Energy
National Research Programmes 70 and 71

Project

Deep-heat mining

Geothermal energy utilisation – researched on a virtual basis

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Extracting geothermal energy from deep layers of rock and producing electricity – while the idea is so enticing, its implementation is complicated. Two attempts at tapping deep geothermal energy in Switzerland as a clean source of energy have had to be discontinued due to earthquakes. Virtual computer-based test facilities should now allow for the secure and targeted development of this technology.

The borehole remains unused for the time being – the Basel pilot project for the geothermal generation of electricity and heat was discontinued due to earthquakes. *Source:* IWB/Erik Rummer

At a glance

- The use of deep geothermal energy for the generation of electricity is a promising but as yet immature technology.
- The threat of earthquakes linked to the use of deep geothermal energy has still not been banished and the pilot systems have been abandoned.
- Computer models allow for the systematic and secure development of deep geothermal energy.

The technology used taps the enormous supply of geothermal energy beneath our feet. In order to retrieve this heat, water is pumped through fissured, warm rock masses at a depth of more than four kilometres as if it was being passed through an instantaneous water heater. When the water returns to the surface, it has a temperature of 150 degrees Celsius – and can be used to generate electricity. The hot water can also be used for heating. The dream of a continuous and sustainable source of clean energy appears within reach.

A tough nut to crack

But the treasure is well sealed. The permeability of the deep rock layers is so low that until now it has only been possible to achieve low flow rates and economically viable energy production is not possible. The key to unlocking the potential of deep geothermal energy would be finding an efficient and secure method for increasing the permeability of the rock: so-called “hydraulic stimulation”. Here, water is pressed into the rock under high pressure so that existing cracks are expanded and a permeable zone emerges from which the heat can then be efficiently removed. However, this technology is still in its infancy and has until now only been applied in experimental systems.

To date, it has also been poorly understood how ground movements are triggered by the hydraulic stimulation. Small underground tremors are normal. They are evidence that the rock has been successfully loosened. What needs to be avoided, however, is the triggering of palpable earthquakes at the surface which under certain conditions may cause damage. This is because such events are alarming and have a severely negative impact on levels of acceptance amongst the population with respect to the use of geothermal energy. Pilot projects that were already up and running have been discontinued due to earthquakes in both Basel and St. Gallen. At present, there are thus no longer any plants for the generation of electricity from geothermal energy in Switzerland.

Deep drilling in a virtual environment

However, the research work aimed at improving the geothermal process continues – using computers. Researchers from several Swiss universities want to understand with simulations which processes are at play underground when the water is pressed into the hot rock.

In order to test this hydraulic stimulation of the rock permeability, a computer model was developed at the University of Applied Sciences and Arts of Southern Switzerland (SUPSI). It describes the behaviour of fine cracks with rough surfaces and calculates how the high water pressure causes displacements along the fracture surfaces during the hydraulic stimulation.

In addition to the pressure, temperature also plays an important role as shown by researchers from the University of Neuchâtel. The penetrating cold water cools the rock and creates tension. This can lead to further fractures and thus increase permeability.

Using a further model, the researchers studied how the small-scale movements in the rock impact the flow of the water and the extraction of heat as well as the earthquake activity. In this test, this simplified but more comprehensive tool was able to very faithfully reproduce a natural earthquake sequence in Nevada.

A model developed at ETH Zurich also simulates natural processes that occur underground. The researchers used the model to calculate the rise of hot water from deep rock fissures. In doing so, they discovered characteristic temperature patterns that can already be demonstrated at lower depths. In future, this new knowledge could make it easier to detect enormous sources of geothermal energy.

Create a development basis

The computer models make the remote realm of the world beneath our feet accessible for virtual experiments. This allows for processes aimed at efficiently and safely increasing the permeability of the rock to be tested on a systematic basis. The researchers are convinced that this will see hydraulic stimulation developed further from a method based purely on trial and error to a real engineering art. In Switzerland, this progress should also contribute to getting to grips with the earthquake risk associated with geothermal energy and to turning economically viable plants into a reality.

However, the acid test will remain application in the field. The findings from the simulation tools need to be examined and substantiated with real demonstration plants. The researchers are therefore calling for further pilot plants to be supported in order to push ahead with the development of deep geothermal energy.

Produkte aus diesem Projekt

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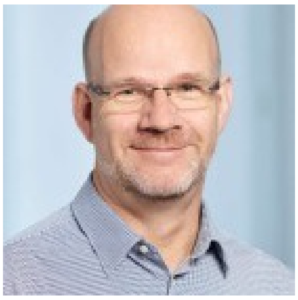

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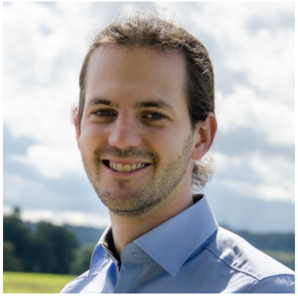

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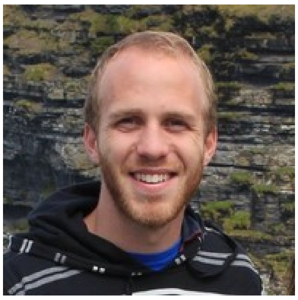

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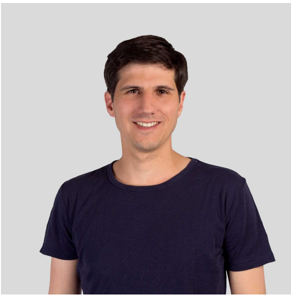

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All information provided on these pages corresponds to the status of knowledge as of 10.05.2019.