CASE STUDY

ISR Amenability Using WIREBmr™

Honeymoon Uranium Mine (Boss Energy)

Site Profile

Uranium is classified as a critical mineral as it is currently required in all commercial nuclear reactors (*US Department of Energy: Critical Minerals Assessment 2023*). Consequently, it plays a key role in carbon-free energy generation.

In-Situ Recovery (ISR) accounts for ~60% of the worlds production of uranium. ISR is where lixiviants are injected through screened wells to dissolve the uranium within the host formation, then produced from extraction wells. The uranium is then removed from solution, often on site, precipitated, dried, and shipped as U_3O_8.

The Honeymoon Uranium project, located 80 kilometres northwest of Broken Hill, NSW, is an ISR uranium mine initially developed between 2011-2013 and placed under care and maintenance in 2014. The asset was purchased by Boss Energy Pty Ltd (Boss) in 2015. First production on a restart plan covering an area containing 36Mlb is expected in December 2023. Recent drilling has also increased the resource satellite deposit at Gould's Dam to 25Mlb (inferred plus Indicated).

Uranium at Honeymoon is hosted within sand packages predominantly within the Yarramba Paleochannel, part of the greater Eyre Formation. The deposits are tabular type which are formed from a slowly migrating enriched geochemical cell whose source of metal is generally uraniferous granites, which were eroded from the surrounding ranges.

The Situation

ISR amenability, being the viability of a uranium deposit to be mined using ISR, requires two critical parameters: a permeable host formation and favourable hydro- and geo-chemistries.

Porosity, and particularly free fluid porosity (portion of fluid that is in large pore spaces), coupled with mineral and groundwater chemistry form the factors required to properly model the required fluid volumes, injection rates and lixiviant chemistry for effective mining. In addition, formation permeability (hydraulic conductivity) is also a primary driver in assessing resource recovery rate.

Traditionally, formation porosity and permeability are measured on core samples in a lab. Core drilling and analysis can be expensive undertakings and slow to deliver final usable results. They require specially drilled core holes not standard in the ISR space, and often result in misleading answers due to poor core condition. Alternatively, permeability and hydraulic conductivity can be determined via pump and slug tests. However, pump and slug tests require fully installed wells screened in the appropriate zone before testing can even take place, adding to the overall operation costs.

Wireline logging technologies are used extensively in uranium ISR. This is primarily because they offer faster data acquisition, providing data within days of drilling instead of the usual weeks or months. Additionally, wireline technology is more cost-effective compared to alternative methods and provides a continuous dataset, making it a preferred choice for uranium exploration, delineation, and mining.

The preferred methods for estimating porosity in the minerals and Oil and Gas industries typically involve using density and neutron tools. However, when applied to the uranium ISR context, these tools encounter notable limitations. Gamma-Gamma Density tools rely

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on gamma rays, which are typically masked by uranium-rich geological formations. Neutron tools face challenges due to significant energy losses when passing through PVC, the main casing type used in wells drilled for ISR mining; this energy loss renders these tools ineffective as a porosity measuring device after the well has been cased. Finally, direct measurement of permeability is not available, so complex multi-parameter correlations that depend on lithology are used instead to estimate this property based on other geophysical characteristics; this process often introduces significant errors.

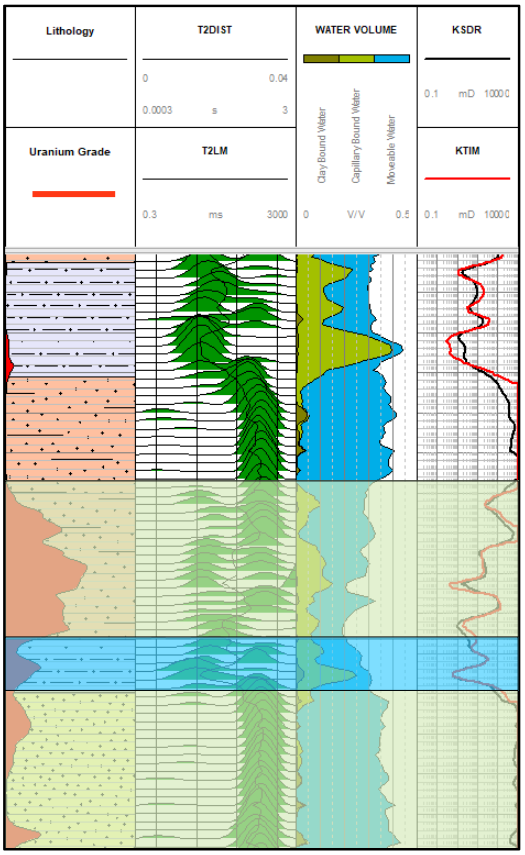
Technical Solutions

WIREBmr™ or Borehole Magnetic Resonance is a downhole geophysics tool that measures water contained in subsurface environments safely and accurately. WIREBmr™ is specifically tuned to sense fluids within the pore network, enabling precise determination of the formation's total porosity, mobile fluid content and bound fluid content. Formation permeability is also calculated without requiring additional wireline data. WIREBmr™ eliminates the need for other wireline methods that may not function well in PVC wells or heavily rely on local calibration, providing a reliable, safer, alternative.

In geological situations where the overall water/brine content remains consistent throughout the borehole but the ratio of free to bound fluids varies, it's crucial to classify intervals as either an aquifer (containing abundant free fluids) or an aquitard (containing mostly bound or no fluids). With WIREBmr™, it becomes possible to break down the total porosity into different mobility categories. This enables accurate estimation of the effective porosity and the identification of fluids trapped in clay and shales, which will not flow under an injection/extraction regime.

The Result

Using WIREBmr™ the mine geology team at Boss Energy now have increased confidence in the reliability of their geological interpretation which was previously based on a combined gamma-gamma density / neutron and resistivity regime. In addition, the team has been able to generate area specific models for porosity and permeability where previously a reliance on sparsely sampled core and pump tests were the only option.



WIREBmr Log: Highlights Uranium accumulation within sand (green) dominated units with minor accumulation in clay dominated units (blue).

The exploration team at Boss Energy have also been able to make more confident decisions faster by quantifying the presence of aquifers and aquitards in exploration areas, as well as whether any intersected grade that is suitable for ISR extraction (high free fluid porosity) or not.

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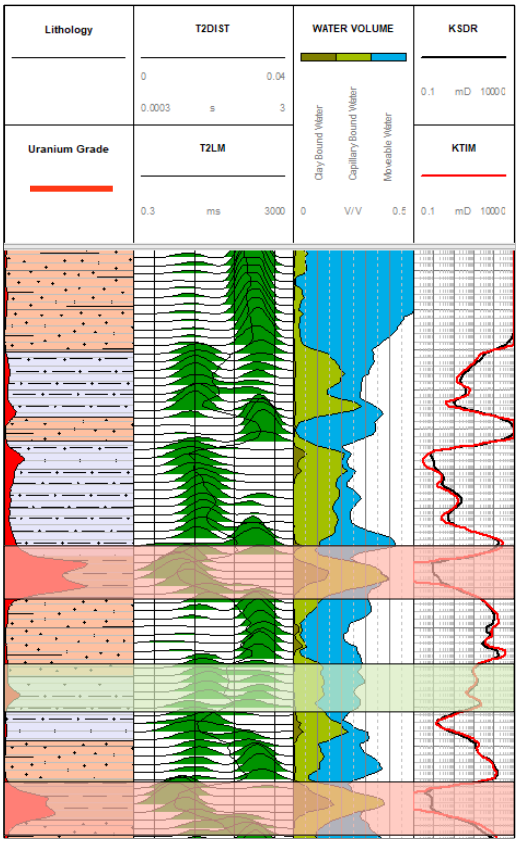

WIREBmr™ Log: Highlights Uranium accumulation within very low permeability clays indicating poor ISR amenability. Minor grade accumulation in sand dominated interval indicates higher ISR amenability in this intersection.

Testimonial

"The BMR has provided us with greater confidence in our lithological interpretation and the planning of our wellfields."

Ryan Gore
Boss Energy, Senior Mine Geologist

Acknowledgements

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