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Design of a Multi-Sidetrack Geothermal System Based on Coiled-Tubing Drilling Technology

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The exploration and exploitation of low-to-medium enthalpy geothermal reservoirs for residential district heating and power generation is closely linked to the development of petrothermal systems. These reservoirs represent 95% of the total geothermal potential in Central Europe. Another 1% is characterized by hydrothermal systems (e.g. in the North Alpine Molasse Basin) and 4 % which are related to tectonically affected parts of the upper crust (e.g. in the Upper Rhine Graben). Geothermal productions from these regimes are technically and geo scientifically established and may generally be defined as state of the art. In contrast, the majority of the petrothermal reservoirs need to be explored and exploited by methods from the mining sector and the hydrocarbon industry.

This process has not been tested much. Thereby water is being pressed under high pressure into the rock. Subsequently, the rock bursts open; cracks and fracture faces develop through which then water will be circulated much like a heat exchanger in order to yield (heat) energy. These systems are called Enhanced Geothermal Systems (EGS). The fracturing process is comparable to micro seismic events within the rock and may be recorded three dimensionally via seismometers. Thus, the development of such artificial heat exchangers may be monitored. In past years such EGS systems have been realized in Soultz-sous-Forets (FRA), Basel (CH) and Cooper Basin (AUS). There the massive hydraulic stimulation did happen more or less on a large scale and uncontrolled. Later on micro seismic events did partially occur with an intensity of > 3 on the Richter scale. This about corresponds to the vibration of a passing tram / metro. These low level micro seismic events didn´t cause any damages, however, they did generate great insecurity in the general public.

Without the massive development of the petrothermal reservoirs the political goals for the renewable energies may not be realized. That is why EGS techniques need to be designed such that a) small scale, better controllable crack systems develop and b) the seismicity will be further reduced and its impact communicated. Europe's deep geothermal future will highly depend on an adequate public acceptance of these systems - that´s why standardized recording and communication strategies are currently just as important as the further development of the exploration technique itself.

The International Geothermal Center Bochum (GZB) will develop a petrothermal EGS via innovative coiled tubing drilling technologies on the campus of the Bochum University of Applied Sciences. This project will be included in the start up phase of the International Geotechnology Pilot Plant on the campus of Bochum University and mostly realized using its own technology. It will provide all the heating needs for the GZB. The overall objective is the stepwise and goal oriented development of petrothermal systems for medium to low permeable reservoirs. The base for this work will be the experience of the oil and gas industry for the production of multiple crack (frac) systems. Therefore, the reservoir rock will be stimulated through one or multiple boreholes with multiple, stacked fracs. For years this has already been a standard procedure for the exploitation of tight gas reservoirs in North America.

In the current past even tight gas shales in North America were successfully developed using this method. The stimulation only reaches the concerned rock on a small scale and often only in shallow depth. The special advantage lies within the specific, small scale stimulation and the connected, very low seismicity. That is the dramatic difference to the traditional geothermal, massive hydraulic stimulations of crystalline rock (Soultz, Basel, Cooper Basin) having been done so far, which permeability only results in a few main leading cracks. The International Geothermal Center is currently purchasing with public money from the state of North Rhine Westphalia (NRW) and the European Union a coiled tubing deep drilling unit for R&D purposes as well as some stimulation and monitoring equipment. Main application in the oil and gas field is the re-entry of vertical holes with the subsequent multiple fraccing in via CT horizontally drilled laterals. The Bochum project aims at transferring these experiences of the carbon industry into geothermal applications. It shall mainly be operated with GZB´s own equipment (drilling, fraccing, perforation and high pressure pumps, in situ monitoring equipment). Added to that will be geophysical monitoring techniques of the project partners and drilling services of the industry.

Because of the for geothermal energies new technological approach and the connected unknowns the project will be realized in 2 phases:

Project phase 1 (Proof-of-concept): site is the in-situ Geotechnology Pilot Plant of GZB on the southern campus of Bochum University of Applied Sciences. There first of all a “proof of concept” on a small scale will be conducted. For that a vertical borehole down to 600-1000 m (2000-3500 ft) will be drilled. Subsequently, the coiled tubing rig will drill several horizontal side tracks (laterals) out of this vertical hole; these laterals will then be connected in pairs with multiple stimulation (fraccing). This project will cover the heating requirements of the GZB.

When this test phase has been successful and the technological development has been finished, a >4000 m (13000 ft) deep hole during project phase 2 (production case) will be drilled in the northern part of the university campus. This large project is supposed to service the campus of the Bochum University of Applied Sciences, the adjacent Ruhr-University and parts of the southern city of Bochum.

In order to warrant a wide public acceptance of this large scale project it will be connected with a strong concept for public awareness. Here the longtime experience of the Ruhr area institutions dealing with georisks from the deep hard coal mining and accidents will play a vital role. Central hub for communication is the German Mining Museum in Bochum. The University of Auckland with its Institute of Science and Engineering (IESE) will design and run a seismic observatory. Together with the IESE and the DMT a concept of an observatory will be developed, where information of daily seismic emissions / events (trams, subways, trains, rail traffic, etc.) will be recorded and compared to the emissions in the drilling and fraccing projects. Finally, using worst / best practice examples, together with the Wuppertal Institute of Climate, Energy and Environment and the German Mining Museum, a didactical and communication concept for the general public will be put into service.