Adrok Technologies
"To Whom It May Concern"

Contents

1 Introduction

This report is an attempt to summarise in a short report, my perspective on Adrok technology, having worked part time as a geological consultant, now for over two years. It is a personal view.

The experience gleaned has been in three onshore UK areas, and the workflows have been continually developing.

2 Response to geology

Always the first question I have wanted to address, is whether the Adrok tool curves are responding clearly to known subsurface geology (potentially including fluid saturations) at known calibration well sites.

I have little doubt after two years that this is the case. There is always a concern that our mind is biased, and prone to see connections where there are none, but the regularity with which sharp lithostratigraphic, well log, or petrophysical contrasts, also manifest in sudden changes in ADR curve behaviour, leads me to believe that the tool is detecting subsurface geology, remotely from the surface.

This kind of analysis is (and sort of should be) totally independent of theory. It is an empirical approach, to find out with an open mind, very simply, what is matching what. This should of course be followed up with an understanding of the theoretical framework to help explain observations, as this will assist attempts to move it into a more predictive realm, and also assist pre-data collection feasibility studies – but it need not be the first step. If we only look for things we expect to find, we place undue limits where there may be none.

That said, recent attempts along these lines, of incorporating theory, have included the use of petrophysical analysis (independently of any ADR results) to model the dielectric constant – a key parameter that the tool aims to detect. These also confirming that tool responses are occurring in the places where contrasts are anticipated. For now, the modelling remains imperfect, but is sufficient to suggest where these contrasts might occur.

3 Uniqueness, correlation, and prediction

However, to be useful, it is not sufficient to just have a response to geologically driven subsurface contrast. For wider usefulness the responses have to be consistent enough and unambiguous enough to make inferences about lithology from particular responses. It is a chase for a uniqueness of response, to find the correct mathematical combinations of data sets that can provide better pointers to lithology and fluid than single curve data sets can on their own.

In short, this has proven the major challenge over the past two years. A variety of methods have been adopted, variously including workflows described in past and current studies as:

- lithological metrics (lith metrics) which mathematically combine different curves,
- the basin specific "lithostratigraphic genome" which uses similarities in multi-curve responses across a pair of wells to extrapolate lithostratigraphy elsewhere,
- and perhaps more simply, as inter-curve correlation coefficients.

For mathematical calculation of the latter, there are three quasi-independent families of data – the raw well logs, the petrophysical curves generated from them (which also incorporate various theoretical petrophysical assumptions), and the ADR curves themselves. To date correlation co-efficient analysis has focussed on the relationships solely within the ADR suite, and visual comparison of these to the other two, but more rigorous mathematical generation between the three suites is an agenda item for ongoing work.

Given the large number of possible pairings in this three-dimensional tensor (roughly of the order ~20x10x10), combined with additional constraints from calibration lithostratigraphy, and theoretical expectations, it may be that artificial intelligence techniques prove more useful and efficient for pattern recognition.

4 Theoretical concerns sometimes raised

It is worth noting that there are some concerns, and when voiced these usually relate to:

- Spurious responses being confused for trends
- Metre-scale depth resolution claims given wave theory constraints
- Noise reduction and repeatability
- Short scale variability

These are recognised and being addressed. The drive to make analysis as mathematical as possible and less dependent on visual inspection is a key feature of workflows I am instigating. Research into further statistical tests to help validate suspected responses mathematically is something that should be considered further, and this is "on-board".

Concerns about depth resolution claims require an addressing of theory that is non-trivial and are outside the remit of this document. Suffice to say the quantum nature of light means that things instinctive to acoustic wave analysis may not always be directly transferable to electromagnetic wave propagation. Readers are referred to the Adrok technical team for further discussions of this matter.

On a purely empirical basis, the frequent correspondence of ADR curve responses, "spot-on" with calibrating well depths, seems to my observations too common to be pure luck. However, it is accepted that "trust us, we know what we are doing" is not enough, and more effort is being made to translate this aspect of the theory into a format palatable to a wider audience, and to investigate ways of further demonstrating that these relationships are statistically significant.

Adrok already goes to some lengths to increase signal to noise ratio by making many thousands of measurements. These would seem to be adequate precautions for noise that is variant over short time frames. Perhaps of more concern is noise that is less variable over the timescale of field acquisition. There is a call from some for more repeatability testing over longer time frames. There are cost implications, but this is perhaps something worth doing in more routinely, because it is a fair point. If the objective is subsurface geological composition and geometry, which is effectively constant over the periods of investigation, then only responses which are consistent over such time frames can be considered candidates for geological signal.

To any geologist accustomed to well log data, the highly variable nature of some ADR curves will be a primary observation made almost instantly (and it is fair to say, at first glance can be disconcerting). The key thing to remember is that atomic dielectric resonance is not called that for no reason. The changes being detected are at atomic scale. Chemical composition and physical microstructure, as well as in a porous rock mixture, the interaction of the different components, are all important. However, on an average basis, certain things should be common to a given lithostratigraphy. That is why average and standard deviation curves, calculated over fixed intervals of data, can (and do seem to) provide further insight.

5 Current status & view

As it stands therefore, clearly there are some things which require further progression, and/or theoretical explanation. Yet in my opinion it is very likely the tool is detecting subsurface geological contrasts, at least on some occasions, to a remarkable degree of resolution. What remains to be done is to extract these responses in a way that can be meaningfully applied for prediction in uncalibrated or less calibrated areas. That is an ongoing challenge, and several routes for doing this are being explored.

Further correlation coefficient analysis to mathematically detect key relationships between the ADR, well log, petrophysical, and lithostrat data suites is desirable to help this. This will in turn help devise the construction of bespoke mathematical metrics to emphasise characteristics of certain lithologies. Artificial intelligence methods (machine learning, deep learning) are also worth considering, and might get to this end-goal quicker than human trial and error methods, but ideally require larger, multiple well data sets, as well as expert input on input data engineering. The dangers of inappropriately applying AI techniques are legion.

The coincidence of strong surface detected ADR tool responses with known geological contrasts detected at wells, should be enough to excitedly raise the eyebrows of any geoscientist. We should be careful in our enthusiasm to not over-trust our own senses and therefore employ mathematical techniques to confirm them, but the extent to which they are occurring suggests that the search for ADR-curve-driven metrics to help constrain lithology and pore fluid fill is worth persevering with.

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