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ROBERTSON GEO
Unlocking Your GeoData

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GLOBAL GEODATA NEWS

ISSUE 04 | SPRING 2019

ROBERTSON GEO HIGH Resolution Acoustic Televiewer (HRAT) used extensively for subsurface investigation of rock strength and the presence of fractures onsite at the expansion project for the Mumbai Metro, India.

Mumbai

EDITORIAL

ROBERTSON GEO

Unlocking Your GeoData

I have been overwhelmed by the positive comments and encouragement received from our customers, suppliers and competitors alike who have praised the rebranding and marketing project we kicked off just ten months ago.

Whilst we are proud of achieving so much in such a short time, this is all just a hint of the exciting future that lies ahead for Robertson Geo.

An ambitious and innovative product development program continues apace and will be key to revolutionising our company and building on a position of technology leadership. We have taken everything that Robertson Geo has learnt and perfected over its 40 years of existence and funnelled that into what will be a completely new range of technologies and systems that will provide further proof of our continuing ability to respond to customers' needs.

Be on the lookout before the end of the year for the first new product releases which will show us as a superior and clear value leader for your operations.

Simon Garantini
Managing Director

The Mumbai Metro is a rapid transit system serving the city of Mumbai, Maharashtra, and the wider metropolitan region.

Hydrofracture test prior to mapping the fractures with the HRAT.

MUMBAI METRO is a US $11.43 billion expansion

The system is designed to reduce traffic congestion in the city and supplement the overcrowded Mumbai Suburban Railway (colloquially called local trains) network.

It is being built in three phases over a 15-year period, with overall completion expected in 2025. When completed, the core system will comprise eight high-capacity metro railway lines, spanning a total of 235 kilometres (146 mi) with 24% of the Metro underground, the rest elevated and serviced by 200 stations.

As of August 2018, Mumbai Metro consisted of one operational line (Line 1 - the elevated Metro from Versova to Ghatkopar), and four lines under various stages of construction.

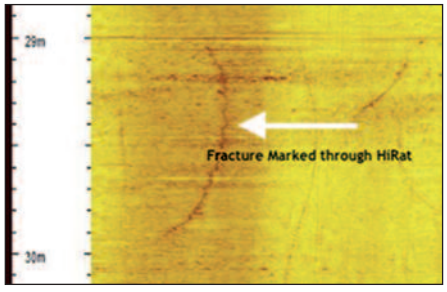
The total financial outlay for the expansion of the Metro system beyond the currently operational Line 1 is reported to be US $11.43 billion.

Mr Subodh Kulkarni is the Commercial Director of Robertson Geo client Soiltech India Pvt. Ltd (SIPL), the Drilling and Geotechnical firm with headquarters in Pune.

"We have successfully conducted many acoustic televiewer investigations all across India. For the Metro project SIPL deployed the Robertson Geo High Resolution Acoustic Televiewer (HRAT) to improve the quality of results of Hydrofracture tests in downtown South Mumbai, Maharashtra.

The HRAT is being extensively used; it provides a continuous high resolution orientated ultrasound map of the borehole wall for marking discontinuities and to find the intact zones where the Hydrofracture tests can be conducted. Once the rock is fractured in-situ, the HRAT is again deployed to mark the fracture along with the fractures inclination and dip and length.

With the use of this combined technology, we are able to map the fractures very accurately and find the K values to determine the final in-situ stresses for tunnel design."



Example of HRAT log showing fracture.

Hi-OPTV logging at the Khumbu Glacier

NEPAL

It says a lot for the portability of the Robertson Geo technology in that the EverDrill (NERC funded) research project acquired its data from the High Resolution Optical Televiewer (Hi-OPTV) probe and supporting surface equipment to log boreholes drilled in the Khumbu Glacier at 5000m above sea level.

The glacier originates in the Western Cwm of Mount Everest and by drilling and using the Hi-OPTV to log the boreholes the ice temperature can be determined and indicate how the glacier will respond to future climate warming.

The Hi-OPTV logs in particular show the debris content and layers within the ice which helps to reconstruct how the glacier flows and deforms internally.

The image shows use of the Hi-OPTV to log a 155m borehole. The base of the Khumbu Ice Fall can be seen to the right with Lingtren and Khumbutse mountains visible in the background, middle and right respectively.

The highly portable Robertson Geo Micrologger2 surface data acquisition unit and its supporting Winlogger software with a mini winch (175m capacity) was used extensively by the project.

Source: Katie Miles, Aberystwyth University.

The versatile Robertson Geo 2,000m marine winch is lifted on board the Omalius prior to it being fixed into its location frame and probe deployment.

This windfarm is *15.5km* off the FIFE COAST of Scotland

The windfarm is estimated to generate on completion 450 megawatts of clean energy, enough electricity for around 375,000 homes (all the homes in a city the size of Edinburgh) and displace 400,000 tonnes of carbon dioxide annually.

It is estimated that over the project's 25-year lifespan, it will contribute 0.6% of GDP (£827m) to the Scottish economy and create thousands of jobs during the construction phase as well as operations and maintenance jobs over its lifetime.

Initial work on the project began in September 2018 on a jack-up rig called the Apollo, where a total of four boreholes were logged using a suite of Robertson Geo specialised probes. The probes involved included the 3-Armed Caliper (3ACS), High Resolution Acoustic Televiewer (HRAT) and PS Logger, the latter being the most commonly used probe for offshore work. These tools were used for characterisation of lithology, locating fractures and to determine rock strength.

The Robertson Geo 2,000m marine winch, along with the probes and accompanying equipment was then transferred from the jack-up to a drill ship called the Omalius. A further five boreholes were successfully logged on this vessel.

For the Omalius logging application the winch was bolted into a steel frame which was mounted on the underside of the rooster box. The depth cable and data cable were connected to the winch and stored on the rooster box, along with the sheave wheel to reduce the risk of leaning out of the rooster box to reach the winch below. These cables were carefully lowered and fed into a container on deck, where the Robertson Geo Micrologger2, winch controller and laptop system was set up for logging.

Robertson Geo's engineers were actively involved in the project for around two months. Total depth of each hole drilled was 45m.

Picture This...

Graham Comber
Logging Services Manager, Robertson Geo

Why borehole televiewers have become the tool of choice for geotechnical and mineral investigation.

Robertson Geo is a global market leader in slim-hole logging instrumentation with in-house design and manufacturing facilities and offers a proven logging service worldwide. The expansion and maturation of the market for borehole televiewers is being matched by ongoing developments to keep abreast of demand.

Borehole televiewers provide a continuous, orientated, high-resolution representation of the borehole wall, offering many advantages to geologists and geotechnical engineers. The data provides information about geology, structure, fractures, stress orientation and acts as a template for orientating cores and providing depth control where core recovery is incomplete. In this age of information technology, objective and precise data, captured in situ, is transferred directly from borehole to computer, where it can be stored, processed, analysed and disseminated, literally at the touch of a button.

HOW TELEVIEWERS WORK

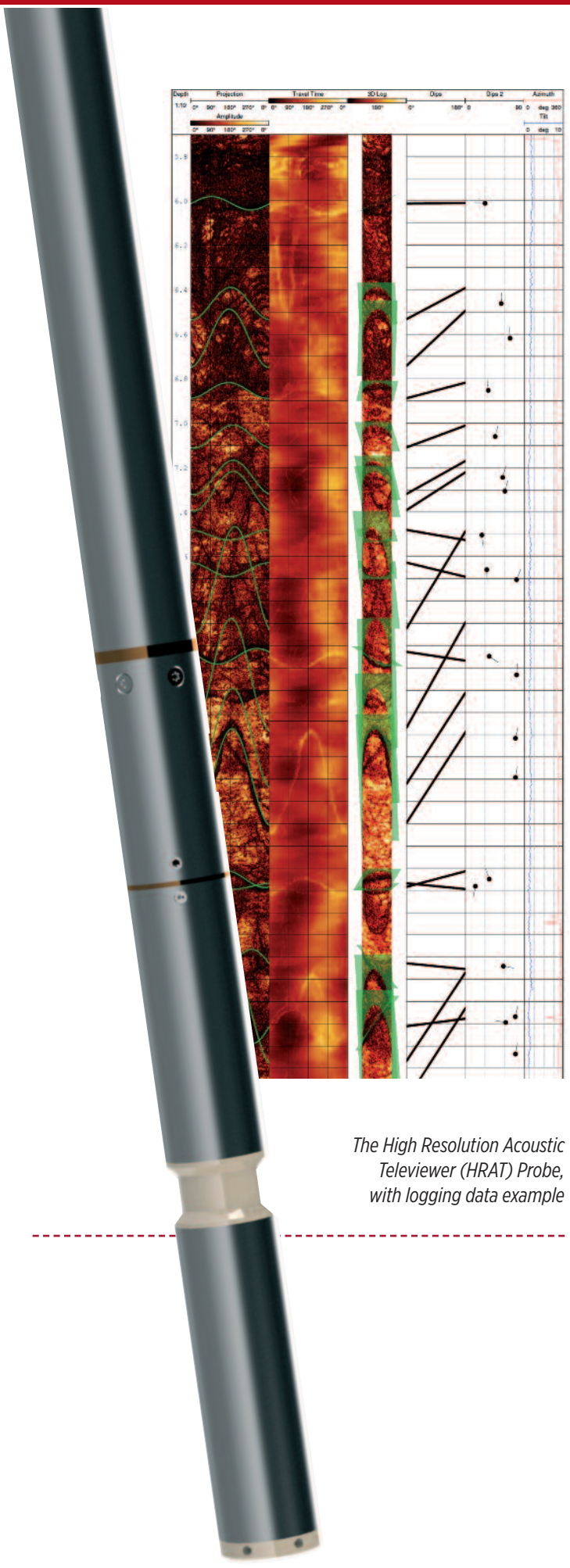
The acoustic televiewer logs the borehole wall in terms of hardness, measuring the amplitude of a high-frequency reflected sonic pulse at very high resolution. It describes the borehole skin rather than the formation beyond. Hard rocks reflect high-amplitude signals and soft rocks and fractures reflect low ones. The individual measurements of reflected amplitude are made continuously by a rotating transducer or, more often in slim tools, a rotating sonic mirror aligned with a stationary transducer. The result is a map of the borehole wall with an individual resolution of about 2mm in ideal conditions. The left edge of the High Resolution Acoustic Televiewer (HRAT) is aligned with magnetic north. Fractures and bedding planes appear as sinusoidal lines where the deepest point on the line is the direction of dip.

On the example to the right, travel times (2nd column from left) for each cycle are mapped in the same way as the amplitudes (left column).

Tool centralisation is important to ensure similar travel time and signal strength in all directions. Resolution is reduced in large boreholes and/or drilling mud where signal dispersal is a problem. Because the acoustic televiewer is sensitive to rock hardness and can measure fracture orientations and apertures (lost in drill core), it has become an important geotechnical tool in both sedimentary and hard-rock formations. A limitation of acoustic tools is that they only function in fluid filled holes.

If data is required from dry boreholes, the High Resolution Optical Televiewer (Hi-OPTV) should be employed. It measures the colour and shade of reflected light. The borehole wall is lit by a ring of diodes on the tool and reflections are directed to a light-sensitive sensor via a conical mirror. Resolution is very high, with pixel sizes down to well below 1mm at HQ borehole diameter.

The optical televiewer provides an orientated photograph of the borehole wall at high resolution and without perspective. The system does not offer a traveltime image, and log quality is dependent on clean borehole fluid if it is run below the water table. In slim holes, optical televiewer images can be of such high quality and value that it is usually worth cleaning the borehole wall and replacing dirty fluid before logging.



The High Resolution Acoustic Televiewer (HRAT) Probe, with logging data example

BATTLE PROVEN TECHNOLOGY

Robertson Geo has been providing borehole televiewer equipment and logging services throughout the world in some of the harshest environments. From offshore wind farms, across the glaciers of Antarctica to underground mines and regular geotechnical applications the televiewer has proved to be a reliable and invaluable tool.

The UK is a world leader in the development of offshore wind farms. Lithological information is key to engineers designing foundations for the massive structures which support the latest generation of turbines. Operating from jack-up platforms or from drill ships, marine resistant technology has allowed televiewers to be included in the armoury of tools available to the geotechnical engineers collecting sub-surface data to feed into the design process. Acoustic televiewers have been deployed offshore on the Dudgeon Wind Farm (UK) and in NW France. Other marine applications include near shore (and onshore) surveys for nuclear build sites at Wylfa and Sizewell B.

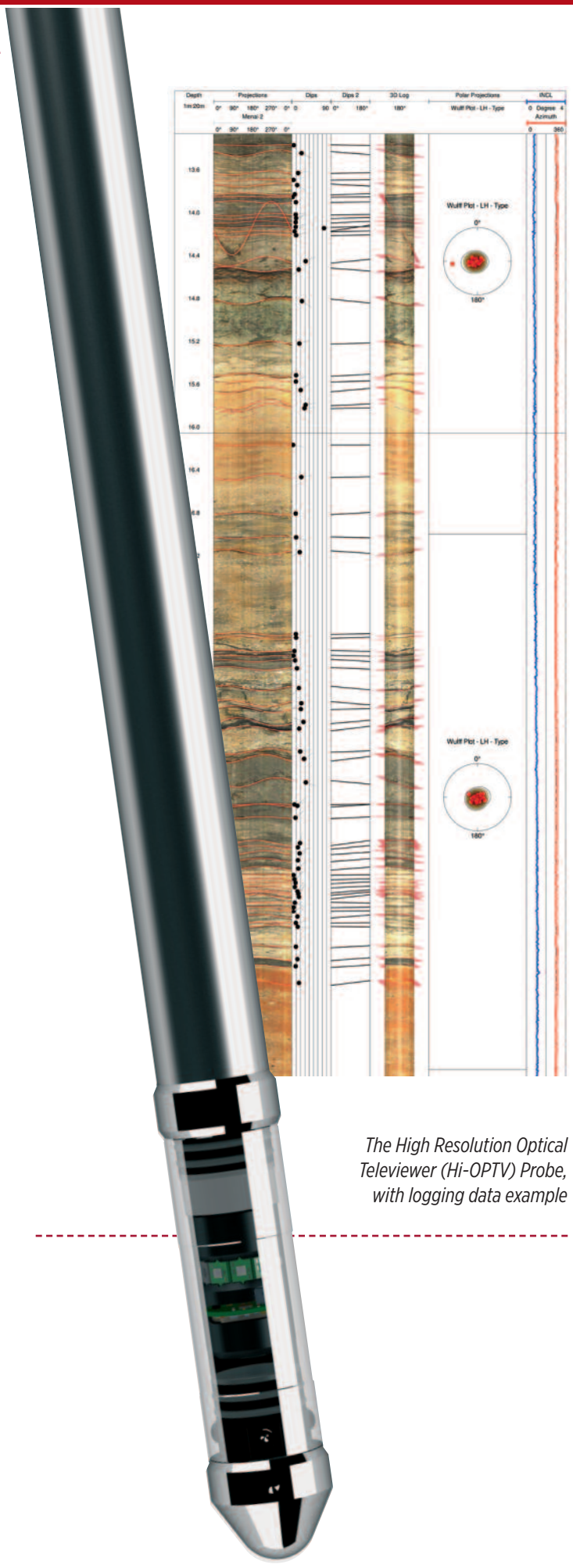
The acoustic televiewer has been deployed extensively in mineral exploration worldwide, quite recently in an underground gold mine development for Dalradian in Northern Ireland where the delineation of the underground fault systems was crucial to the project.

Televiewers have been routinely deployed on many of the UK's largest infrastructure projects including Canary Wharf, HS2, Queensferry Crossing and Lower Thames Crossing in addition to many other linear infrastructure projects. However, the ease of deployment and cost effectiveness of the technology means affordability for even the smallest of projects. Televiewers are deployed extensively worldwide for geotechnical applications such as slope stability.

A seasonal project in Antarctica has seen portable systems with optical televiewers used on glaciers to view ice bands in hot-water drilled boreholes for research purposes.

DRILLING MATTERS

Borehole conditions play a big part in image quality and that is where the drilling personnel should be involved. Rotary drilled boreholes always provide the best images (low rugosity). Televiewers can produce good images in boreholes from 60mm to 300mm with the optimum range being from 75mm to 150mm.



The High Resolution Optical Televiewer (Hi-OPTV) Probe, with logging data example

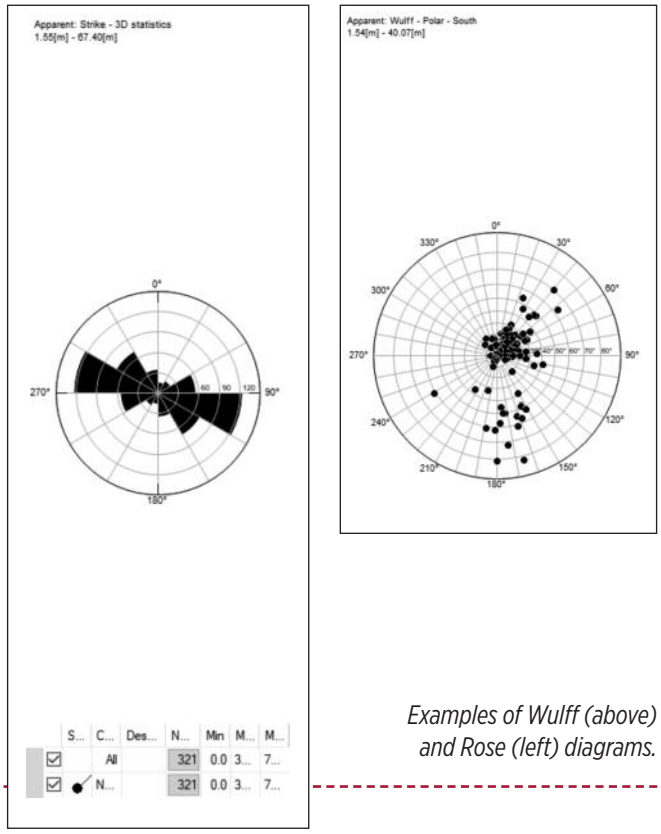
It is important that the borehole be prepared to offer the best conditions for the selected methodology. That might mean, where possible, flushing and cleaning for the optical televiewer. Depending upon the formation a period of time may be required to allow particulates in the fluid time to settle. This time period can be from zero for hard rocks to several days for softer rocks and unconsolidated sedimentary layers. The acoustic televiewer is wholly dependent on a fluid filled borehole but is quite tolerant to mud filled boreholes.

Where borehole stability is an issue the logging is often split into separate runs whereby the drill string is retrieved in stages. To minimise possible loss of data, close liaison with the drillers, geologists and geotechnical personnel is required to confirm where the suspect layers are (e.g. gravel beds). A shooting plan can then be made whereby the drill string can be withdrawn in stages to provide some open borehole while providing protection for the problematic zones. Wherever possible, overlaps should be made between the discreet logs to ensure depth integrity across the borehole.

Using this staged logging method necessitates the televiewer being able to pass through the drill string and drill bit into the open borehole. As the televiewer must be centralised this presents a challenge as the centralisation must be sufficiently weak to allow passage through the smaller diameter drill bit and still maintain centralisation in the larger diameter open borehole. Drill sizes with a relatively large internal diameter compared to borehole diameter (e.g. Geobor S) minimise the centralisation issue.

IMMEDIATE DATA

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. It can be enlightening for drillers to view the logs as this provides invaluable feedback for them and the image often confirms the 'feel' they had for the borehole conditions whilst drilling. The fast turnaround of images in the field is now a common requirement for geotechnical personnel and geologists who need to make decisions on depths for further tests, temporary/permanent monitoring installations and potentially amendments to the drilling programme.



Examples of Wulff (above) and Rose (left) diagrams.

PROCESSING

All televiewer data is fully oriented, usually with respect to magnetic north. The tilt and azimuth of the borehole are 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 and classifying by a geologist (fracture, fault, sedimentary bed, vein etc.), the structure log is orientated with respect to horizontal and true north and displayed as a tadpole plot. Feature dips can also be displayed from different view angles and the data can be summarised into various histogram plots and Wulff and Rose diagrams over selected depth ranges and grouped by dip angles or azimuth.

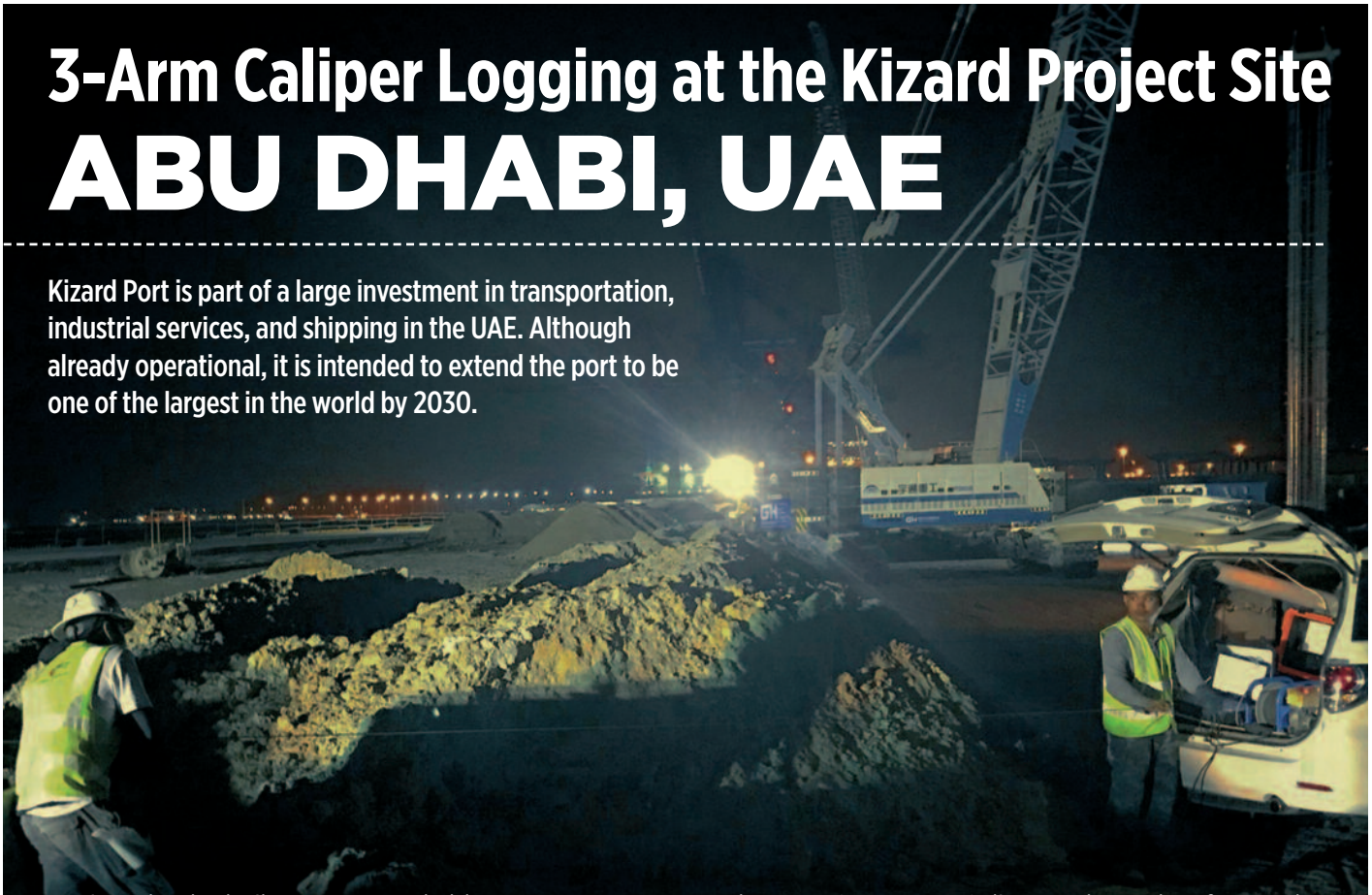
The acoustic televiewer can also produce a breakout log from the travel time data to show washout zones within the borehole. This can be especially useful for calculating grout volumes for boreholes that are to be cased.

'Geobor' is a registered tradename of Atlas Copco
'Q' is a registered trade mark of Boart Longyear International Holdings

3-Arm Caliper Logging at the Kizard Project Site

ABU DHABI, UAE

Kizard Port is part of a large investment in transportation, industrial services, and shipping in the UAE. Although already operational, it is intended to extend the port to be one of the largest in the world by 2030.



Designed to be built over a remarkable 418 square kilometres it will become one of the world's largest industrial zones. The huge project is a major element of the Abu Dhabi Economic Vision 2030 with the objective of diversifying the economy in search of non-oil and gas revenue, it is expected within 18 years to contribute to Abu Dhabi's non-oil GDP by up to 15%.

Robertson Geo 3-Arm Caliper Probe and surface and deployment equipment is in use in this image, providing a single continuity log of borehole diameters, defining the actual profiles down the length of the borehole and identifying the location of any fractures or cavities, prior to the installation of the cage and concreting of deep foundation piles.

GEOTECHNICAL INVESTIGATION

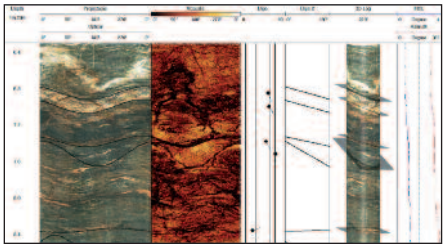
for a new three lane bypass road in

NORTH WALES

Work on a £135m bypass in Gwynedd, North Wales is underway with construction on the new six-mile (10km) road between Caernarfon and Bontnewydd to avoid the town centres along its way and improving the A487, an important commuter and holiday route into the Llyn Peninsular. It is targeted for completion in spring 2021.

The Welsh Government is investing substantially in the project and Transport Minister Ken Skates said the scheme would "provide a boost for the region's economy and make a real difference to local communities as well as the travelling public".

Being a geotechnical project Robertson Geo has been contracted to provide subsurface data using the High Resolution Acoustic and Optical televiewer probes, providing fracture identification and orientation (dip and direction), stratigraphic studies, local stress analysis (breakouts) and core orientation. The probes were deployed by a Robertson Geo service crew in a number of relatively shallow boreholes ranging from 9m to 25m.



One of the Robertson Geo fleet of logging vehicles at Hinkley Point C, fully equipped for on-site data acquisition and surface deployment, supporting Service Crews in the toughest of field applications.

Hinkley Point C Nuclear Power Station
IS EUROPE'S LARGEST CONSTRUCTION SITE

The first new nuclear power station to be built in the UK in over 20 years, Hinkley Point C in Somerset, UK will on completion provide low-carbon electricity for around six million homes.

There have been sixteen site visits so far by Robertson Geo service logging crews, with work still on-going. Sixty one boreholes have been logged to date, with some boreholes being visited on more than one occasion. Probes used so far have mainly been Optical and Acoustic Televiewers, 3-Arm Caliper, High Resolution Flowmeter and Electric Log (Extended range).

When it comes to challenging locations...

Robertson Geo is the preferred choice for water well exploration, evaluation and maintenance.

After years of international experience and the evaluation of thousands of wells, wherever the challenge comes the highly portable systems continue to deliver quality and reliable calibrated data.

This image, the winner of the recent photo competition, is from Estonia of logging water wells from the nearest vehicular access position some 12m from the well.

Various Robertson Geo probes were in use to monitor and determine the well integrity and for assessing the cementation behind the PVC casing.

Robertson Geo has joined GeoMôn - Anglesey UNESCO GeoPark as a Corporate Member

The Isle of Anglesey is an internationally recognised GeoPark, with a spectacular geological heritage.

The GeoPark is a registered charitable trust established to promote the unique geology of the Isle of Anglesey through geo-education and geo-tourism. It is run by volunteers who assist in a wide range of activities, including guided walks, field trips, management of the trust, and manning the Visitor Centre at the Watch House in Amlwch Port.

To help with the running of the trust, the GeoPark is seeking to gain support from companies that are aligned with the geoscience aims of the organisation. Robertson Geo will help to promote the GeoPark and provide support to this community run project.

Ian Jones is the new Finance Manager for Robertson Geo

"I'm Ian Jones and have been recently appointed by Robertson Geo as Finance Manager replacing Richard Rees who retires at the end of March.

I am CIMA qualified and have over twenty years experience in accountancy gained from a variety of industries including computer software development and civil engineering.

I have joined at a very busy time for the company during reorganisation and the introduction of new systems and products and feel very fortunate to have been offered the opportunity to be part of the Robertson Geo ongoing development. I trust my skills and experience will help me contribute to the company's success."

Trouble shooting and maintaining Robertson Geo equipment

Even with the best will in the world and the most peerless maintenance schedule, problems can occur out in the field. The software doesn't work, no data comes from the probe or the winch is doing something odd.

What can you do?

Check out our troubleshooting document at the GeoInfo download on our site www.robertson-geo.com

Competition Winner...

Here's the winner of our photo competition, its Siim Tarros of the Geological Survey of Estonia, seen here with his prize of an Apple iPad Pro.

You can see his winning entry on page 6 opposite.

Edward Greenly 1861 - 1951
Pioneering Geologist

As a North Wales based Geoscience Company, it would be remiss of us to enter 2019 without a mention of the pioneering British Geologist, Edward Greenly.

This year marks the 100th anniversary of the publication of *Greenly's Geology of Anglesey*, a momentous two volume publication based on many years of field work and research. This was followed in 1920 by the publication of the one-inch geological map of the island.

The complex geology of the island took Greenly 25 years to unravel and the Precambrian, in particular, proved a great challenge. His field experience in N.W. Scotland helped in unravelling the tectonic sequence. But his correlation was hampered by poor rock exposure, an obscured older Precambrian basement, and the presence of tectonic breaks such as faults and shear zones.

Although aspects of the survey were revised by later workers, it remains a classic study. It provided the inspiration for later generations of geology students, as the island became a popular destination for university field trips. Anglesey was awarded UNESCO Global GeoPark status in 2010, in recognition of its unique and spectacular geological heritage.

Edward Greenly will be remembered by geologists as a pioneer in grass roots geological field work and techniques, in one of the most complex geological settings in the UK.

Local irrigation wells for new crops IN CALIFORNIA

Robertson Geo (USA) customer Belknap Well Drilling Inc is a water well contractor based in Dinuba, California.

The Belknap family has been drilling wells for over 100 years and is considered the "first call" for drilling and geophysical services in the San Joaquin Valley.

This image shows a wireline logging deployment of the Electric Log; the classic water well combination probe combining shallow, medium and deep penetrating resistivity measurements with Self-Potential (SP). Together with a Robertson Geo deviation tool the rig ensures proper depths and locations of the wells are achieved. An existing Aries Industries water well video inspection van has been adapted with a 600m winch mounted on a rotating base unit.

On-site training performed at Cali, Colombia

The Colombian Company COLPOZOS, a division of Mexichem, purchased an Electric Log Probe and the Micrologger2 surface interface with the MS Windows based operating system to provide field acquisition capability, together with a 600m deployment winch.

Jorge Ramirez of Robertson Geo (USA) travelled to Cali, Colombia to provide system training on location.

The logging system was used for data acquisition for water well construction for agricultural needs. It has subsequently been in use in various other surrounding countries such as Venezuela, Ecuador and Peru.

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