Exploration for EGS fields: innovative approach in deep geothermal contexts and R&D strategy

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ABSTRACT

TLS-Geothermics has undertaken its own exploratory assessment and strategies to identify technology options and geological models which could improve substantially the success of exploration in deep non-conventional geothermal systems which we consider having the potential to unlock vast renewable energy resources, and further potential to yield results that may benefit many industries and investors. As far as the installed electricity capacities, these geological contexts still remain the main supplier in the world compared with the hydrothermal and volcanic contexts. Our exploration strategy focused narrowly on R&D by setting closed partnerships with academic researchers and independent technological companies on their applied research and deploying their innovative technologies on the field. Beyond technology, a documented geological and structural "a priori" model is required to choose the suitable methods and select the appropriate geophysical methods. Whatever the technology used, it nevertheless should comply the geological model and subsequently geodynamic environments, which is the key issue to characterize thermal anomalies typology, assume geometry of structural elements and determine petrophysical properties of the geothermal system. Passive geophysical methods are commonly used in geothermal activities since years and provide a range of methods. Depending of these geological contexts to be enlightened, appropriate methods are going to be revisited and performed on field since 2014 to comply with the cost effectiveness, relied on the petrophysical and petro elastic conditions of the rocks and locate the origin of the thermal anomaly. Nevertheless several main requirements have to be implemented which significantly must improve the identification of resource before drilling:

-improvement of existing advanced technologies especially on high resolution passive geophysics and 3D depth imaging,

-develop emergent geological concepts supported by worldwide reference cases

-enhance geophysical high resolution networks and deploy dense broadband seismic experiment,

-combine reliable technologies to enlighten different structural elements of the geothermal system through depth (from shallow subsurface to deep lower crust),

-develop combined methods by 3D joint inversions to enhance 3D model of high density broad band soundings (seismic and non-seismic methods).

-proving efficiency of noise-based seismic tomography for shallow and deep images.

In this perspective, TLS Geothermics, which is a 2012-created engineering company and developer, is currently developing a new approach on conducting collaborating research projects dedicated to this industrial strategy in order to unlock and answer scientific questions and optimize geothermal exploration in these different areas and analogue regions which was studied (see Poster at the EGC2016). Some geological and geophysical aspects of these approaches will be displayed at EGC2016 (See posters M.Bellanger et al, and J-M.Ars and al.) particularly on 3D joint inversion methods, seismic tomography with continuous records of ambient noises and new paradigm on structural context.

1. MAIN ISSSUES AND CHALLENGES

No doubt that geothermal resource has the potential to play a much more significant role in the European energy mix.

Nevertheless, parameters that determine the boundary conditions of their existence are hypothetical and do not reduce enough the upstream risk of any investment. Today, the breakthrough must occur in the

very early phases of exploration by appropriate research and development to address the geothermal sector economic conditions. Thus, it must significantly reduce the financial risks of geothermal exploration phases.

Critical issues will still remain in the upstream phase to qualify the resource potential as long as dedicated research projects focusing on deep seated resource characterization will not be achieved.

In unconventional geothermal resources, criteria governing the existence of a geothermal system are still poorly understood, or poorly constrained. In spite of their potential, the geothermal option for Europe has been largely ignored probably due to a lack of comprehensive assessment including less conventional geological contexts. In Europe, the scientific research and the implementation of new methodologies, including depth imaging to determine these resources are still limited to geological contexts that can be described as conventional (Rhine Graben, Bavaria, Iceland ...). Therefore they do not represent sufficient reliable analogues or similar thematic guides to lead, in a medium term, to a geothermal resources assessment at the European level.

According to TLS Geothermics, other contexts in complex structural domains are still enigmatic and their original processes are nevertheless not entirely understood, but much more promising, unless its shows deep geothermal system precursors (high heat flow at surface, surface proxies, surrendered volcanic structures, major tectonic elements, favourable geodynamic context, etc.). Worldwide reference cases has been studied (Basin & Ranges-USA, Italy, Turkey, Mexico) and criteria which governs their existence has been properly compared with their geodynamic context, in order to determine critical parameters.

Beyond the specific scientific and technical issues of projects currently operated by TLS Geothermics, in terms of innovative field acquisitions, the regional specificity of those focusing structural contexts will play a dominant role (see M.Bellanger et al.). If our studies are conclusive, in a near future, the induced industrial consequences will be major because adjustable to other comparable sectors in France and Europe.

So far, benefits from the last recent geological research and technology transfers from the oil industry in particular, did not contribute to improve significantly the understanding of these contexts.

In the last recent term, except the Rhine graben EGS, R&D funding levels and government policies and incentives have not favoured growth of European geothermal capacity from unconventional, high-grade hydrothermal resources. Because of limited R&D support of EGS in Europe on newer geological targets, field testing and supporting applied geosciences and engineering research has been lacking for more than a decade. However the potential for progress is significant, both from a geosciences point of view (understanding and characterizing the resource) and from a technological point of view (imaging the context). Partnership with academic and institutions are the key role of our industry to maintaining and enhancing expertise in exploration geology and geophysics and meeting future challenges. Then participants will contribute to maintain effective exploration and applied field geophysics projects.

2. NEW APPROACHES AND TECHNOLOGY BREAKTHROUGHS

Geothermal exploration projects have a significant amount of risk associated with uncertainties encountered in the discovery of the geothermal resource. The largest issue is to understand how to proceed and particularly how to evaluate best fitted methods to minimize costs in the upstream phase. The poster first discusses on different methodologies implemented and recent advanced seismic studies, new structural concept and then achieved depth imaging technologies. Passive seismic (seismic tomography) and non-seismic (magnetotellururic methods, gravimetric measurements) on field and how they relate to the geological and geodynamical deep seated crustal geometry including rock properties and how the 3D joint inversion applied on multi parameters could improve drastically the final geological model as long as the “a priori” conceptual geological model integrate all observed data.

Nevertheless the application of passive geophysics to geothermal resource exploration is more effective when it is directed at constraining an integrated conceptual model relying on for example architecture of the deep upper and lower crust to identify origin of heat flows. Since the two basic criteria which determine the performance of a field are reservoir temperature and permeability of the rocks delivering sufficient flows at surface, the choice of methods should be appropriated to investigate different structural geometries, rock properties and crust architecture(magmatic cores complex, volcanic reservoirs, major faults) at different depths.

All methods has to be evaluated according to several criteria but mainly on best fitted geological environments and limitation of each method according to their costs.

3. SUMMARY

The main points obtained from our review suggest that architecture, geometry and thermal conditions of proven fault dominated geothermal fields in the world (or Basin & Ranges type) could be reconsidered with new ideas and concepts and consequently be transferred positively in others countries in the world, within the EGS domain. The transformation of unconventional deep geothermal sector will require continued improvement of existing advanced technologies as well as breakthroughs. Innovative strategy must focus narrowly on research and development investments and should support specific technologies. Emerged technologies currently tested on passive geophysics methods, in particular on seismic methods seems significantly improve the resolution of depth imaging.