advance.

The geological conditions around Munich are well known to be favourable to deep geothermal energy. At a depth between 2000 m and over 3000 m the Malm permeable limestone aquifer offers a temperature from 80°C to over 100°C. The targeted Malm carbonate formation is some 500m thick and located below a clastic sequence. The Top Lithothmanienkalk reflector at #1.7s twt, (XL2278 -

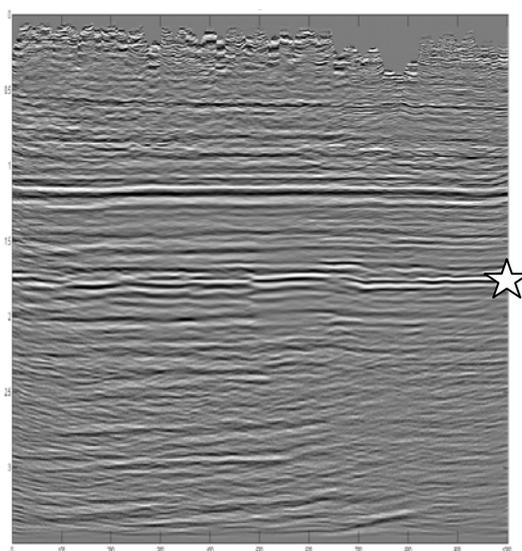
Figure 2 - marked with white arrows) is clearly visible on the fast track PSTM cube. The Top Malm should be some ms (2 or 3 phases) below. The carbonate formation is known to have sparse diffraction signatures and no strong reflections events.

CGG's Simultaneous Random Sweep (SRS) was implemented to ensure rapid acquisition. This new method requires using vibrators in autonomous mode (here 45000lbs), each one using a dedicated "coloured" sweep (frequencies swept randomly). This enabled the overlapping in time of the 60 s sweeps between vibrators without any need of distance separation. The start time of each sweep is random, GPS clock coded and controlled by each vibrator. Recording is continuous throughout the day. The extraction of the individual vibroseis records is done in 2 steps:

- Cross-correlation to extract each vibrator's source record as we have a unique "coloured" sweep for each vibrator and GPS stamp start time for each sweep;
- Deblending: removing the cross-talk interference from the other vibrators.

CGG's highest productivity in Europe using the old slip sweep technology (2003) passed the 1000VP/d in the early 2010's. With this latest SRS technology it recently passed the 3000VP/day on single shift. Timing was of critical importance due to environmental restrictions.

This survey has been acquired using a true 5 octaves broadband sweep (Emphaseis™) between 3 and 96Hz with 500ms tapers enabling higher resolution and definition. Immediately after last VP was harvested and before deblending was completed, a TerraMig™ PSTM cube (no FK, no velocity or mute optimization, AGC + elevation statics) was provided to the client (Figure 2).



**Figure 2** Inline brute PSTM TerraMig™ section (location Figure 1).

## Conclusions

Seismic in a suburban densely populated environment is a technical and operational challenge, but it is the best way to derisk drilling targets when developing a deep geothermal project in a sedimentary basin context. It was proved by this 3D seismic survey recorded in Pullach, that despite of traffic and a high noise level, an excellent broadband seismic volume can be obtained at economical costs due to this fast acquisition technology. However, the seismic survey is only possible if the affected population is well informed and has a positive attitude to the use of geothermal energy.

## Acknowledgments

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