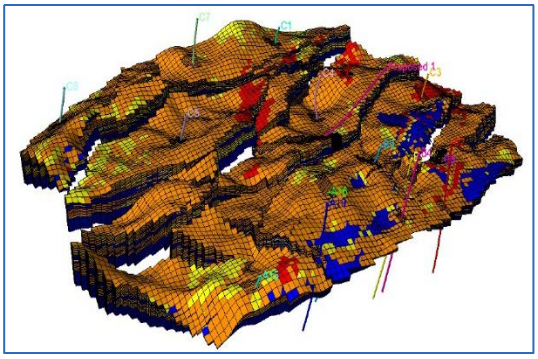
NMR SERVICES AUSTRALIA

Coal Gas Content & Permeability

NMR Answer Products

Need



Coal plays an important role as the primary source of energy for the generation of electricity worldwide. However, the coalification process that converts plant matter to fuel also produces methane and carbon dioxide gases. When mining coal underground, release of those gases presents serious safety challenges through two mechanisms – outburst and explosive gas.

Predicting under what conditions coal walls may pose outburst risk requires knowledge of coal gas content and coal cleat permeability, as these parameters dictate how much and how fast free gas can accumulate behind the wall. That information enables mine operators and regulatory agencies to identify the threshold gas content below which mining is deemed safe. Knowledge of gas content and permeability also enables mine operators to:

- Plan mine layout to minimize methane emissions.
- Size mine ventilation systems in order to maintain unavoidable methane emission below explosive levels.
- Determine whether a particular coal requires gas pre-drainage prior to longwall mining, and if so, plan appropriate well locations and spacings to dewater and drain the seam quickly and effectively.

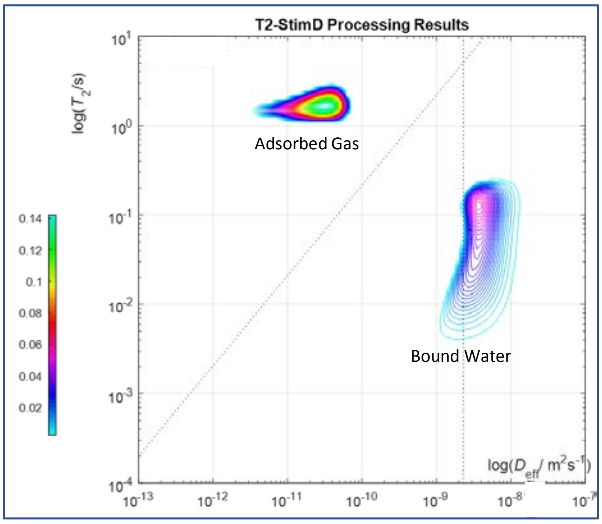
Furthermore, coal seam properties can vary signficantly, over very short distances, both laterally and vertically. As such, successful gas management plans require access to realistic distribution maps of gas content and permeability, based on closely spaced, accurate measurements to adequately capture this heterogeneity.

Existing Methods

Coal gas content (Q_t) is typically measured *ex-situ* using slow or fast desorption methods on freshly cut samples. However, overall results can be greatly influenced by artifacts of the test apparatus and procedures used, by core sample type, sample collection methodology and by the analysis conditions. Even if all these factors are precisely controlled, Q_t accuracy can still be compromised through large errors in Q_1 estimates of gas lost during core retrieval.

It is also possible to quantify permeability from tests on whole cores under precise controlled laboratory conditions. However, accuracy of such tests can be impacted by number of factors, including method used to capture the cores, extent of filtrate invasion, damage to cores during retrieval, poor core preservation at surface, improper re-stressing of cores in the laboratory, re-stress hysteresis of cores, and scaling effects (core diameter relative to primary, secondary and tertiary fracture network spacing).

New Method



Total gas content and system permeability can be determined *in-situ* using Nuclear Magnetic Resonance (NMR) technology. As borehole NMR is specifically tuned to sense the fluid-filled cleat structure and coal matrix nano-pores only, measurement accuracy is completely unaffected by matrix composition, and so does not need to be calibrated for coal type, grade or ash content. This superior response capability contrasts the lithology-dependent measurement principle of conventional logging tools. A proprietary NMR excitation pulse sequence and analysis technique, referred to as ***T2-StimD***, has been developed to detect and quantify adsorbed gas content in the coal matrix, as well as any free gas content in the cleat structure. Coal system permeability is also derived from analysis of NMR responses.

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BMR Features & Benefits

While NMR has been used routinely in the oil and gas logging industry for decades, uptake by the coal mining industry has, until now, not been possible, due to NMR tool size, cost of the logging service, and lack of scientific knowhow to detect gas in the adsorbed state using NMR. NMRSA have addressed this capability gap through development of an advanced miniaturised, slim borehole Magnetic Resonance (BMR) logging tool.

- Advanced NMR pulsing sequences and signal processing techniques enable adsorbed gas to be determined with a high degree of precision and accuracy.
- Exceptional measurement repeatability enables changes in gas content over time, as a result of site pre-drainage, post dewatering mining operations and groundwater recharge from rainfall, to be tracked through repeat BMR logs.
- Ultrafast wireline telemetry, complemented by powerful analysis software, enables a detailed log of these geophysical parameters to be generated real-time.
- Despite miniaturization, the BMR logging tool has impressive signal-to-noise (SNR) characteristics, resulting in a large depth of investigation.

The Right Data for the Best Value

To fit inside the typically small diameter boreholes drilled to explore and delineate coal deposits, development of the BMR logging tool necessitated a high degree of hardware miniaturisation and implementation of new, advanced NMR excitation and NMR relaxation measurement techniques, posing major technical challenges. These challenges were successfully overcome through pioneering applied research, innovative design and a number of inventive steps. As a consequence of these breakthrough achievements, BMR is able to deliver high quality, high density actionable data, on a wide range of geophysical pore-related parameters, providing an in-depth view of coal gas content and permeability distribution. Furthermore, owing to the simple method of use and minimal support equipment and personnel requirements, the BMR logging service also delivers best value in comparison to other alternative methods, as showcased in the table below.

	BMR Logging	Conventional Logging	Coal Desorption Testing
In-situ measurement	✓	✓	✗
Measurement accuracy[1]	✓✓✓	✓	✓✓
Gas content	✓	✗	✓
Permeability	✓	✓	✓
Real-time data	✓	✓	✗
Continuous depth profile	✓	✓	✗
Crane-free operation	✓	✗	✓
Test speed[1]	✓✓	✓✓✓	✓
Test efficacy[1]	✓✓✓	✓✓	✓
Test cost[2]	$$	$$$	$
Cost benefit ranking	1	3	2

NOTES

1. ✓ = worst, ✓✓✓ = best
2. $ = least costly, $$$ = most costly

