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Submission ID

5

Title (required)

Pulsed electromagnetic techniques for non-destructively classifying rocks and rock sequences below the ground to help guide drilling programmes

Abstract (required)

Using geophysics to visualize below the ground is crucial for several reasons, primarily revolving around its non-invasive nature and the comprehensive information it can provide. Geophysical methods can provide information from different depths below the ground surface, ranging from a few meters to several kilometres deep, depending on the technique used. This flexibility allows for a better understanding of subsurface conditions at multiple levels. Most geophysics techniques produce images of the subsurface to highlight structures. There are not many techniques that can classify the rock types and rock sequences below the ground in terms of material composition. The researchers have been working with a pulsed electromagnetic (EM) technique to non-destructively classify the rock types, rock layers and rock sequences in the Earth. This paper presents the findings on 3 separate onshore sedimentary basins in the United Kingdom (UK). The technique provides low cost pre-drilling surveying intelligence to help drilling program decision making (Stove, 2023).

The technology works by sending electromagnetic waves into the ground and measuring how these waves are altered by the materials they pass through, providing clues about the subsurface's electrical and dielectric properties. Since different materials, including various minerals, respond differently to electromagnetic waves, in theory, ADR technology could be calibrated to detect anomalies indicative of different rock types.

The pulsed radar geoscientific system transmits a conditioned beam that resonates and reacts with sub-surface materials. This transmitted the pulsed radar wave packet contains several frequency components in the range of 1-100MHz (Doel et al., 2014) where the low frequencies achieve deep penetration and the higher frequencies enhance vertical resolution. Simulation software has been developed based on ray tracing and finite-difference time-domain (FDTD) for numerical simulation of the pulsed EM wave propagation through various

The technology measures the dielectric permittivity of the subsurface as well as characterizing the nature of the rock types based on analysis of both the spectroscopic and resonant energy responses (Stove, 2018). To highlight key zones of interest, each V-bore was first divided into lithological zones based on the following spectroscopic log responses: Correlation Method, Bandwidth Harmonics, Elog (Energy Log) and WMF (Weighted Mean Frequency). Each graph was systematically divided into individual zones based on where major changes and overall trends occurred within the section, from which overall zones were inferred.

Zones of similar responses are grouped together and a zonation classification of the entire depth column is analysed and interpreted to give a final virtual lithological log. The Zonation technique has been shown to differentiate different lithologies especially, sandstones, shales & limestones (figures 1 and 2).

The specific goals of a pulsed EM survey, such as mineral exploration, hydrocarbon detection, or subsurface mapping, can influence the survey design and, consequently, its cost. Costs can increase with the size of the area to be surveyed, especially in remote or difficult-to-access locations that require special logistics and support. Higher resolution and deeper investigation depth require more time and resources, affecting the total cost. Given the customized nature of EM surveys and the variability in project requirements, costs can range from tens of thousands to several hundred thousand dollars or more. Smaller projects with limited objectives might be on the lower end of this spectrum, while extensive surveys requiring detailed subsurface mapping over large areas could be significantly more expensive. Either way, the pulsed EM method looks like a viable predrilling tool to help guide drilling programmes to help increase success rates in finding key subsurface geological targets, in a cost-effective and environmentally-friendly way.

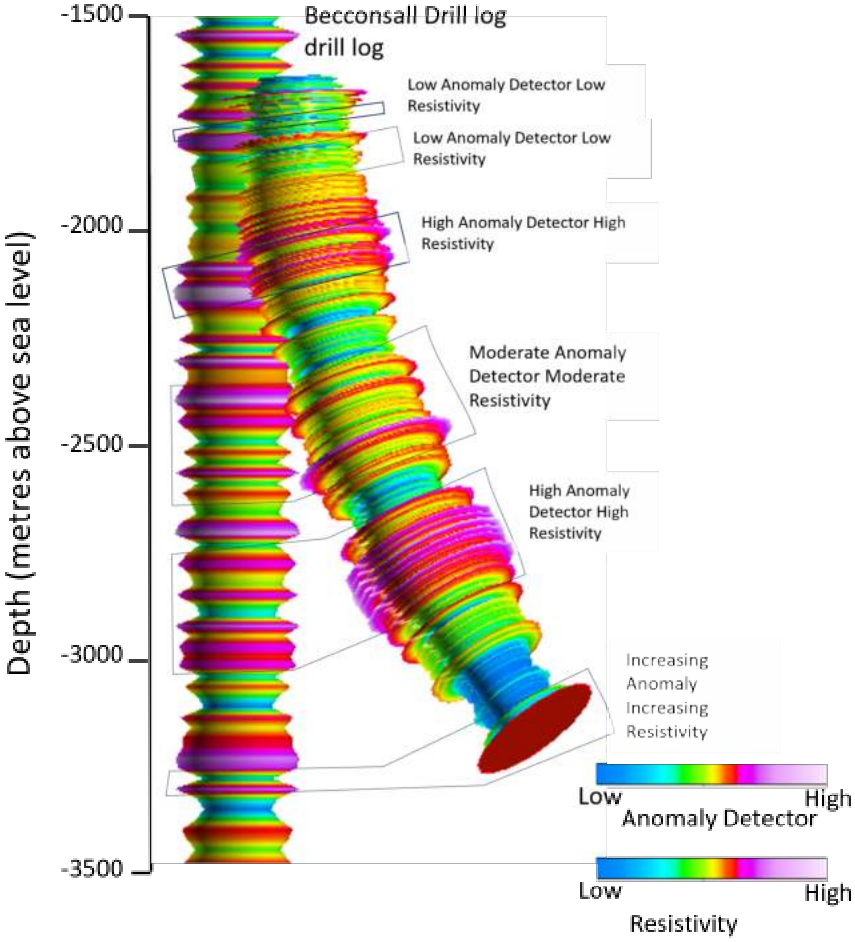

Figure1 - Zonation using anomaly detector trained on resistivity

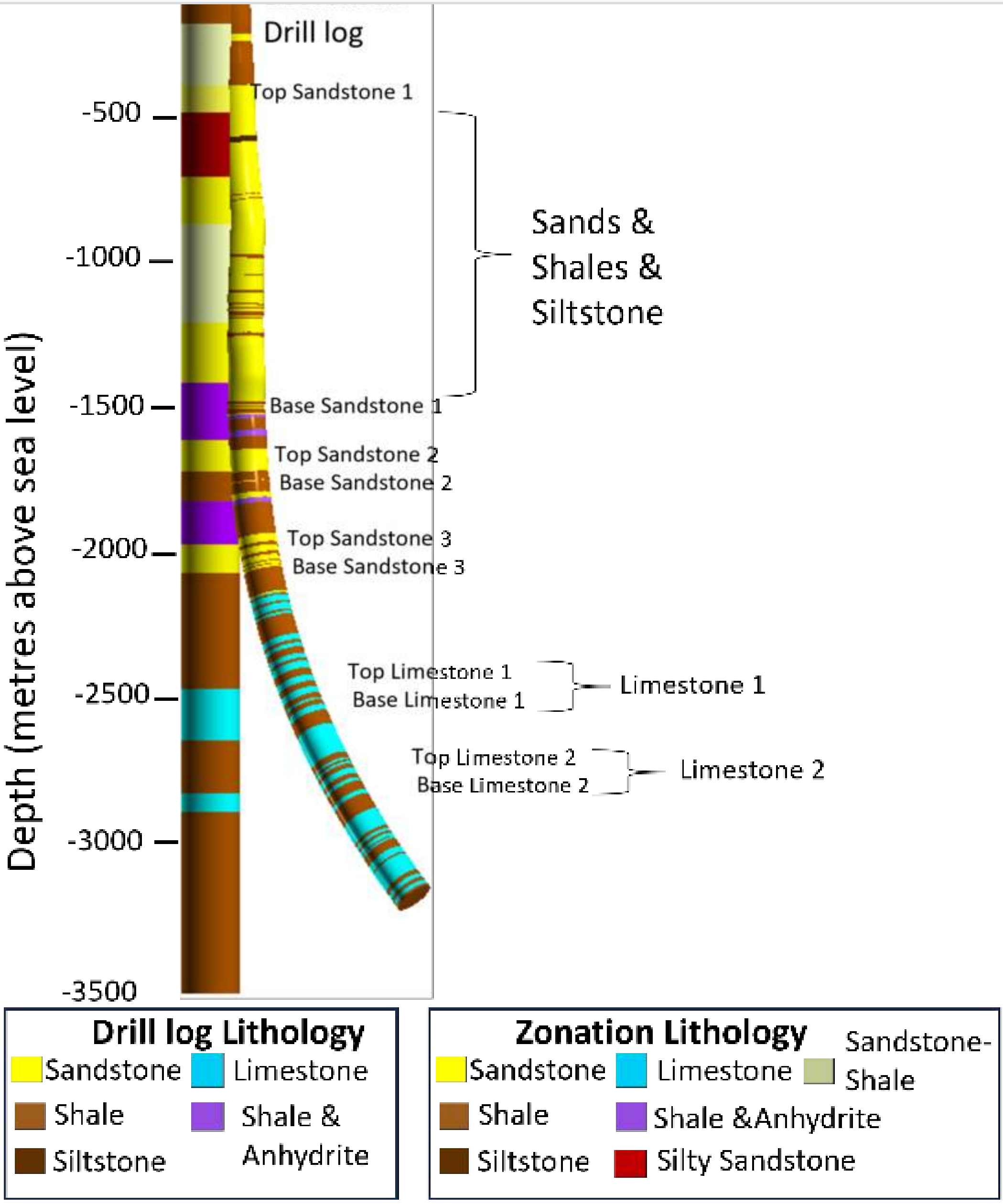

Figure2 - Zonation using reflected energy trained on sedimentary rock layers

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/ PETEX 2024

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