European Union
European Regional Development Fund

UNITED DOWNS DEEP GEOTHERMAL POWER

GEL GEOTHERMAL ENGINEERING LIMITED

An Overview of the United Downs Deep Geothermal Power (UDDGP) Project

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Introduction

The United Downs Deep Geothermal Power (UDDGP) project will be the first geothermal power project in the United Kingdom. It is being developed by Geothermal Engineering Ltd (GEL) and is co-financed by the European Regional Development Fund, Cornwall Council and private investors.

Geological Setting

Heat Flow

Cornwall has the highest geothermal gradient in the UK with the Cornubian Batholith elevating heat flow values to +125mW/m^2, compared to the UK average of 54mW/m^2. The distribution of these values is largely determined by proximity to the granite batholith. Surface heat flow values at United Downs are expected to be ~120mW/m^2.

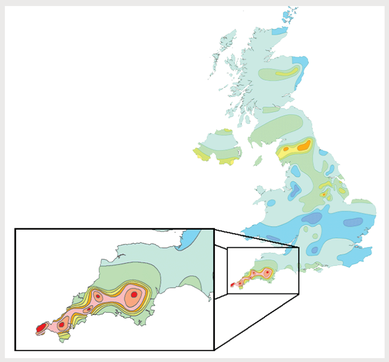

Figure 1. Heat flow map of the UK

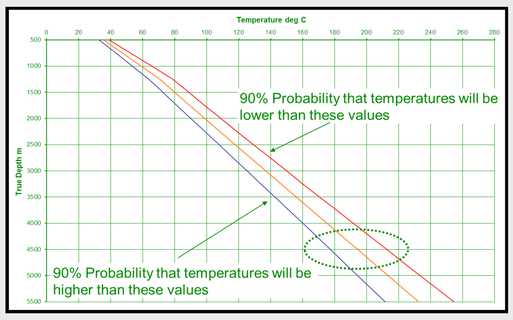

Figure 2. Predicted geothermal gradient at United Downs

Permeable Structures at Depth

Cornwall is home to a family of NNW-SSE striking faults with a multiphase history. The main period of deformation occurred throughout the Variscan Orogeny during the late Eifelian (398-392Ma) with compression acting in a NNW-SSE direction, consistent with the dominant thrusting direction and deformation style of South-West England (Sanderson, 1984).

The NNW-SSE structures left by the Variscan Orogeny and hosting many of the cross-courses (a local term for mineral veins of this trend) were subject to two possible phases of extension – the first coeval with the emplacement of the granite in the Permian (290-240 Ma) and a second reactivation phase during the Tertiary (240-205 Ma).

These features exhibit strike lengths of tens of kilometres. For example, the Porthtowan Fault Zone (PTF) can be seen in outcrop at Porthtowan on the north coast and traced to Falmouth on the south coast, a distance of nearly 20km. Such a large strike length increases confidence that the structure will persist at a substantial depth.

The cross courses are a geologically long-lived important focus of fluid flow. Thermal springs recorded in South Crofty mine (8km from the United Downs site) within the Carnmenellis Granite originated from flow paths following the NNW-SSE trend; at a depth of 800m the highest recorded temperature was 53°C. Figure 4 shows the location of recorded anomalous thermal springs and the concentration of uranium, a mobile element showing evidence of fluid flow within the structures of the PTF.

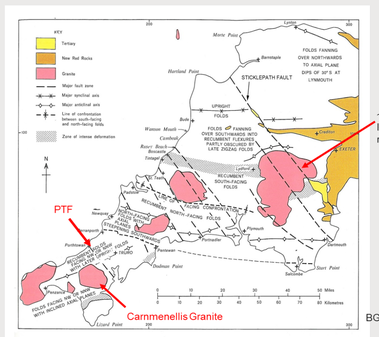

Figure 3. Fault map of Cornwall (BGS Regional Memoir, 1975)

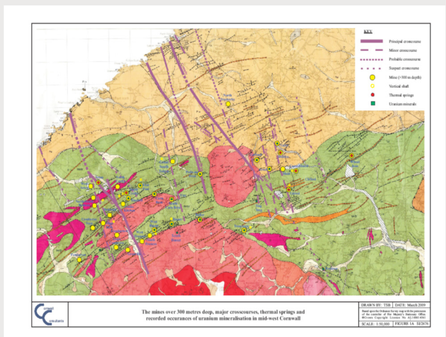

Figure 4. Thermal springs and Uranium associated with fluid flow in NNW-SSE structures

Background to the UDDGP Project

The Hot Dry Rock (HDR) geothermal research project at the nearby Rosemanowes Quarry during the 1980s investigated the geothermal potential to 2,500m in undisturbed granite. The UDDGP project is the long awaited second phase of this work and aims to explore and develop the geothermal resources at greater depth.

UDDGP will target a natural fracture system that, it is believed, will exhibit high enough permeability to allow circulation between the wells at a rate that can sustain power production.

The data and knowledge gained during the HDR project has been invaluable to the development at United Downs. Temperatures were measured to a depth of 2660m TVD and an increasing geothermal gradient was recorded, enhancing the economic viability of the proposed deep geothermal project. *In situ* stress orientation data showed that the maximum horizontal stress is oblique to NNW-SSE trending fractures, creating ideal conditions for shear stimulation (Figure 6).

These are the main fluid conducting features in the region, providing target structures with good permeability. Microseismic monitoring during the HDR project showed, contrary to expectations that injected water migrated down to a depth of at least 4km. This discovery paved the way for the proposed concept at United Downs; a system involving a shallow injection well and a deep producer with a large well separation of 2km.

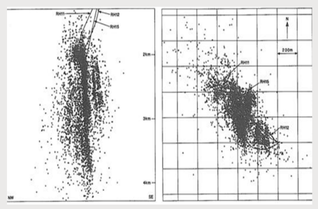

Figure 5. Microseismic data from the HDR project

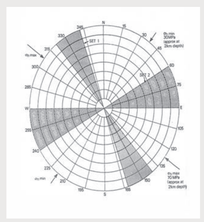

Figure 6. Stress orientation from ultrasonic image log data (HDR, 1986)

Concept

The project will drill two deviated wells from a site within the United Downs Industrial Estate, a few miles to the east of Redruth in Cornwall, UK. The doublet will consist of an injection well to 2,500m and a production well to a target depth of 4,500m where the bottom hole temperature is predicted to be 190°C (Figure 7). It is expected that the temperature of the water delivered to surface will be ~175°C. The development will form part of a demonstration system to produce between 1MW and 3MW of electricity. Water will be reinjected at a temperature of approximately 80°C.

The wells will be drilled initially through the Devonian slates and are expected to penetrate the Carnmenellis Granite within the top kilometre. They will be deviated at depth to target a significant NNW-SSE striking fault zone identified as the Porthtowan Fault Zone (PTF); a sub-vertical inactive fault structure that is thought to provide enhanced permeability at depth.

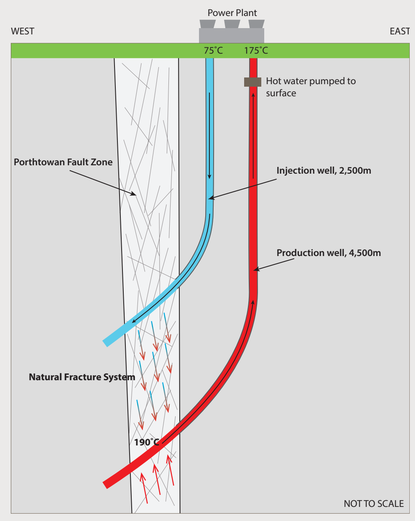

Figure 7. The UDDGP project concept

Figure 8. The HAS Innova Rig (courtesy of Anger's Söhne)

Current Activity

Site preparation is complete and the UDDGP project is awaiting the arrival of the HAS Innovarig, in early October, 2018.

GEL has selected a modern 'new generation' semi-automated hydraulic rig to drill the wells. It is based in Germany and has just successfully completed drilling the first well in the Otaniemi project in Finland to a total depth of 6.4km.

The drilling will take between six and seven months, operating 24 hours a day. Once the wells have been completed, the drilling rig will be removed from the site and GEL will carry out various production, injection and circulation tests to characterise the reservoir and determine the amount of heat and power it will be able to produce.

Dissemination through Education and Public Engagement

Dissemination of information through education and public engagement is an important element of UDDGP.

GEL is currently preparing an education programme suitable for all ages from Primary School to University. Interactive sessions from Key Stage 2 (Figure 9) to Degree Level are offered to local schools giving children and students the opportunity to better understand the generation of heat from the earth and how we can utilise this heat to produce clean, reliable and renewable energy.

To date the team has visited 12 local primary schools, with class sizes ranging from 8 to 64 children and 6 secondary schools where GEL has presented to whole year groups. As part of the education package, GEL commissioned the production of two educational animation videos about geothermal energy and the project, aimed at different age groups.

The animations are proving hugely popular; in particular the children seem to engage with Miss Molecule, the main character from the primary school animation (Figure 10).

Work is underway at the site office, in preparation for it to accommodate groups of up to 40 students for site visits and lectures.

Figure 9. Primary School Education Programme

Figure 10. Miss Molecule, a character from the Primary School Education Animation

Parallel Research

Plymouth University is a delivery partner in UDDGP, undertaking a parallel research programme into the public perceptions of geothermal exploration, understanding of the sub surface and the influence of media, particularly social media, in shaping opinion. Understanding these social aspects is an important element in gaining a social licence to operate.

The project also provides an opportunity for other research programmes to collaborate on related subjects, taking advantage of the unique data set resulting from the deep drilling. Areas already underway relate to mechanical properties, mineralogy, fracture modelling, heat flow, metals extraction and Enhanced Geothermal System (EGS) technology.

Communication with the Local Population

GEL places great importance on its relationship with the local community and understands the need for transparent, open communication. A Community Liaison Group meets at regular intervals, serving as a means of communication between GEL and the community. As well as members of staff from GEL and other project partners, the group has representatives from local residents and businesses, nearby parish councils, Cornwall Council and the Environment Agency. The Community Relations Manager from GEL also meets at regular intervals with local residents, maintaining a clear and easy dialogue.

Figure 11. A Public Information Event, hosted by GEL

The Future

UDDGP aims to prove the technical and commercial viability of a novel concept for harnessing deep geothermal energy in an area far removed from the conventional tectonically active and volcanic regions. If successful, GEL hopes not only to encourage the investment required to develop a significant geothermal generation base in the UK but also to encourage other non-conventional geothermal developments around the world.

Reference

Sanderson, D.J., (1984). Structural variation across the northern margin of the Variscides in NW Europe, The Geological Society, London, Special Publications, Vol. 14, pp. 149-165.

Acknowledgements

GEL would like to express their gratitude to the funding bodies ERDF and Cornwall Council and to our private investors by acknowledging them in this poster.

GeoScience

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