THE POSTER PRESENTATION

- **We're not presenting something here that is the final perfect package.**
- **We're not presenting something that is without the odd frustration – the" what on earth does that mean" feeling?**
- **We are presenting something that increasingly, sends a signal back from the subsurface and we think wow, we can really hang our hat on that!**

INTRODUCTION – FOUR THINGS

- There are four things I'd like you to take away, if nothing else
- **Firstly** - **this is a new and different electromagnetic technology**
  - It's probably unlike things you have seen before
  - It's not like marine CSEM
  - It's not ground penetrating radar
  - In many ways a better analogy is LIDAR
  - Amongst other things, it sees the geology influenced by contrasts in the relative permittivity, or dielectric constant.
- **Secondly** – **from surface remote sensing, it's seeing elements of subsurface geology to km-scale depths and a resolution of a few metres**
  - That makes it very different in a very important way.
  - It's not seeing everything – let's manage some expectations on that
  - But with background knowledge we can confirm in advance what we *might* see.
  - We do see a recognisable tool response from porous sandstones, limestones, and hydrocarbon fluid fill.
- **Thirdly** – **look at the size & versatility of this tool**
  - Its portable in a back pack, it's easy to set up, you can take it anywhere you can walk.
  - It operates on the surface, doing its thing without any need for drilling.
  - That means related studies are cheaper
  - It means it can go places others can't – rough terrain, and urban locations.
  - It might not deliver everything we want to know geologically – but to achieve what it does has significant value worth understanding and developing.
- **Lastly** – **progress in using it predictively is steady and accelerating**
  - Let's not lie, it can be hard and involves lots of processing.
  - The enemies we face are electromagnetic noise and non-uniqueness of atomic level responses.
  - This means we sometimes get blips where we don't expect it.
  - Noise is reduced by repeating the signal many thousands of times.
  - Uniqueness is increased by looking at all the different energy, frequency and phase depth-variables in combination with calibration data at sites of known geology.
  - We use information from these many different outputs to help constrain stratigraphy, lithology, and fluid fill.
  - So one difficult to explain blip here and there isn't the end of the world.
  - There is work to do, but progress is steady.
  - Every new field-study adds to the pool of knowledge and workflow efficiencies.

HOW DID IT HAPPEN, WHAT DOES IT DO, AND HOW IS IT DIFFERENT?

- The technique uses ADR which stands for atomic dielectric resonance.
- It has evolved from an ancestry of early ground penetrating radar and synthetic aperture radar experiments conducted by various militaries and space agencies, including the space shuttle program.
- These researched radar techniques looking at the subsurface from the air or space, and first led to the recognition that narrow beams penetrate deeper.
- Also, that lower frequencies penetrate deeper.
- This is different to ground penetrating radar which is omnidirectional and higher frequency.
- Developments in lasers and LIDAR helped apply similar beam technologies to radio and microwaves.
- Adrok has developed other methods of taking the beams deeper, with the first patent in 1999 and many since.
- The pulsed electromagnetic beams excite a resonant response in the materials that depends on the dielectric constant.
- This is received a bit like a seismic reflection.
- The frequencies used, depth of penetration and depth resolution are hence very different to other subsurface electromagnetic techniques.

SO WHAT? WHAT DOES THE DIELECTRIC CONSTANT TELL US?

- It’s not the only thing the tool observes
- There is a whole lot of spectroscopy too
- But the dielectric constant is a key one
- It’s related to absorption
- It’s the ability of a material to store and release electromagnetic energy.
- What you need to know is that for water it’s about 80 to 81, for hydrocarbons it’s between 1 and 2, and for most minerals it’s between 2 and 10.
- Immediately we see that if we can measure this – we should observe a difference for porous rocks, and we should be able to distinguish pores filled with hydrocarbons.
- The overlaps of values for various minerals means that distinguishing lithologies can be trickier, but with local and lab calibration, progress is possible there.
- Our ability to take the scanner to historical well sites means we can calibrate with known geology – this is supplemented by a library of ADR scanned rock samples from the lab.

WHAT's NEW IN THIS STUDY?

- This study doesn't need the theory – it's purely empirical – to test whether we are seeing geology with the tool's responses.
- Does it do what it says on the tin?
- If so, is it doing so reliably enough to predict subsurface geology at "blind sites".
- An aim in this study has been to analyse things in a way that is mathematically derived from the raw data, and therefore objective, auditable, and repeatable by 3rd parties.
- We've also thought about how best to visualise the data, mathematically highlighting responses and background trends in a way more accessible to the eye.
- **Some steps forward include**:

  Results:

  - Clear indications from tool response of lithology and porosity changes in the Weald Basin.
  - These are confirmed by well calibration to depths of 1.8 km and likely continue to the end of recording – currently at 3km.
  - To be able to do this from a tool at the surface – that - if nothing else should prick our ears up as geoscientists.
  - Indications of HC responses, despite non-optimal saturations and porosities
  - Maturing ability to predict lithostratigraphy and fluid fill utilising paired well calibrations.
    - That's what we have here – we've nicknamed it a stratigraphic genome
    - A curve template from calibration sites applied to a new site
    - Gives a preliminary stratigraphic frame
    - Within which we can then infer HC responses

  Method:

  - The use of mathematical metrics from combined curves designed to highlight responses to geology.
  - We build in petrophysical analysis from historical wells rather than an artificially discrete interpreted lithology.
  - We conduct simple modelling of the dielectric constant and reservoir fluid substitutions, from petrophysical analysis.
  - Allowing us to predict what DC contrasts the tool might see.
  - The modelling at this stage is still crude but it serves to highlight contrasts.
  - Of use as a feasibility study for clients, and for verifying tool behaviour when we do get results.
  - We use this "stratigraphic genome" already mentioned to create a shared ADR lithostratigraphic signature in an area.
  - This anchors responses at new sites and assists prediction.

WHAT OF THE FUTURE?

More. More of the same:

- More testing. Continued applications in mineral, geothermal, and hydrocarbon exploration and production
- That will keep advancing the global data-set and techniques.
- Basin studies where lithology is relatively bimodal will help minimise non-uniqueness issues.
- Deltaic and turbiditic sequences spring to mind, but carbonate-shale and carbonate-evaporite sequences too, lend themselves to this.
- It opens up a whole array of possibilities for exploration and de-risking of fault sealed or stratigraphic compartments and sub-thrust traps.

Something new:

- Adrok has R&D ongoing to achieve a downhole version, to help any modelling and increase calibration.
- But this is a bonus, not a requirement.
- Machine learning pattern recognition amongst the large matrix of curve relationships will address the non-uniqueness issue and assist prediction.
- Geothermal aquifer exploration is growing in importance globally relies on a thick sand with good porosity and permeability character. ADR is well suited to detecting that.
- However, use with district heating requires a nearby urban or industrial customer where shooting seismic would be difficult. ADR is well suited to that problem.
- Geological burial of radioactive waste is designed to be walkaway safe without monitoring, but ADR could be a relatively cheap method of providing additional assurance.

SUMMARY

- **It's new, it sees deep, it sees with hi-res.**
- **It doesn't see everything, it's still in development, and we are still learning.**
- **Yet what it does see already adds value, de-risking exploration and monitoring production in ways and places other techniques can't.**
- **It lessens the need for seismic, helps detect optimal sites for drilling and therefore reduces costs.**
- **In an environment conscious world, completing a further step of non-invasive de-risking before the more intrusive heavy lifters of sesimic and drilling – makes a lot of sense.**