Iron Ore Moisture Content

Need

As iron ore deposits in the vadose zone are depleted, mining companies are forced to extract ore below the water table, where moisture content is much greater. There is a strong business case for understanding in-situ ore moisture content and dry weight density as well as vadose zone porosity and permeability, and mapping variations vertically and laterally throughout the ore deposit and overburden. The resulting distribution models will benefit a variety of technical disciplines within asset teams responsible for each area of the value chain, from resource evaluation to shipping. Specifically, the insight provided by these distribution models help to shape drainage strategies, lead to understanding of ore handleability, guide crushing plant design, optimize operational feed and determine extent of blending required for final safe shipment.

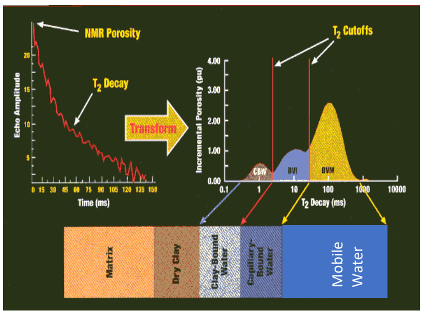
Beneficial uses of 3D moisture content, specific yield & dry weight density distribution models

Geophysicists	Ore porosity and moisture content distribution used to determine blend for feed stock to the crusher
Metallurgist	Ore dry weight density fed into mine plans for resource calculations
Geologist	Ore porosity, moisture content and dry weight combined with OTV/ATV to pick open and closed fractures
Hydrogeologist	Vadose zone poro-perm data is used to model groundwater recharge rates, develop pre-mining dewatering strategies, develop water re-injection from dewatered areas and guide mine planning (dewatering can take 1-2 years)
Geotechnical	Track changes in Free Fluid Volume to Bound Fluid Volume (FFV/BFV) ratio to monitor pit slope stability

Blending must comply with the Transport Moisture Limit (TML) specified by the IMSBC Code. There are substantial economic benefits to minimising ore moisture in the final shipped product. Ore porosity can reach ~40%, with moisture content below the water table rising to ~16%. A 1% reduction from 9-8% represents potential savings of $63M, based on freight costs from Australia to China (680 Mt production at a typical freight cost of $8/t). For Brazil, with a higher freight cost of approximately $20/t, the potential savings for 340Mt of iron ore are $81M. However, the complex nature of local pit geology, coupled with factors affecting ground water movement, leads to a high uncertainty in determining **in-situ** ore moisture, using traditional **ex-situ** measurement techniques.

New In-Situ Method

Traditionally, ore moisture content is determined **ex-situ** by drying samples in an oven and comparing sample mass before and after. This measurement, specific yield, specific retention, dry matrix density and permeability can now all be directly measured **in-situ** using Nuclear Magnetic Resonance (NMR) technology. As borehole NMR is specifically tuned to sense the fluid-filled pores only, measurement accuracy is completely unaffected by matrix composition, and so does not need to be calibrated to formation lithology. This superior response capability contrasts the lithology-dependent measurement principle of conventional logging tools.



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BMR Features and Benefits

While NMR has been used routinely in logging of oil and gas wells for decades, uptake by the iron ore industry has been hindered by NMR tool size and cost of the logging service. NMRSA have addressed this capability gap through development of an advanced short, miniaturised borehole Magnetic Resonance (BMR) logging tool.

- Advanced NMR pulsing sequences and signal processing techniques enable iron ore total moisture content, specific yield and specific retention to be determined with a high degree of precision and accuracy.
- Exceptional measurement repeatability enables changes in moisture distribution 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.
- Raw data transmission, complemented by a powerful analysis software, enables a detailed log of these geophysical parameters to be generated real-time.
- Despite miniaturisation, the BMR logging tool has impressive signal-to-noise (SNR) characteristics, resulting in a large depth of investigation.
- High SNR, coupled with rapid data acquisition and processing, enables variation in geophysical parameters through the aquifer to be mapped while continuously logging at 1 m/min (~200ft/hr).

The Right Data for the Best Value

To fit inside the typically small diameter boreholes drilled to explore and delineate iron ore deposits, development of the BMR logging tool necessitated a high degree of hardware miniaturization 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 moisture content distribution and mobility. Furthermore, owing to the simple method of use and minimal support equipment and personnel requirements, the BMR logging service also delivers the best value, as showcased in the comparison table below.

	BMR Logging	Conventional Logging	Ore Sample Testing
In-situ measurement	✓	✓	✗
Measurement accuracy[1]	✓✓	✓	✓✓✓
Total moisture	✓	✓	✓
Specific yield	✓	✗	✗
Specific retention	✓	✗	✓
Dry weight density[2]	✓	✗	✓
Real time data	✓	✓	✗
Continuous depth profile	✓	✓	✗
Crane-free operation	✓	✗	✓
Test speed[1]	✓✓✓	✓✓	✓
Test efficacy[1]	✓✓✓	✓✓	✓
Test cost[3]	$$	$$$	$
Cost benefit ranking	1	3	2

Notes:

1 ✓ = worst, ✓✓✓ = best

2 In combination with bulk density measurements from conventional logs

3 $ = least costly, $$$ = most costly

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