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Empirical and simulated earth-friendly subsurface geothermal surveillance technology

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1) Introduction

The deep geothermal development at the Eden Geothermal site has shown that, without an appropriate geophysical survey to delineate the resource target (a fluid bearing fault), it is very risky and may dissuade further investment and thus deep geothermal development in Cornwall. It is therefore worth investigating techniques which can reduce such a risk.

There are a number of such techniques available which uses change in the electrical properties of the rock mass to delimited storage of fluid and fault associated with it such as MT, AMT, Adrok and others.

The Electromagnetic (EM) technology that Adrok has been developing aims to locate sources of geothermal heat prior to drilling. Through empirical fieldwork, the EM technology can non-invasively provide a proxy temperature measurement of the subsurface without physical drilling. Key aspects of the technology have been field tested, including depth and capacity to identify water. Furthermore, simulated models have been developed for different European geothermal settings. (Doel et al., 2020).

The EM techniques merit further investigation to enable efficient and optimal exploration of the natural resources useful for geothermal energy generation.

2) Adrok's Methodology

The Atomic Dielectric Resonance (ADR) technology is based on the principle that different materials will reflect and absorb electromagnetic radiation (radio waves) at specific frequencies and energy levels. The ADR geophysical system transmits a pulse of electromagnetic (EM) energy containing a multispectral, patented (Stove G.C. et al, 2023) wave packet that resonates and reacts with the sub-surface materials. The reflections from the subsurface are recorded as a time domain trace and provide information about the location and composition of the materials encountered.

Specification of Adrok's EM System in the field:

- transmits pulsed EM waves into the ground in the frequency range of 10kHz to 300GHz;
- carrier waves (or "Standing Waves") are the high frequencies within the transmitting antenna, modulated by resonances in transmitter result in a pulse with spectral content of 1MHz to 100MHz.
- Pulse Repetition Frequency (PRF) range is 10-200kHz;
- power emitted is less than 5 milliwatts (mW). This is extremely low power and does not damage the solid material it propagates.
- power consumption of the system is 250W;
- power supply to transmitter is 15v DC Li-Ion battery;
- batteries are rechargeable and recyclable;
- majority of raw materials used in the system are selected on recyclability and reusability.

In January and June 2012, the ADR Scanner was independently assessed for signal strength and non-destructiveness by military personnel. E-field measurements were recorded in Volts per metre (V/m). H-field measurements were recorded in milliamps per metre (mA/m). The measurements showed that E-field readings were very weak at less than 1.0V/m at 0.1m to 2m ranges away from the Transmitting antenna. Similarly, their findings showed that the H-Field readings were very weak at less than 10.0 mA/m at 0.1m to 2m ranges away from the Adrok Scanner's Transmitter. Based on the results of this assessment, E3A can conclude that none of the E-field, H-field or power flux density occupational reference levels were exceeded during the trial. Such low readings would not cause any harm to the ground or surrounding vegetation or fauna.

The UN defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The goals are independent but interconnected. An Independent Assessment showed that Adrok contribute positively to 10 of the 17 SDGs. https://www.adrokgroup.com/technology/deeper-faster-greener-cheaper

References

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3) Case Studies

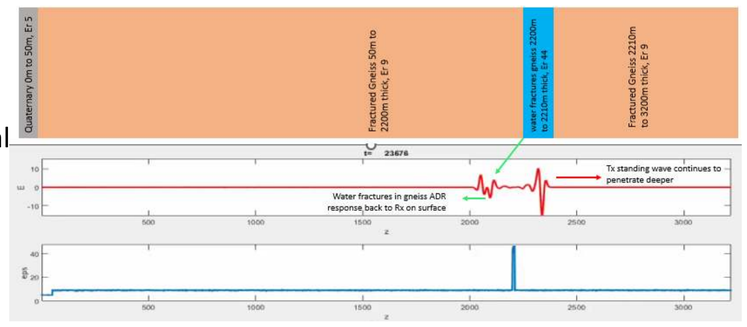
Adrok's EM technology is an environmentally friendly non-destructive way to see below the ground surface for geology. The method of deployment, on the ground, as opposed to airborne or downhole, means that there are zero emissions generation. The only carbon footprint is created by the transportation of the two-person survey crew and equipment to and from survey location (ideally not be aeroplane, preferably by car or train) and a small amount of carbon generation from computer data processors.

The depth of penetration of the transmitted EM wave packets can be tuned to different transmission frequencies and energies (and two-way travel times) to suit different distance scales of propagation through solid objects (Stove, Doel, Edwards, Paling, Scovell, 2023).

Simulated models in different types of geothermal plays:

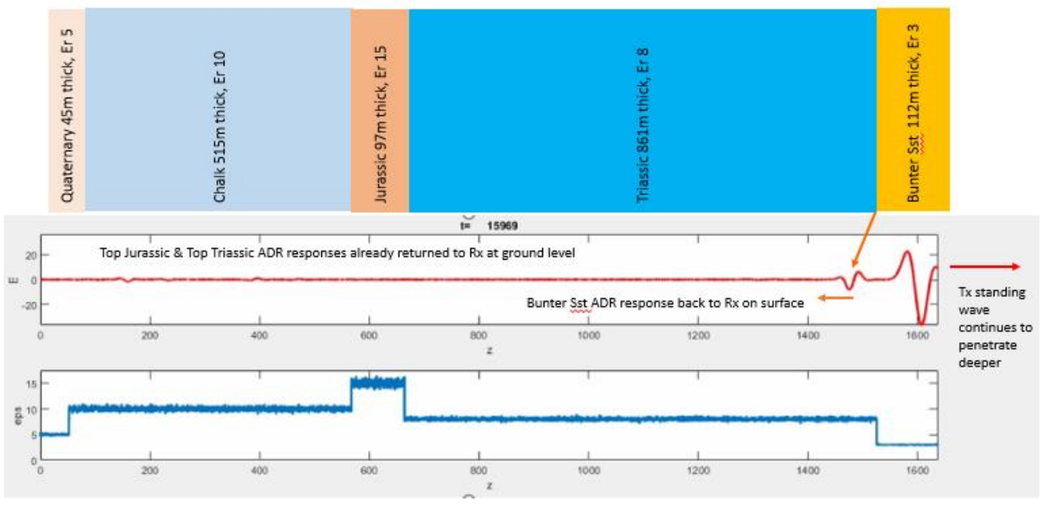
3.1) Rhône Valley, Switzerland

Simulated model input data based on Switz Alps geological data for drillhole Lavey-1 well (Link, K., et al, 2020) and theoretical dielectric values, based on Adrok's experience of similar rock types.

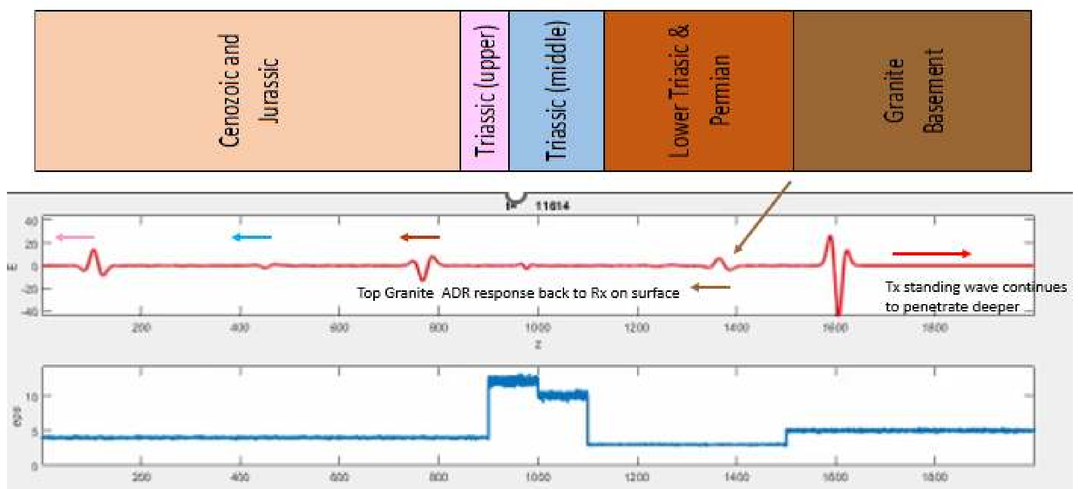


Simulated EM pulse and reflections (red line) modelled against dielectric values in the ground (blue line). Depth below ground level shown in the x-axis. The electromagnetic pulse emitted by Tx enters the ground and subsurface reflections are recorded at the receiver Rx. Noise level is defined as the ratio of the background noise at the receiver and the peak signal when entering the ground.

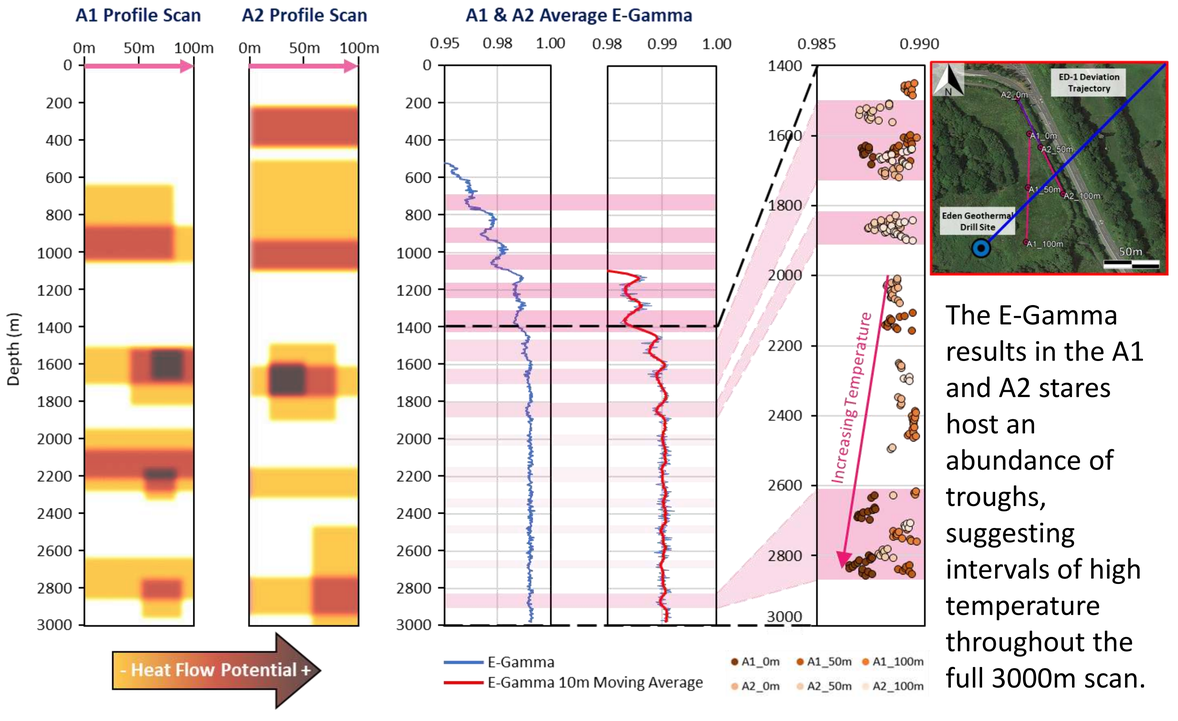
3.2) North German Basin, Denmark (Fuchs, S., et al., 2020);



3.3) Upper Rhine Graben, France (Link, K., et al, 2020).



3.4) Cornwall, Eden Project (empirical EM measures)



The E-Gamma results in the A1 and A2 stares host an abundance of troughs, suggesting intervals of high temperature throughout the full 3000m scan.