ENGINE

ENhanced Geothermal Innovative Network for Europe

Workshop 7

Risk analysis for the development of geothermal energy

07 - 09 November 2007

NATURALIS MUSEUM - LEIDEN - THE NETHERLANDS

Workshop Abstracts

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Thumbnail lower top: The burcht in Leiden.
Background: Bleiswijk drilling site, The Netherlands, by J. Ammerlaan.

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ABSTRACT SUMMARY

SESSION 1:

GENERIC METHODS FOR MANAGING EXPLORATION AND DEVELOPMENT RISK

Technical and socio-economic risk evaluation for the development of the geothermal energy in Europe

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After two years, 6 workshops and 2 conferences, the ENGINE Coordination Action has strengthened the scientific community, gained an audience at the European scale and developed links with other initiative worldwide like the IEA-GIA, US or Australia. The framework of ongoing activities is clearer and a lot of new cooperation has been initiated among the partners. Moreover, expertises in progress have already identified some priority issues that have been presented to the second stakeholder meeting in September 2007.

During this period, the economic and environmental constrains have changed as a result of the increase of the energy price and of the threats of global warming as a consequence of greenhouse gas concentration in the atmosphere. In parallel, several major geothermal projects have been developed, especially in Germany (Gross Schönebeck, Landau, Unterhaching…) and Iceland, and the interest for unconventional geothermal energy worldwide has been renewed.

What is now missing for starting up new ambitious projects, rally industrial partners and get support form politics at the national and European level? Calibration of the "learning curve" and quantification of geologic and technical risk are among the main issues that come out from the contact with the stakeholders. It is important on one hand to evaluate the investment and the expected savings on cost operation at the 2020 horizon for each R&D initiative and industrial project. On the other hand, it must be demonstrated that geothermal energy can contribute to achieve the goals defined in the European Strategic Energy Technology Plan, i.e. to reach a target of 20% renewable market penetration in 2020. It is also noted in this document that if prospects for market penetration are presented for biofuels, photovoltaics or wind energy, reference to geothermal energy is still missing.

The evaluation of the technical and socio-economic risk for the development of the geothermal energy in Europe is thus the main task on which all our efforts must be put on during the last semester of ENGINE. Data available from the updated framework of activities and expertises performed must converge to select discrete and significant parameters for the risk analysis. This work can be done qualitatively but should be quantified in particular through the use of Decision Support Systems that will integrate the critical parameters defined. From this modelling, a definition of the most favourable contexts for the development of Unconventional Geothermal Energy in Europe is expected.

Decision & Risk Analysis in the oil and gas exploration & production industry

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New methodologies to improve Decision and Risk Analysis (D&RA) are gradually gaining ground in the E&P industry. For good reasons, since the E&P industry has a poor track record in delivering upon promise. Problem framing, uncertainty modelling, designing options as a function of the quantified uncertainties, and full value chain modelling are key to this new approach.

We will discuss why the new generation of petroleum engineers may have advantage in moving away from detailed, “accurate” (or precise) models containing a lot of spatial detail and physics. Such models too often result in poor predictions, with few learning opportunities. Depending on the decision to be made, simpler though still representative models may yield better results, provided that they are integrated with the entire value chain (from static modelling up to portfolio modelling) and that they model all significant uncertainties (“fully probabilistic”). These simple models need to capture the “essence” of the physics.

Such holistic approach should enable us to weigh decision alternatives in their full context and allow more value to be added to the investments we make. The "bias" that characterizes the current practice would be reduced. A work process would be created that allows improved learning from the past (we repeat again and again the same mistakes of systematically inflated expectations).

To achieve this, however, a paradigm shift to more integrated and more probabilistic models is required. In this process, "adding value" is everybody's prime consideration. Our generation of engineers is trained primarily with a technical focus. We learn to look at technology first and economy later, almost as an afterthought. During those crucial years of formal education (university, early career at an oil company), the different multi-disciplines in oil/gas Exploration & Production shape their different paradigms and languages. We tend to forget the primary binding factor, however, viz. the common language of adding value. We need to learn that language from the onset of our training so as to allow truly multidisciplinary work later. Technology is just a means, not a goal. What the industry therefore needs is engineers who have followed the inverse approach: how does the process of 'adding value' work exactly, and how can we exploit available or new technologies to achieve this goal?

That is where a new professional is shaped: the Petroleum Business Engineer. First the business, then the engineering.

SESSION 2:

ASSESSING AND MANAGING TECHNO-ECONOMICAL UNCERTAINTIES FOR GEOTHERMAL ASSETS

Using Decision support models to analyse the performance of deep geothermal projects

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In this study we present a techno-economic models for deep geothermal projects using best practices for asset evaluation from the Oil&Gas industry, taking into account natural uncertainties and decision trees to evaluate sensitivities and different scenarios (cf. Floris and Peersmann, 2002). In this approach Fast model calculations for the techno-economic evaluation are used to calculate the performance of the geothermal systems, investigating sensitivities of the performance due to both natural uncertainties beyond control (e.g. flow characteristics, subsurface temperatures), engineering options (bore layout and surface facilities options) and economic uncertainties (e.g. electricity price, tax regimes).

We developed the methodology first for the re-use of deep boreholes drilled by oil and gas industry for a Deep Borehole Heat Exchanger (DBHE). A DBHE is based on the principle of a fluid migrating through a coaxial pipe in the subsurface, heated gradually by migrating downwards in the outer pipe, whereas the inner pipe acts as the return path for the heated fluid. The energy performance of the DBHE is proportional to the temperature difference between injected and produced water multiplied by the injection rate (m3/h). Kohl et al, 2002 have presented a full numerical performance analysis of such systems. In our decision support approach we use fast models for the temperature evolution of the water in the well based on fast analytical solutions of Kujawa and Nowak (2000a, 2000b). This allows to calculate in a matter of seconds the performance and its sensitivity to uncertainties and the effect of various engineering options.

For doublet systems in deep (enhanced) geothermal systems we use analytical methodologies developed for the Soultz project (Heindiger et al., 2006). Preliminary results indicate that the performance of the system is primary sensitive to subsurface temperature, flow rates which can be sustained in the fractured rock, and the fracture area involved in the fluid flow.

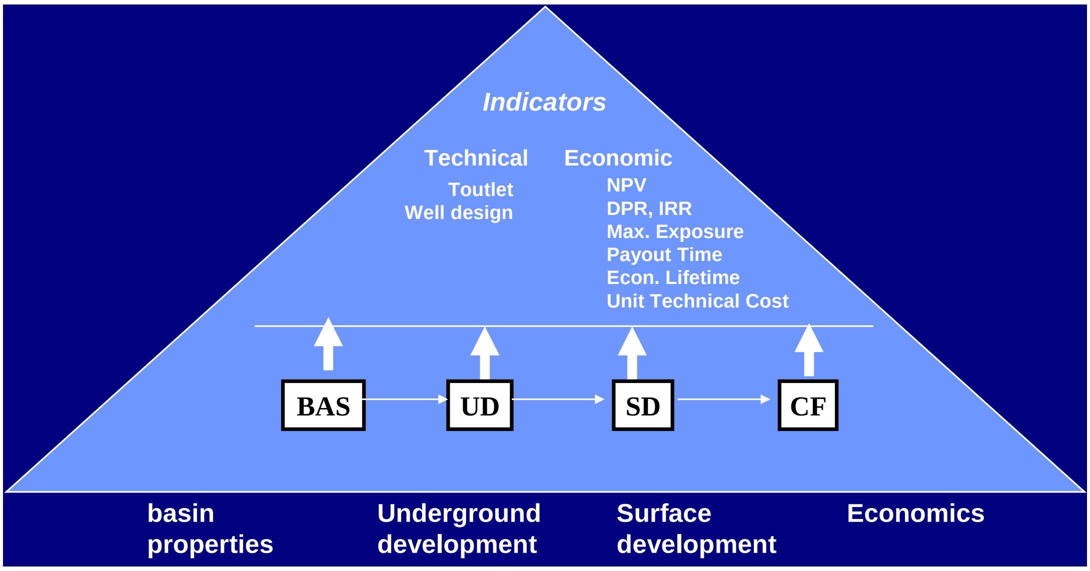

Fig. 1 fastmodel components for deep Geothermal systems.

References :

Heidinger, P., Dornstadter, J., Fabritius, A., 2006. HDR economic modelling: HDRec software. Geothermics, 35, 683-710.

Kohl T., R. Brenni., W. Eugster. [2002] System performance of a deep borehole heat exchanger. Geothermics, v. 31, 687-708.

Kujawa T., W. Nowak. [2000a] Shallow and deep vertical Geothermal heat exchangers as low temperatures sources for heat pumps. Proceedings World Geothermal Congress 2000 Kyushu, Tohoku, Japan, May 28 - June 10.

Kujawa T., W. Nowak [2000b] Thermal Calculations of geothermal heat utilizing one-well systems with both injection and production. Proceedings World Geothermal Congress 2000 Kyushu,Tohoku, Japan, May 28 - June 10.

Geothermal Power in Turkey (GEOPOT)

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Currently, Turkey's rich geothermal resources are used only to a small degree for the generation of the country's electric energy needs. Turkey in this regard is a promising country to develop, test, and apply new methodology for the exploration, development, and operation of geothermal low/medium-enthalpy reservoirs. At the same time, all these three stages required for the conversion of geothermal energy into electric energy are associated with uncertainty and risk.

Our project (GEOPOT) will apply, in the region of Simav (Turkey), techniques developed in the parallel method-oriented MeProRisk project (RWTH, Aachen). This project is based on (1) a novel multi-stage strategy for the exploration of geothermal reservoirs and (2) prognostic simulation tools with risk assessment capabilities for the development and operation of geothermal reservoirs. The strategy consists of a combination of surface and borehole geophysics, petrophysics, geology, and numerical simulation technology. Simulations are performed on a hierarchy of models for flow and transport which differ in complexity and data quality: an initial zero-generation model is based on available a priori information. Then a combination of forward and inverse simulations is used to optimize location, depth, and number of exploration boreholes and quantify the uncertainty of the model's predictions. In an iterative process, information on these boreholes is then used to generate the first-generation model. Simulations based on this model are tested against independent data from existing boreholes. Then, a calibrated version of the model is used again to optimize location, depth, and number of additional exploration boreholes. Information from these boreholes is then used to generate the secondgeneration model. This process is iterated until a model is obtained with sufficiently high prognostic probability to optimize location, depth, and number of production and injection boreholes for the reservoir to be developed.

Another part of the project addresses seismic risk assessment. Indeed, Simav's geothermal reservoirs are located in a tectonically active area where seismicity is to be expected even without operation of a geothermal plant. However, as reinjection may trigger seismicity, seismic risk inherent to the development and operation of the geothermal reservoir has to be quantified. A level of ground tremors which would present a serious disturbance or threat to the local population needs to be quantified and avoided.

In terms of socio-economic issues and public acceptance, the population of Simav already benefits from geothermal energy as the district heating system is the largest in Turkey, still it needs to be convinced of the benefit derived from a local production of electric energy. 3D reservoir model simulations will be used to optimize and guarantee the parallel production of electricity and heat for space heating.

Finally, the scientific benefits of such a project lie in the development and verification of a unified exploration, production, and development technology with prognostic and risk assessment capability for geothermal steam reservoirs. This extends the currently available technology significantly and will enable a much better and qualitative judgment of the scientific and technological uncertainties and financial and environmental risks involved.

Combining Areal Underground and Infrastructure Data to Minimize Exploration and Economic Risks

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Quantification of resources and localisation of most promising areas for geothermal prospecting are today key tasks for the development of geothermal energy. Such an analysis was lead for the Canton of Zürich, for surface geothermal energy (borehole heat exchangers and surface groundwater) and for deep geothermal energy (doublet systems). The first step of the work consisted in regrouping geological datas (from well, geological cross section and 2D seismic profiles essentially), hydrogeological datas (hydraulic conductivities of different layers derived from well tests) and thermal datas (estimation of thermal conductivities of layers, mean surface temperature and borehole temperature logs). In a second phase of the project, 3D numerical models were built in order to compute temperature in the underground, relying on a simplified geological model and on thermal datas acquired in the first phase of the project. Then, temperature of the identified aquifers has been extracted from the 3D models, and the geothermal potential of such target horizons could be calculated (Gringarten, 1978).

As a result, maps showing the temperature, depth and potential of geothermal energy of different identified aquifers the over the Canton were built, and the total amount of available and recoverable energy was estimated.

References :

Gringarten, A.C., 1978. Reservoir lifetime and heat recovery factor in geothermal aquifers used for urban heating. Pageoph, 117: 298-308.

How to optimize drilling strategies and reservoir management: lessons learned from the Soultz EGS project.

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Three 5 km depth wells have been drilled into the Soultz geothermal reservoir, which is made of highly fractured granite. The bottom hole zone of the 2 last boreholes were targeted using the development of microseismic clouds induced during hydraulic stimulation tests. This was done under the assumption that the more you get seismic events the higher the density of fractures should be. This method was successful for drilling GPK3, as it was proved that a good hydraulic connection with GPK3 does exist, but not so good for GPK4, which showed a low productivity index. The difference is due to the fact that GPK3 crosses a large, permeable fracture zone at 4.3 km depth and this seems not to be the case for GPK4. As it appears that, for EGS reservoirs, the underground water circulation is mainly driven by several large, permeable fractures, the challenge is to obtain the best reliable characterization of the geometry of these faults.

The VSP experiment achieved last April in Soultz could strongly help to get an optimized view of a fractured reservoir. Based on the reprocessing of older VSP data recorded in GPK1, which showed the ability of the method to define the extension of a main fracture intersecting the well at 3.5 km depth, it was decided to apply a similar technique at greater depth in GPK3 and GPK4. Preliminary results show at least two fractures or fracture zones near GPK4 that are known at borehole's wall.

Thus for future exploration projects, a methodology for targeting borehole trajectories through a fractured reservoir and reducing the risks of low productive wells could be the following:

- Compilation at regional scale and re-interpretation of geological and geophysical data (wells, 2D seismics);

- Integration of these datasets in a 3D geo-modelling tool in order to produce a geometrically coherent model;

- Perform at local scale (25 km²) a surface 3D seismic survey in order to get a first characterization of the geometry of the fractured medium,

- Drill a first exploratory borehole, which trajectory would be defined by the 3D seismics and analyze the logging data to get the main fractures intersecting the well,

- Perform a VSP survey in order to:

Define the extension of the fractures intersecting the first well;

Locate other main fractures that are not crossed by the well and characterize their geometry;

Optimize the trajectories of future wells, i.e., try to intersect the observed large fractures zones, using the technique of deviated drilling.

Applying this large-scale faults driven procedure could allow to minimize the risks of getting a low productive well, to have a better characterization of the reservoir and consequently to reduce a part of the uncertainty related to the underground.

Quantification of Exploration Risks for Hydrogeothermal Wells

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Exploration risk concerning hydrogeothermal wells is defined as the risk of not achieving a geothermal reservoir by one (or more) well(s) in sufficient quantity or quality.

The term quality in the definition can in general be interpreted as fluid composition (fluid chemistry). Component parts (gas, salinity, oil, etc.) can appear in the fluid, which, if they exceed certain limiting values, hinder or complicate the thermal utilization. The term quantity is defined by the (thermal) power which can be achieved by one well (or more wells). Therefore, the essential parameters regarding the quantity for the exploration risk are flow rate Q and aquifer temperature T. Both parameters are decoupled und independently measurable. The flow rate Q will be determined by production tests, the temperature T can be measured by wireline measurements.

A geothermal well is successful, if minimum level of thermal water production (minimum flow rate) Q at maximum drawdown s and if minimum level of reservoir temperature T are achieved; for that the depth of the aquifer is determined as exactly as possible from seismic reflection surveys.

Information about the hydraulic parameters of the aquifer can mostly be determined in a regional scale only. Information from boreholes nearby or other boreholes having similar conditions can be weighted in a suitable manner. For the temperature prognosis, local conditions must be considered besides regional trends. An area of

1000 km² was normally chosen in the previous assessments. Because of the small data base, the simplest way to calculate the POS of a project is to multiply the single POS of flow rate and temperature.

The composition of all fluids explored in deep aquifers in Central Europe has not topped geothermal utilization. But sometimes the technical effort can be great and induce additional costs. Nevertheless, there is no approach to assess the possibility of success for the quality.

SESSION 3:

ASSESSING AND MANAGING ORGANISATIONAL AND ENVIRONMENTAL ISSUES FOR GEOTHERMAL ASSETS

Analysis of Local Environmental Impacts through Geothermal Power Generation – A case study how to assess environmental risks in Germany -

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Geothermal energy has experienced a rising interest in the last years in Germany. Encouraged by the German Energy Research Programme and even more by the amendment of the German feed-in law, several projects aiming for geothermal electricity generation are under development. However, a wider use of geothermal energy for power generation is only acceptable if it results in general benefits for the environment. Based on this background, the environmental impacts and risks need to be analysed precisely before a broader market introduction, in order to meet respective mitigation measures such as regulatory guidelines or administrative directives.

To analyse environmental impacts trough geothermal power generation and identify possible environmental risks, a study was commissioned by the Federal Environ¬ment Agency of Germany (UBA). For this study, a methodology has been developed, where firstly, all possible local environmental impacts within the different phases of the life cycle of a geothermal power plant (i.e. construction, operation and deconstruction) are identified regarding the specific surrounding conditions in Germany. Thereby, effects on humans, animals, plants, soil, water, air, climate, landscape and objects of cultural value have been considered as environmental impacts.

Subsequently, the identified impacts are analysed and evaluated following a consistent methodology. The protection of the environment is an integral part of German law. Therefore the evaluation of the environmental impacts and the identification of environmental risks is based on a comparison to the existing regulations. The applicability of these regulations for the impacts of geothermal power generation and its compliance with environmental goals are assessed. This consistent approach can be characterised by the following steps:

(i) Probability of appearance: Will the identified impact occur during normal operation or is it related to failure? Analysis of site-specific geological and technical conditions.

(ii) Prevention measures: Can the identified impact be technically avoided? Analysis of the corresponding state-of-the-art.

(iii) Legal regulation: In case of existing prevention measures, are there any regulations or directives referring to the prevention measures?

(iv) Expected environmental effects: Which effects on the environment must be expected? Can they be mitigated?

(v) Identification of environmental risks: Can the effects on the environment turn into environmental risks, i.e. is the existing legal regulation (respectively the state of knowledge) sufficient or are additional regulations (respectively research) necessary?

The method developed in this study provides a way to analyse and visualise environmental risks but is potentially adaptable to the assessment of other risks.

The EGS Soultz project and its social environment: How to reduce the risk of public opposition

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Problems with public acceptance of geothermal projects and, the possible annoyance that they could cause are known obviously known from the experience of numerous projects in Europe. As it is sometimes difficult to avoid any disturbance during the development of a geothermal site, it is important to try to either minimize them or to deal with people's fear.

The main problem that we have to face at Soultz is related to induced seismicity. We performed 4 massive hydraulic stimulation tests between 2000 and 2005. During each experiment around ten earthquakes reached a magnitude 2 or higher among the thousand of recorded events. The strongest event was of magnitude 2.9 and several other were above 2.6. Our experience shows that magnitude 2 is the threshold above which people begin to feel the induced earthquakes. The stronger ones provoked lots of troubles among the inhabitants. They were felt quite largely in the region around the site and, especially after the M=2.9 event, we had to face several complaints about presumed damages and a growing anger among population and local authorities. Knowing that induced seismicity is somehow unavoidable during hydraulic stimulation process, we take different measures to reduce the risk of getting any strong opposition from the population. Three different ways were followed: scientific, technical (both aiming at reducing the number and the magnitude of seismic events) and communication.

- Scientific: Focus was made on the understanding of the processes responsible for higher magnitude earthquakes (research studies by our partners, creation of an independent group of experts to evaluate the seismic risk, international cooperation). A permanent surface seismological network was installed by EOST. Additional accelerometers were installed by EOST to measure the effective acceleration of the ground at different locations around Soultz.

- Technical: Instead of achieving massive hydraulic stimulation, we try to act on the medium by performing chemical stimulations which are generally softer procedures. As fractures are sealed with hydrothermal deposits (calcite, silica, clays …), a testing program was built to define different proper chemicals to target each minerals. This allows reducing the injected flowrates and consequently the overpressure in the reservoir and thus leads to less numerous seismic events and no larger magnitude.

- Communication: Public information meetings were organized to explain what we were doing on the site and give information on earthquakes. Local authorities were also informed of each planned hydraulic experiment. A small macroseismic investigation was achieved after the 2.9 earthquake to collect information about how people felt the vibrations. One accelerometer was installed in the Gendarmerie buildings and another one in the cellar of one inhabitant's house. Since then public information meeting are organized every 2 months and we noticed that a lot of participants are coming from the region around Soultz and are very interested and satisfied in knowing more

about the project. Moreover, a regular 2-fold flyer written in three different languages is distributed and mailed to a large audience in order to increase the communication process. The web site is also regularly updated. The extensive scientific studies, which helped to better understand the stimulation processes, the use of low seismicity-inducing tests and a better information to motivated population have contributed to significantly increase the social acceptability by producing a more quiet social environment around the project for 2 years now. And we hope that, once our project (and other) will run and that people will see concrete results, they will be able to make a better balance between the benefits given by a geothermal project and the possible disturbances that it could induce.

Increasing policy makers' awareness and public acceptance

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It is widely accepted that the geothermal energy is a versatile renewable energy source that is among the cleanest of the commercially viable technologies available today. Towards this direction, there has been a lot of scientific substantiation. Regardless of this positive opinion the development of geothermal exploitation has not followed the pace of the development as most other "alternative" energy sources have had. An important reason is that many geothermal projects face strong opposition from politicians, neighbouring communities or environmental pressure groups. This is the main reason which has led to a global tendency for geothermal companies to develop their own policy and their own social responsibility.

The goal of the geothermal community is to make policy makers aware of the need of a strategy by examining the policy that should be followed in order to eliminate any social opposition, analyzing the reasons for the generally weak social acceptance, and identifying possible solutions for changing the situation. 1) The initial phase of project development, 2) the environmental impact, 3) the public acceptance, 4) the political acceptance and 5) the technologies that are used for the geothermal energy applications are the main aspects that affect the success of the geothermal projects.

Nowadays successful geothermal companies and governments are trying to develop their own policy and their own social responsibility during development of new geothermal plants. The policy that these companies and these governments have successfully followed should be taken into account as a positive example for all the geothermal community (case study of Paris Basin, of Mt. Apo National Park in Mindanao in Philippines, in El Salvador by LaGeo company, in Larderello - Italy). As far as it concerns the case of Milos and Nissyros islands in Greece, there have been studies in the area of Geothermal energy which concentrated to the recording, processing and evaluation of data that structure the relation between geothermal development and local community. This public survey covered a major sample of the two societies and multiple parts in the subject of geothermal energy and configured a frame of self-examination that can constitute the creative base for the development of geothermal applications with assistance of the local society.

A step in the management of a project: uncertainties related to regulation. Example of the juridical and administrative environment of the Soultz EGS project.

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In the management of the development of a project, every decision has to be taken knowing the uncertainties or difficulties related to the juridical and administrative environment, i.e. regulation. Different authorizations are needed at each phase of the project. And those have to be planned at an early stage so that it does not disturb the development. Then several uncertainties arise, mainly linked to the time schedule: different files have to be constituted, the administrative study of the files can last several months, amendments could be requested and finally you are not sure to get a positive answer. As an example, following is a list of the diverse permissions that we had to apply for during the development of the Soultz project. In France deep geothermal energy projects are ruled by the Mining Code. Therefore, they are, from the administrative point of view, treated as coal or oil mining projects.

In order to start a deep geothermal project, it is necessary to ask for a “Geothermal Research Exclusive Permit” (PER in French), which is then put in a competitive call by national authorities. The PER determines an area within which the permit holder has exclusive rights of prospecting, in exchange of which he is committed to realize a certain amount of works within 5 years.

Then, so as to begin to drill a borehole, it is necessary to send to authorities a “request for exploration workings beginning permit” (DOTEX in French), which is subjected to a public inquiry among the population.

Once the geothermal field has been discovered, an exploitation concession has to be requested to get the exploitation rights. It defines the conditions which the concession holder is subjected to, so as to be able to benefit from the discovered geothermal field.

The French law distinguishes high temperature geothermal resources (≥ 150°C) and low temperature geothermal resources (< 150°C). For the latter, procedures are more simple.

Moreover, if, as in the case of the Soultz project, it is necessary to use binary fluids (like isobutane), a specific authorization has to be asked for exploitation, which is called “Plant listed for environmental conservation” (ICPE in French). Depending on the case, this could also be subjected to a public inquiry. Consequently, the administrative study of all the above procedures could last up to 3 years. And this is in the best case, that is, without any opposition or complaint…

Correlation between hydrocarbon reservoir properties and induced seismicity in the Netherlands

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Earthquakes induced by gas production are a social concern in the Netherlands. Over the last two decades, a total of about 350 such earthquakes have been recorded, with magnitudes ranging up to 3.5 on Richter's scale. The new Dutch mining law prescribes the operators to give a quantitative estimation of the likelihood of future seismic activity (hazard) and the associated damage (risk). This estimation has to be given for every onshore field (producing, or to be produced). A traditional probabilistic seismic hazard analysis (PSHA) can not give an estimation of the hazard for a field before the occurrence of seismic activity. We have therefore investigated the correlation between parameters related to reservoir and production properties and the occurrence of induced seismicity in a hydrocarbon field statistically, using Bayes' theorem and the Rule of Succession. Three key parameters have been identified that show a good correlation with the occurrence of earthquakes: pressure drop, fault density of the reservoir and stiffness ratio between seal- and reservoir rock. Based on the observed correlation a probability for the occurrence of earthquakes in fields that have no historical earthquake record has been calculated. This has resulted in the definition of four groups of hydrocarbon fields having all a different probability.

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