SCOTLAND

Over the top and from a bogie - logging at the Harry Potter viaduct.

DENMARK

Three new Danish offshore wind farms by 2030.

SAUDI ARABIA

Optical Televiewer logging for phosphate exploration.

ROBERTSON GEO

Unlocking Your GeoData

GeoUnlocked©

GLOBAL GEODATA NEWS

ISSUE 09 | SUMMER/AUTUMN 2020

Hydro-electric power scheme

GRAMPIAN MOUNTAINS

Televiewer and Caliper Gamma Survey

DERBY

Borehole Nuclear Magnetic Resonance

JAVELIN PROBE

RGeo-eye®

Introducing the new four-core 3,000m high speed wireline borehole camera

England

Robertson Geo Services logging at Hinkley Point C Nuclear Power Station - probably Europe's largest construction site.

INSIDE:

FOUR PAGE EDITORIAL INSERT

RGeo-eye®

The new four-core 3,000m world first high speed wireline borehole camera system

EDITORIAL

ROBERTSON GEO
Unlocking Your GeoData

Changing times

A rapidly changing operating environment has emerged since the last publication of our magazine amid the continuing threat of the Covid 19 pandemic. Here at Robertson Geo we have adopted rigorous procedures and practices to ensure a safe work environment for our staff as we continue to support our customers with technologies and services from our geophysical portfolio.

Our service teams have continued to work on locations both on and offshore and our manufacturing, quality control and engineering teams have adapted to new work methods, enabling Robertson Geo to continue to be "open for business", while respecting the safety guidelines necessary to protect our staff and customers in these difficult times.

In this issue we announce the introduction of a new four core borehole camera system, **RGeo-Eye®**, which brings a new dimension to real time downhole vison. It incorporates the first use of Robertson Geo's innovative **RGeo-fast®** communication technique that delivers reliable 1 megabit/sec communication speeds over wireline for unmatched performance in the acquisition of high quality video feed from deep subsurface applications.

This new camera system is the beginning of the introduction of a series of ambitious and innovative technologies resulting from our extensive R&D programme as we continue our positive commitment to remain at the forefront of the global geophysical logging industry.

Our thanks and best wishes to all - stay safe.

Simon Garantini
Managing Director

The **Glenfinnan Viaduct** famously featured in the Harry Potter movie series. It was opened in 1901 after a four year build using a then pioneering technique called "mass concrete", involving the use of concrete cast in-situ by means of shuttering and without internal reinforcement.

Over the top and from a bogie
Logging at the Harry Potter viaduct

THE BRIDGE IS 380m long and 30m high comprising 21 semi-circular spans which support a single-track rail line which runs from Fort William to Mallaig, Scotland.

An inspection of key parts of the underside track bed was required. This involved drilling 10 x 102mm diameter boreholes horizontally into the top of the arch supports some 3m below the track level, through more than 1m of concrete. This revealed cavities which allowed visual access to the underside of the track bed. Several solutions to imaging the track bed were considered with Robertson Geo offering a camera system which could provide sufficient light to illuminate the internal structure. All borehole operations required the use of rope access from above - at night - the only time when the track was available.

The camera deployed was an Aries Industries BT 9000 series with a bottom and rotatable side facing camera, together with a powerful integrated light source. Due to the known access issues two different surface systems were mobilised for the operation to ensure success.

For the first night, a portable system was deployed from a bogie on the rail track above. This involved moving all the surface equipment up a steep track where it was installed in a tent on the bogie (as rain was a possibility).

For the second night it was decided that the operation would be simplified if utilising a system based on the logging vehicle being located on the ground. Some 250m of cable were hauled up to the track and secured, enabling access to all the boreholes with less equipment at the top.

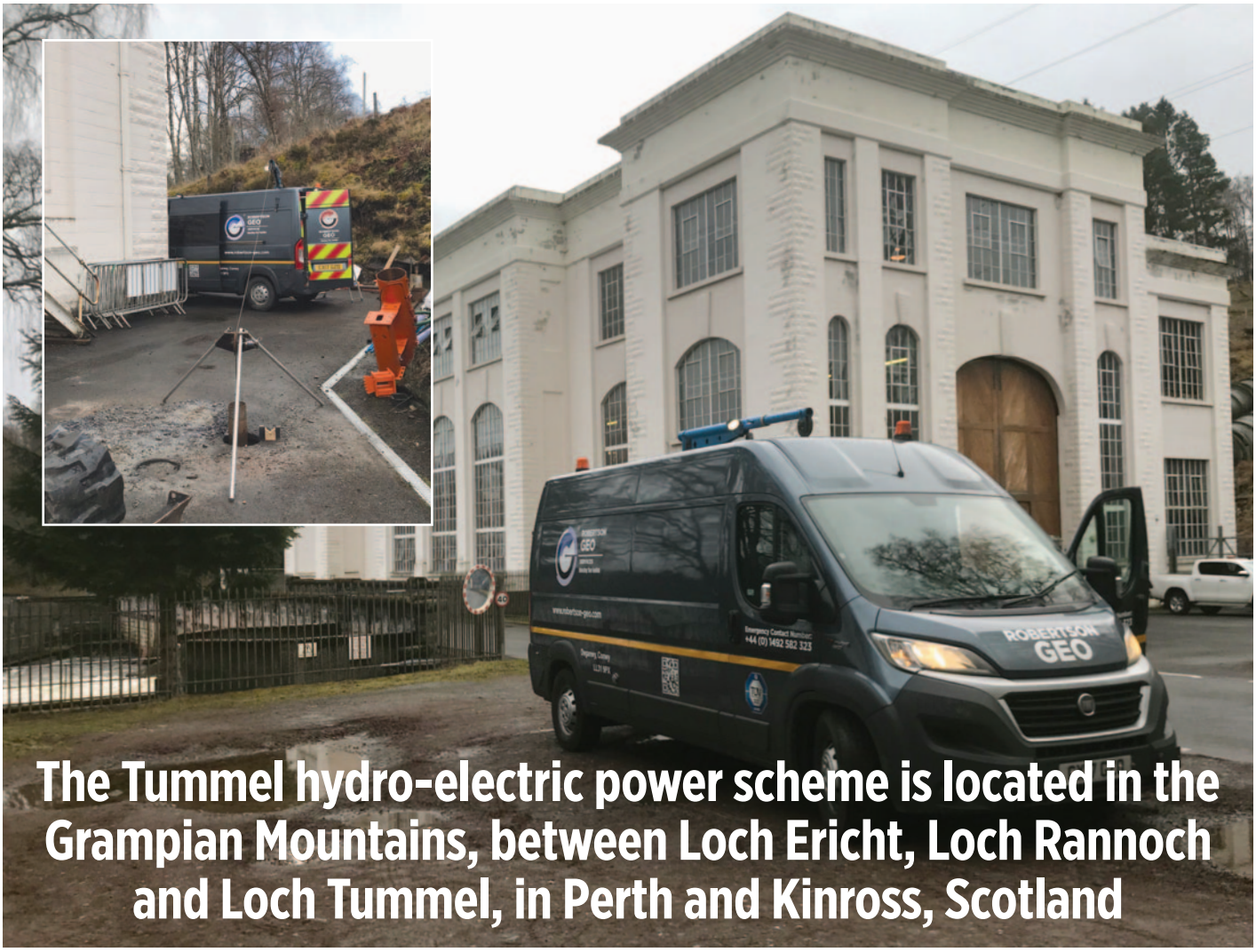
For each borehole the roping engineers would set up and drop over the side of the bridge to a position ready for the camera. The camera was lowered down by rope and the engineers would insert it into the horizontal borehole. One Robertson Geo engineer managed the recording and a second engineer set up the camera at the borehole. Communication was maintained between the Robertson Geo engineers in order to instruct the roping engineers on where to position the camera.

Once inserted in the borehole recording was started and the camera was slowly pushed into the borehole until the side camera had emerged into the cavity. The camera was then held steady while the side camera was rotated giving an image of the underside of the track bed. When complete, the camera was withdrawn and hauled back to the rail track level. The roping engineers then climbed back up, rigged down and moved onto the next borehole.

The project presented a number of challenges:

- **Limited vehicular access in remote location**
- **Two surface systems deployed to cover all possibilities**
- **Working at night - Head torches and portable lighting used**
- **Communications - Clear procedures were essential**
- **Horizontal boreholes 30m up - Coordination required with roping engineers**
- **The Infamous Scottish midge swarms - Mosquito hats required**
- **Overall H & S - Risk assessments, inductions and liaison between all parties, full PPE worn**
- **COVID-19 safety protocols - Social distancing required throughout**

This project was carefully and professionally managed with no H & S incidents throughout. The client was able to see the images in real time for QC purposes and the quality of the images was sufficient for the objectives to be met. All parties were very happy with the outcome given the number of potential problems that had to be overcome.



The Tummel hydro-electric power scheme is located in the Grampian Mountains, between Loch Ericht, Loch Rannoch and Loch Tummel, in Perth and Kinross, Scotland

THE WATER FLOWS from Loch Rannoch down to Loch Tummel via a small reservoir at Dunalastair, from which it is carried in a 15m wide aqueduct to the next power station at Tummel Bridge.

The two generating sets, completed as early as 1935, can produce a total of 34MW and they are unusual in that each turbine has two horizontal runners and spiral casings. This 34MW output is now being upgraded to 45MW.

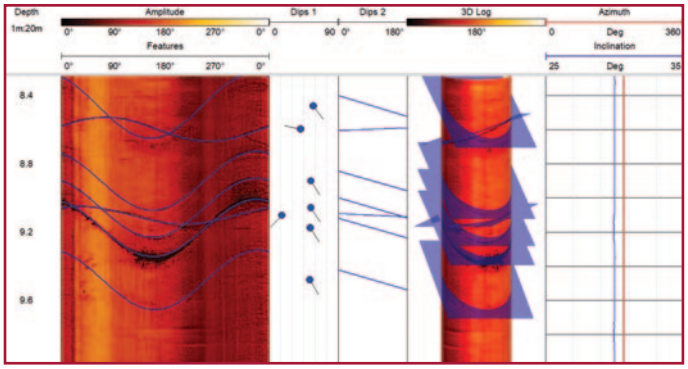
Robertson Geo are contracted to run Optical and Acoustic Televiewers to identify any present fractures. Multiple boreholes have been logged, with the majority being inclined at 30 degrees from the vertical.

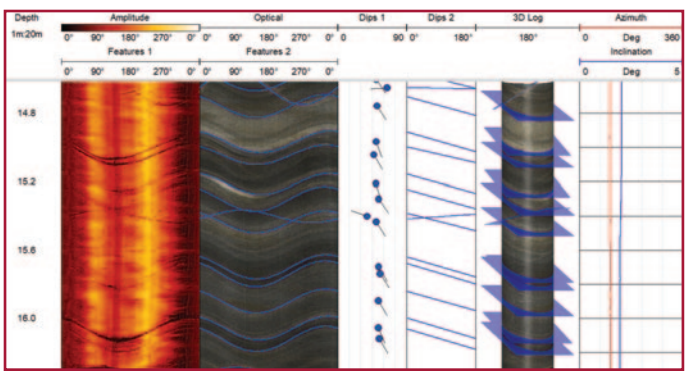
The High Resolution Optical Televiewer (Hi-OPTV) provides a continuous very high resolution-oriented image of the borehole wall using a conventional light source. A unique optical system based on a fisheye lens allows the probe to survey 360 degrees simultaneously. This information is processed in real time to produce a complete 'unwrapped' image of the borehole oriented to magnetic north.

In addition to the image data being inspected in real time as the logging proceeds; upon completion of the log, the image can be viewed in detail if immediate results are required. The fast turnaround of images in the field is now a common requirement for geotechnical personnel and geologists who need to make quick decisions on depths for further tests or for installations. This is requested on this application.

All Televiewer data is fully oriented, usually with respect to magnetic north. The tilt and azimuth of the borehole is always recorded to allow correction to true vertical depth and to provide automatic correction for the delineation of features.

Data processing of acoustic and optical images is normally performed in the same way. An empty log is placed over the image and populated by manually picked orientations; sinusoids are fitted over selected features. After picking, the features can be displayed as a tadpole plot, slab core, rose and polar diagrams and other various options.





ROBERTSON GEO
Unlocking Your GeoData

RGeo-eye®

New Four-Core 3,000m (10,000ft) world first high speed wireline borehole camera system

Seeing is believing

Seeing is believing

GeoDrilling International gets an exclusive first look at Robertson Geo's RGeo-eye – a world-first four-core, high-speed borehole camera system

Above: RGeo-eye is a world-first from Robertson Geo, a slimline, full-colour, downward view camera, operating on a four-core or coax cable at a high transmission rate

RGeo-eye is a slimline, full-colour, downward view camera, operating on a four-core or coax cable at high transmission rate and is fully compatible with existing Robertson Geo winches and surface systems.

Borehole video cameras have a wide variety of applications including borehole and casing integrity inspection; water well monitoring; surveillance of mines, shafts, caverns and voids; pre-logging borehole examination; assessing concrete piles and damage detection in dams, bridges and subsurface structures. Video logs are being used globally across a variety of sectors including the water industry, for geotechnical inspections, in the mining industry and for oil and gas applications.

Video logs are a cost-effective method of inspection, providing data that cannot be obtained by other means and are now being routinely adopted across a variety of sectors in many diverse applications.

"Video logs are a cost-effective method of inspection"

Local and industry regulations often require video inspection of newly installed well casing and many consultants and contractors require verification that the well was installed in compliance with the design criteria of the geologist or engineer. The video log then constitutes part of the permanent record of the well and can be used as an integral component of the contractual acceptance procedure.

A video log can capture the depth of static water level, total depth of the well, joint condition, location of perforated section(s) and detection of any anomalies that could have appeared during installation.

For water wells, downhole video logs are an essential way to monitor the condition of existing or previously used wells and to investigate potential causes of production loss. A video log can collect visual proof of casing condition, downhole pump condition, biological build-up on the well casing and perforated sections, loss of filter pack material and damage to casing which could allow ingress of sediments potentially leading to pump failure.

High-quality video data, especially when collected routinely, can be used to identify potential failures before they happen. This ensures that the condition of the well is kept optimised, saving significant costs in well repairs whereby remedial action can be undertaken in a controlled manner avoiding operational crises.

In some instances, maintenance itself may result in damage to a well. The act of removing or installing a pump, treating or attempting to repair casing or attempting to remove a blockage can have unexpected consequences such as pump detachment or damage to the column pipe, well casing or electrical wiring. Videos logs are useful in these instances, as they can identify lost equipment, such as a pump, tools, tremie pipes or drill string rods accidentally dropped down the well. With a diameter of only 43mm the RGeo-eye camera can easily descend past column pipes to view a pump without disturbance.

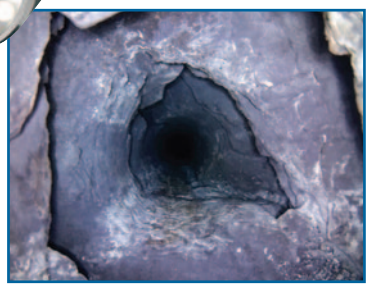
In the mining industry, video logs are used for the inspection ►

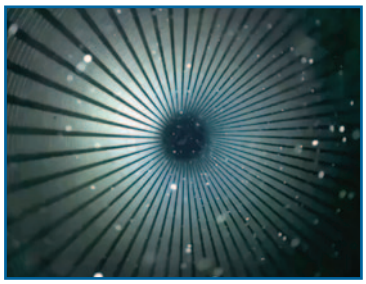
RGeo-eye®

ROBERTSON GEO
Unlocking Your GeoData

New Four-Core 3,000m (10,000ft) world first high speed wireline borehole camera system

Seeing is believing





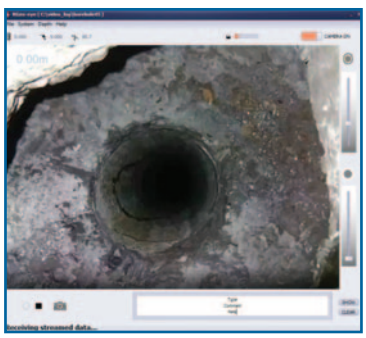
RGeo-eye®

is a slimline full colour downward view camera, operating on a 4-core or coaxial cable at high transmission rate, fully compatible with existing Robertson Geo winches and surface systems.

It offers pressure ratings of 5000psi and a minimum 75°C temperature rating (with 85°C & 100°C versions to be released in Q4 2020 and a 125°C version in development).

The software package provided with the RGeo-eye® camera system allows extensive operator control including – video resolution, frame rate, lighting, white balance, 'snapshot' mode and real time video annotations. Video is recorded in AVI and converted to MP4 for storage and replay.

RGeo-fast® *delivers a world beating 1 Megabit/sec communication speed for high resolution video feed from downhole in air or water filled open or cased boreholes while allowing real-time viewing.*



The acquisition software allows screen shots to be captured and text editing while viewing/recording. Where more detail is required, full colour 'snapshot' images can also be captured at 1600 x 1200.

www.RGeo-eye.com

RGeo-eye at a glance

- The RGeo-eye camera system is a new introduction of a design and build development by the North Wales-based OEM Robertson Geo. It has a deep operating range, operates on industry-standard four-core wireline cable, and offers pressure ratings to 5,000psi and a minimum 75C temperature rating. It is set to lead an exciting and innovative development of downhole camera use for the geophysical data market
- The system incorporates RGeo-FAST delivering one-megabit/sec communication speed enabling the acquisition of high-resolution video feed from downhole (to 3,000m) in air or water-filled open or cased boreholes while allowing real-time viewing for the surface operative
- The camera has autofocus, a frontal LED internal array with adjustable lighting intensity, and a viewing resolution of SVGA (800 x 600) at 25 frames/sec
- The acquisition software supplied with RGeo-eye allows screenshots to be captured and text editing while viewing/recording. Where more detail is required, full colour 'snapshot' images can also be captured at 1,600 x 1,200
- First release of the RGeo-eye camera is rated at 75C with 85C and 100C versions to be released in Q4 2020. A 125C version is also in development for release by mid-2021
- The software package provided with the RGeo-eye camera system allows extensive operator control including – video resolution, frame rate, lighting, white balance, 'snapshot' mode and real-time video annotations. Video is recorded in AVI and converted to MP4 for storage and replay.

The RGeo-Eye is a robust, easy to deploy downhole camera at 1,000 x 43mm and only 5kg

of shafts, drifts, old stopes, risers, roofs or mine workings that may be unsafe to enter.

Videos can also be used to safely inspect flooded underground workings. For flooded workings and for dewatering projects a video log can be used to record water level conditions where they are not continuously monitored. This can help determine if the pumps are working efficiently or if pump capacity needs to be increased.

For exploratory boreholes, prior to geophysical logging, a video log can determine the depth of surface casing, location of lithological contacts, water level and areas of possible blockages or washouts with videos also being an accurate way to detect contact and fault zones. They can be used to identify fractures and locate cascading water entering the borehole above static water level.

In piling applications, video cameras can be utilised for the internal and external assessment of deep concrete piles. When investigating historical piling, where there may be a paucity of information regarding the details of the installation, there is sometimes little choice but to conduct some exploratory drilling.

Boreholes can be drilled into the pile itself and the camera video can then reveal the pile depth, confirming the pile is in the rock socket and to determine the underlying lithology, concrete composition and condition, as well as detecting voids, inclusions, fractures and discontinuities from the concrete pouring process. Where additional proof of compliance to rigorous standards is required, sample piles may be drilled internally and video logged to confirm the integrity of the installation.

For geotechnical applications, videos can be used for dam safety, bridge inspection and underwater pilings. Camera use for reservoir or dam safety includes the inspection of outlet works to identify any evidence of jointing and cracks, or to help detect ingress or egress of water seepage within the works conduit.

Across all sectors, the drilling process itself can sometimes be halted by problems such as loss of drilling fluid circulation, unexpected voids or downhole problems with equipment. In order to first understand and then rectify the problem a video inspection can often be the most cost-effective solution. In many cases the slimline RGeo-eye camera can pass through the drill string and bit without the need to remove the whole drill string.

Future developments planned for the RGeo-eye camera include a software facility to extract a 360-degree side view from the data and additional lighting options to provide illumination for voids and caverns and shafts up to 1,000mm diameter

In a world where social, environmental and corporate responsibility are now pre-requisites, the need for robust digital records are essential for conformance to standards across all sectors. Video logs can augment the compliance process by providing an irrefutable image record in a highly cost-effective manner. Seeing can be truly believing.

"A video inspection can often be the most cost-effective solution"

Three new Danish OFFSHORE WIND FARMS by 2030

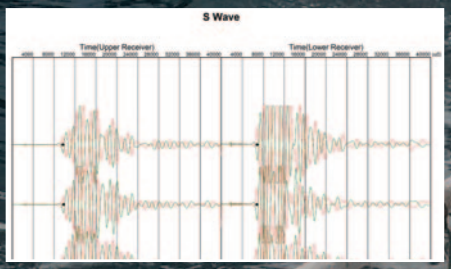
Robertson Geo's 2,000m marine winch secured to the drilling deck with the PS Logger laid out to its left and ready to be deployed.

BY CONSENSUS OF political parties in the Danish Parliament and as part of the Energy Agreement of June 29, 2018 three new offshore wind farms are to be established before 2030.

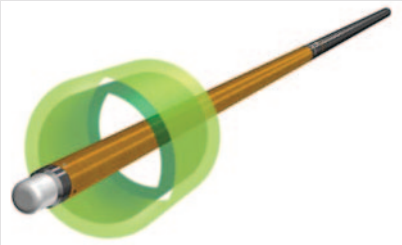
Fred Olsen Windcarrier's jack-up vessel Jill is nearing completion of the preliminary geotechnical surveys at the Thor offshore wind project. The wind farm is planned to have a capacity of minimum 800 MW and maximum 1,000 MW and planned to be in full operation no later than 2027. The offshore wind farm will be established in the North Sea, west of Nissum Fjord, some 20 km from shore and will be named "Thor" after the name of the town "Thorsminde".

As part of the preliminary geotechnical surveys, Robertson Geo conducted PS Logger operations on four 70m boreholes over a two-week period. The geology encountered was mainly moderate to stiff clay with some dense sands, predominately producing excellent data from the PS Logger with both the compression and shear waves being well defined.

The PS Logger probe measures P (compression) and S (shear) wave velocities in a single borehole without the need for external energy sources, making it simple and quick to deploy. When combined with bulk density values (from a density log or in this case from core sample tests) small strain moduli (Young's, Shear and Bulk) can be calculated using simple formulae. The data is logged and processed onboard by the Robertson Geo service engineer and further assessed at the HQ by a senior engineer.



Robertson Geo and **OEM Vista Clara Inc.** have collaborated to bring their **Javelin JPY238 NMR Probe** into the UK market for application in geotechnical/hydrogeology investigations.



Borehole Nuclear Magnetic Resonance (NMR) for Geotechnical and Hydrogeological Applications

What is Borehole NMR?

Borehole NMR is a technique that measures fluid volumes and the distribution of those fluids as a function of pore geometry enabling detailed characterisation of the storage and flow capacity of subsurface formations.

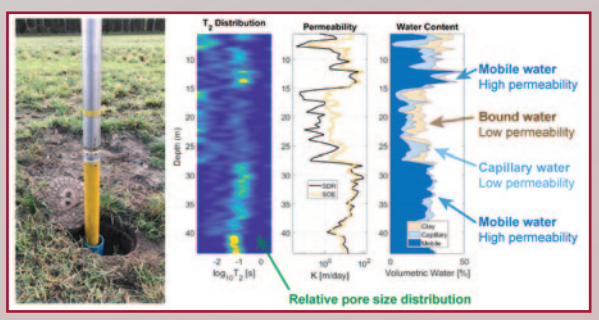
The History of NMR

The phenomenon of nuclear magnetic resonance, discovered in the 1930's, is the ability of atomic nuclei to absorb RF energy of specific frequencies when placed in a strong magnetic field. After many years of development work, earning Nobel Prize awards, technology was developed using this principle for many applications including the MRI scanner used today in medical imaging. The technology was also developed as a downhole wireline probe for use in the oil and gas industry. Finally, with reduced costs, borehole NMR has found its place in groundwater investigations for geotechnical and hydrogeological purposes.

How Borehole NMR Works

Using RF frequencies selected to influence only Hydrogen nuclei, a powerful permanent magnet and a sophisticated RF transmitter/receiver are used to align, precess and then measure an induced RF signal from the nuclei. The nuclei are thus "excited" and the rate of decay measured.

Hydrogen nuclei in water are naturally randomly aligned magnetically. By applying a strong magnetic field for a period the nuclei can be aligned (longitudinal). The RF transmitter then tilts the nuclei through 90° (transverse) and nudges them at a specific frequency such that they wobble or precess in phase. This precession generates an oscillating RF signal which decays as the nuclei de-phase and can be detected by the receiver. In practice a precise sequence of electromagnetic pulses (CPMG) are used: 90°, then a series of 180° pulses to reverse and realign the precessing nuclei producing new peaks or spin echoes. Several precession decay processes influence the resulting signals, most notably from surface interactions within the formation where the signal decays faster in smaller pore spaces.



Data Outputs

T1 is the longitudinal relaxation time derived from the decay rate following polarisation by the permanent magnet, describing the rate of polarisation. T2 is the transverse relaxation time describing the rate of decay, influenced by pore size. The peak amplitude of the RF signal following polarisation is used to determine the total porosity. The total porosity can be further split into clay based, capillary and mobile components using the T2 decay information whereby permeability (K) can be reliably estimated.

Vista Clara's advanced Javelin family of borehole NMR magnetic resonance logging tools provide direct, low-cost, high-resolution measurements of hydrogeological properties including: Volumetric water content; Pore size distribution; Bound and mobile porosity; Hydraulic conductivity and Transmissivity.

In Practice

Effects from washout and drilling disturbance and also RF interference are effectively eliminated as the Javelin JPY238 uses multiple frequencies giving different depths of investigation. The system is deployed using a conventional wireline setup making it a cost effective means of providing a unique set of data invaluable for geotechnical and hydrogeological investigations.

Televiewer and Caliper Gamma Survey at the busy A38 near Derby

Road side working at night with limited services vehicle access

THE A38 IS an important route from Birmingham to Derby and through to the M1 at Junction 28.

Where it passes through Derby, long distance traffic interacts with a large volume of vehicles making local journeys. In order to ease traffic congestion, Highways England committed to works to improve traffic flow, in this case at the A38/A52 Markeaton roundabout.

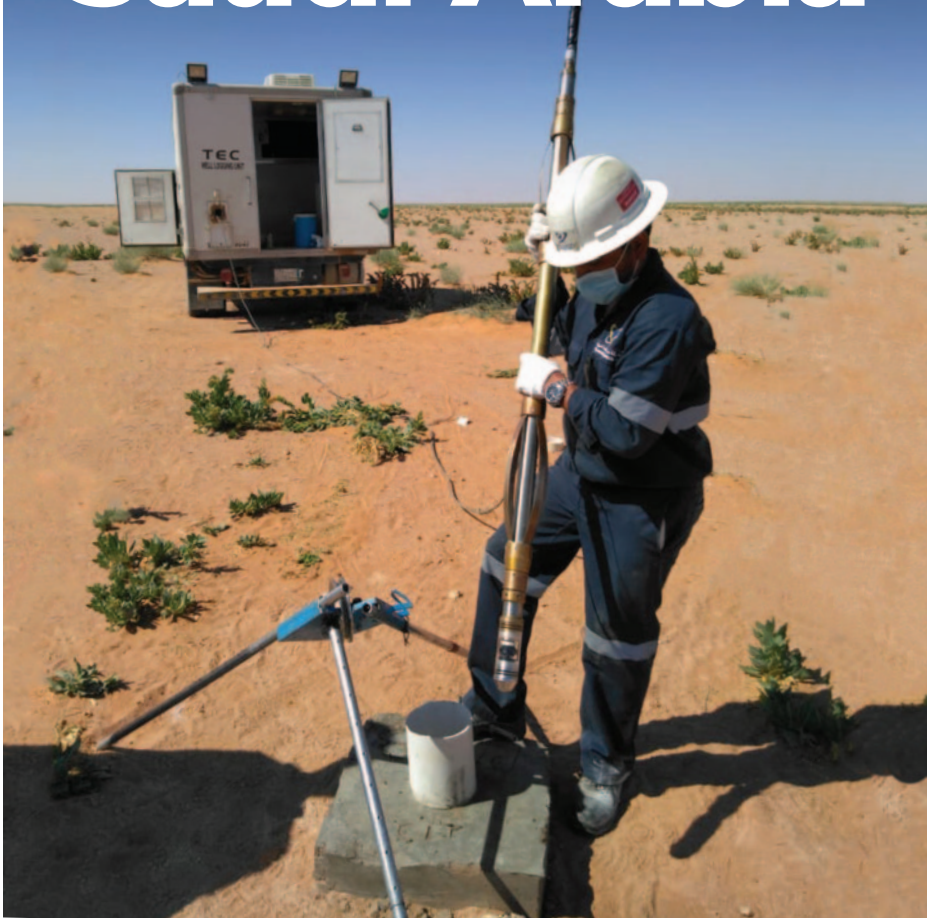
Robertson Geo was commissioned to conduct Televiewer and Caliper Gamma surveys on a number of boreholes x 30m deep x 146mm diameter on the A38 close to the Markeaton roundabout.

One of the fleet of 4x4 logging vehicles was deployed and data collated from Optical Televiewer, Acoustic Televiewer and 3-Arm Caliper (natural gamma) sub surface probes. Prior to the logging operation a risk assessment was produced and a client induction with special emphasis on traffic management was held.

Logging of the boreholes was completed in four site visits with the first application being undertaken at night when traffic volume was lower as the work was adjacent to a very busy roundabout. Subsequent visits were all conducted in daytime. 4x4 service vehicles were deployed throughout.

Optical Televiewer Logging for Phosphate Exploration

Saudi Arabia



Technology Experts is a Saudi based company servicing its Clients for nearly two decades in the field of surface and boreholes geophysics.

MAADEN IS A Saudi Arabia state owned mining company with various operating mines for Gold, Copper, Phosphates, Bauxite and Magnesite. It has exploration permits for phosphates and other industrial minerals and most of them are in the advanced stage of exploration.

Maaden has two exploration permits for Phosphates which are located in the northern part of Saudi Arabia, approximately 1,500km north of Jeddah, close to the Jordan/Iraq border. The phosphate deposition is intercalated with Chert, Vuggy limestone and friable sand layers which are difficult to core but RC drilling was a quick, reliable and cost effective method of sampling for resource estimation. Technology Experts suggested Maaden ran the Optical Televiewer probe for visual inspection of its boreholes which was approved and executed in almost 1,000 boreholes throughout the project along with Spectral Gamma and Caliper logging tools. The combination of Spectral Gamma and Optical Televiewer probes was very useful in marking the exact thickness and depths of phosphate bearing strata and serve as replacement of core samples.

After the success of the project Optical Televiewer logging was adopted by Maaden in several other projects in Saudi Arabia.

ROBERTSON GEO®

Unlocking Your GeoData

Robertson Geologging Ltd.
Deganwy, Conwy, LL31 9PX,
United Kingdom
T: +44 (0) 1492 582 323
E: info@robertson-geo.com

Robertson Geologging (USA) Inc.
1809 N. Helm Ave., Suite 4,
Fresno, CA 93727, USA
T: +1 (559) 456 1711
E: sstroud@robertson-geo.com

Robertson Geologging (Asia) Inc.
Flat 21A, Village Tower, 7 Village Road,
Happy Valley, Hong Kong
T: +852 650 33486
E: steveparry@robertson-geo.com

www.robertson-geo.com

ISO 9001
Certified
Quality Management System
www.tuv-sud.com/ms-cert