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IDENTIFICATION OF THE FRACTURED BASEMENT/COVER UNCONFORMITY ON FORMER OIL SEISMIC PROFILES IN THE UPPER RHINE GRABEN

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Abstract

Fluid circulation at fractured basement/cover unconformity is of first importance for geothermal energy exploitation especially in continental rifting as the Upper Rhine Graben. This unconformity presents lot of natural fractures which constitute a large permeable fracture network driving brine movement. That constitutes a reservoir of hot water, which is exploited by several geothermal power projects at great depth with flow rate between 50 and 80 l/s of water produced.

On the French territory of the Upper Rhine Graben, about 6.800 kilometres of seismic reflection have been acquired since 1954 to the 80's for the petroleum exploration. Raw seismic data which were recovered from oil and seismic companies were retreated by modern processing techniques. However, as the acquisition parameters of these old seismic profiles aimed to better image shallow petroleum reservoir from Tertiary to Jurassic sediments, the deepest levels were not imaged properly.

In the Rhine Graben, the base of the basin is constituted by lower Triassic Buntsandstein and locally by Permian sediments. These both levels are clastic sediments yielded by the degradation of the Hercynian Massif and are constituted by fluvial deposits in an arid climatic environment (red sandstones) (Bourquin *et al.*, 2007). These levels could not be distinguished from each other on seismic profiles because they have similar origin and composition. They overlain the Palaeozoic basement constituted by different granites, gneiss and metamorphic rocks, volcanic and volcano-sedimentary rocks (Edel and Fluck, 1989).

Some seismic profiles, acquired in 70's and 80's, have been recently retreated to improve the seismic images, particularly the continuity of the horizontal reflectors, faults and deep zones (Capar *et al.*, 2009). On these seismic profiles, the basement/cover unconformity has been mapped systematically in the northern part of the Rhine Graben, from Wissembourg to Selestat. However, few boreholes are deep enough to identify with certainty the reflector corresponding to the basement/cover unconformity. Moreover, we tried to find a relation between the signature of the seismic reflector of the basement/cover unconformity and the nature of the underlying basement. It appears low magnetic rocks, such as granites, or Palaeozoic sediments, show a more continuous reflector than high magnetic rocks like gabbro, diorites, ...

Three recent seismic profiles have been retreated with a different signal process, the post stack time migration or PSTM, in order to improve the image of faults and their dip. The interpretation of these seismic profiles shows two types of faults, which cross-cut the basement /cover unconformity:

- 1- Major faults, which cross-cut the whole infill basin, except the Quaternary, and extend down-ward in the basement. Two different structural features have been identified: normal faults are bound to the early stage of the graben formation and negative flower structures, which reactive older fault systems in transtension during the recent tectonic stage.
- 2- Normal faults, which affect the top of the basement, the Buntsandstein and locally the Muschelkalk.

This study shows that the base of the basin is highly affected by large-scale fractures and constitutes a good target for geothermal projects. However, former petroleum seismic profiles, even if they are retreated, are not really appropriate to explore in detail the deep-seated basin of the Rhine Graben (detail mapping of the top of basement, trend of the deep-seated fractures...). Thus, in the framework of deep geothermal exploration, dedicated acquisition of 2D or 3D seismic surveys would provide a better image of the underground and would contribute strongly to minimize the risks of future projects.

This study has been done in the framework of an ADEME-BRGM joint project, namely CLASTIQ 2.

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