UNITED KINGDOM
Enough to supply 270,000 homes with gas for 12 months.
03

HONG KONG
Fracture analysis using High Resolution Acoustic Televiewers.
04

ANTARCTICA
Logging in Antarctica with the British Antarctic Survey.
05

ROBERTSON GEO
Unlocking Your GeoData

GeoUnlocked©

GLOBAL GEODATA NEWS

ISSUE 02 | AUTUMN 2018

A SINGLE CONTINUOUS LOG OF BOREHOLE DIAMETER

Directly after excavation, drilled pile boreholes logged for continuity of diameter using Robertson Geo surface equipment and the 3-Arm Caliper probe.

Dubai UAE

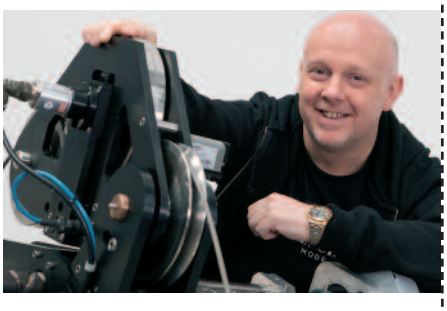
EDITORIAL

ROBERTSON GEO

Unlocking Your GeoData

Robertson Geo has been a global player for almost 40 years, initially via our logging services with bases in Indonesia, Philippines, Australia, New Zealand and South Africa, and then through our equipment sales to more than 150 countries around the world.

Supporting our international client base has been the key to our success. As a service provider ourselves, we know first-hand how important aftersales service and support are and by relying on our local agents to deal with client's day to day issues, was simply not enough. This was the reasoning behind Robertson Geo's decision to establish its own regional offices as we wanted to ensure our own staff were accessible to our clients at a timely manner no matter which time zone it is. Our offices in California and Hong Kong now give us the edge, and enables client access to Robertson Geo 24hrs a day. This coupled with our extensive agency network, regionally based service engineers/trainers and spares/repair centres in key locations ensure a service that is second to none.



Steve Parry
Sales and Marketing Director

IMPROVING THE EXPO 2020 ROAD NETWORK PROJECT

Robertson Geo technology successful in logging new drilled pile boreholes

ALBATECH TESTING SERVICES LLC through its Deep Foundation and Geophysical Division was commissioned to perform caliper logging testing (CLT) on drilled pile boreholes to determine the actual profile of the boreholes down the length and define the location of fractures or cavities, if any, prior to the installation of the reinforcement cage and concreting of deep foundation piles at the R1048/1 site for the improvements of the EXPO 2020 road network.

The Robertson Geo 3-Arm Caliper Probe provides a single continuity log of borehole diameters, recorded by three mechanically coupled arms in contact with the borehole wall. Opening and closing of the motor-driven caliper arms is by surface command, allowing the probe to run into the borehole with arms retracted. Once opened the spring loaded arms respond to borehole diameter variations as the probe is raised. The Robertson Geo Mini Winch, Micrologger2 and Winlogger Operating Software provided the surface equipment to collect and record the data.

HSSG Foundation Contracting LLC completed the drilling of the boreholes on 21 February 2018 with the CLT testing performed on the pile boreholes right after excavation and prior to the installation of the reinforced cages and concreting.

Testing was carried out in accordance with ASTM D6167-11 "Standard Test Method for Conducting Borehole Geophysical Logging" and showed the boreholes were consistent with the acceptance borehole diameter of 1200mm as per the project specifications.

ENOUGH TO SUPPLY **270,000 HOMES** WITH GAS FOR **12 MONTHS**

Storengy owns and operates the **Stublach Gas Storage Facility** located near the town of Northwich, England.

NATURAL GAS IS stored over 500 metres below the surface in salt caverns. These salt caverns are formed by pumping water into ground (solution mining) to dissolve the salt and create large underground chambers connected to the surface by a series of metal tubes cemented into the overlying rock.

Gas is withdrawn from the national transmission system (a network of underground pipes crossing the UK) and stored in the salt caverns until it is required.

Robertson Geo has been a key contributor to the development monitoring project, from the very early stages by running a selection of probes to monitor the size and shape of the developing caverns, depth check casing collars and performing Mechanical Integrity Tests (MIT) of the well completion while under storage pressure.

Mapping the size and shape of the caverns, Robertson Geo in partnership with Flodim has been running a specially developed sonar probe that can operate in fluid or dense Gas that has a 360° rotating head that can also tilt to enable complete data coverage.

As part of the cavern development project Robertson Geo has been present and available on call 24hrs a day at the workover campaigns stages where the height of the varying casings is adjusted to enable the cavern to be developed vertically. It has been crucial that the depths of the casings are known accurately to enable the cavern development specialist to make the relevant calculations for direct or reverse leaching, which in turn determines if the cavern is leached vertically or horizontally.

Near the completion stages MIT's have checked that the caverns are holding the pressure and there are no leaks in the cavern or well completion. This is done by running a pressure and temperature probe followed by a Pulse Neutron probe. Both probes are logged twice with a 48-hour gap between the same probe logs. The two sets of data are checked to ensure no difference has been observed over the 48-hour period confirming cavern and well completion integrity.

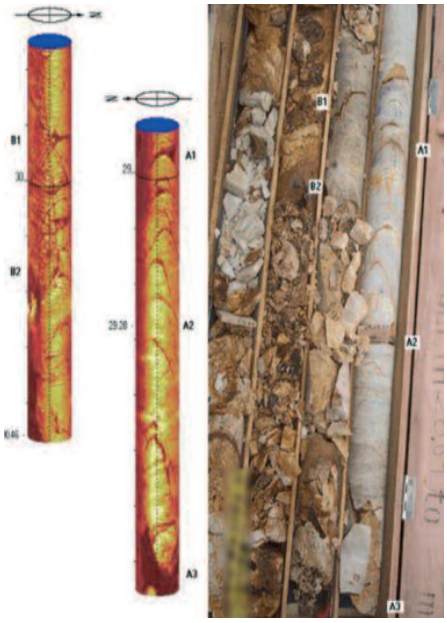
Once fully developed, Stublach will be the largest onshore gas storage facility in the UK The 450 million cubic metres of gas stored a Stublach is enough to supply 270,000 homes with gas for cooking and heating for 12 months.

Fracture analysis using HIGH RESOLUTION ACOUSTIC TELEVIEWERS

THE PROJECT INVOLVED logging several geotechnical boreholes of up to 30m deep on an embankment in the central mid-level district of Hong Kong as a ground investigation for the Shatin to Central Link with the emphasis on slope stability. Weathered granite posed a risk to slopes in the area and poor core recovery made it difficult to assess the same.

The Robertson Geo High Resolution Acoustic Televiewer (HRAT) was used to determine the lithology and fracture analysis of the boreholes. The probe provides a continuous high-resolution oriented ultrasound image of the borehole wall and can be used to characterise features that intersect the wall. These include bedding, drilling-induced/natural fractures and faults. Integrated orientation measurements allow the inclination and direction of features to be measured relative to true north, magnetic north or the borehole dip direction.

The example shown clearly shows that the HRAT was able to make a 100% continuous 360 degree image of the borehole, including those areas where no intact core recovery could be made. Furthermore, the dip and direction of the fractures and bedding in those highly fractured zones could be clear identified and measured using the HRAT, yet could not be seen on the recovered core samples.



Core/HRAT comparison.

Poor core recovery.

MINERAL EXPLORATION LOGGING IN MYANMAR

LOGGING WITH 3-Arm Caliper, Electric Log, Full Waveform Sonic and Verticality probes. Occasionally some snakes were passing by!

WORKING WITH WIRELINE TECHNOLOGY

Paul Worthington, Robertson Geo, UK, and Brad Posner, Consultant, USA, discuss the development of a new open-hole oil and gas wireline logging system for exploration and production wells, from design through to engineering and manufacture

Outside of the major service companies, oil and gas wireline logging technology has been developing too slowly for many decades due to the domination and control of these large majors. The lack of market scope for independent companies has traditionally restricted R&D efforts to the majors, whilst smaller service providers have struggled to upgrade outdated analogue equipment. Yet, against this market backdrop, the availability of quality logging tools is as critical as ever for assessing the potential of both new exploration and existing production wells.

British company, Robertson Geo, has collaborated with a North American oil and gas service organisation to create and bring to market a new digital solution for open hole evaluation, in a project which

Figure 1. *An array of Robertson GeoKey logging tools.*

aims to meet the numerous challenges posed by modern wells. The greater well depths and higher temperatures being tackled today are bringing new technical requirements for hardware, while producers need the full range of measurements from this technology, in a system that is as compact as possible in terms of length, weight and external diameter.

Robertson Geo and its US based development partner identified the key requirements of a competitive system development, participated in some initial field trials which culminated in the decision to proceed with the design of the Air Quad logging suite, as it was known over the course of the collaborative project. This extensive development has led more recently to the commercialisation of the Robertson GeoKey tool suite, a new family of slim, open-hole oil and gas logging technologies, born from the Air Quad project.

The success of an earlier technical collaboration in which analogue tool measurements were digitised downhole, led to the creation of a smaller, lighter Air Quad open-hole logging concept, similar to the industry familiar 'Triple Combo' suite of density, porosity, and induction resistivity measurements.

It was also recognised that two additional features would be critical – an Ultrasonic Gas Detector (UGD) and a fast-responding temperature sensor. These were necessary because the customer's major market was in boreholes which were air-drilled and logged, with little or no fluid present.

The collaborators identified that the currently available Air Quad kit was too big and heavy, approaching 15 m in length and over 300 kg at an OD of 3 ⅝ in. A new 'fit for purpose' solution was needed, one that offered excellent reliability, measurement repeatability and easier field deployment.

Robertson Geo already possessed the in-house knowledge and resources to tackle the requirements of a new product design. Its development teams, equipment manufacturing expertise, logging tool verification facilities, test borehole and autoclaves were all on-site at its HQ in North Wales. These facilities were augmented through use of the Callisto Test Facility in Leicestershire, the major centre for wireline logging tool calibration and appraisal in Europe.

This background formed the basis of the partners agreeing to develop the new Air Quad combo. Subsequent commitment by Robertson Geo soon after, led to the expansion of the logging suite's initial capabilities by adding fluid-filled borehole measurements.

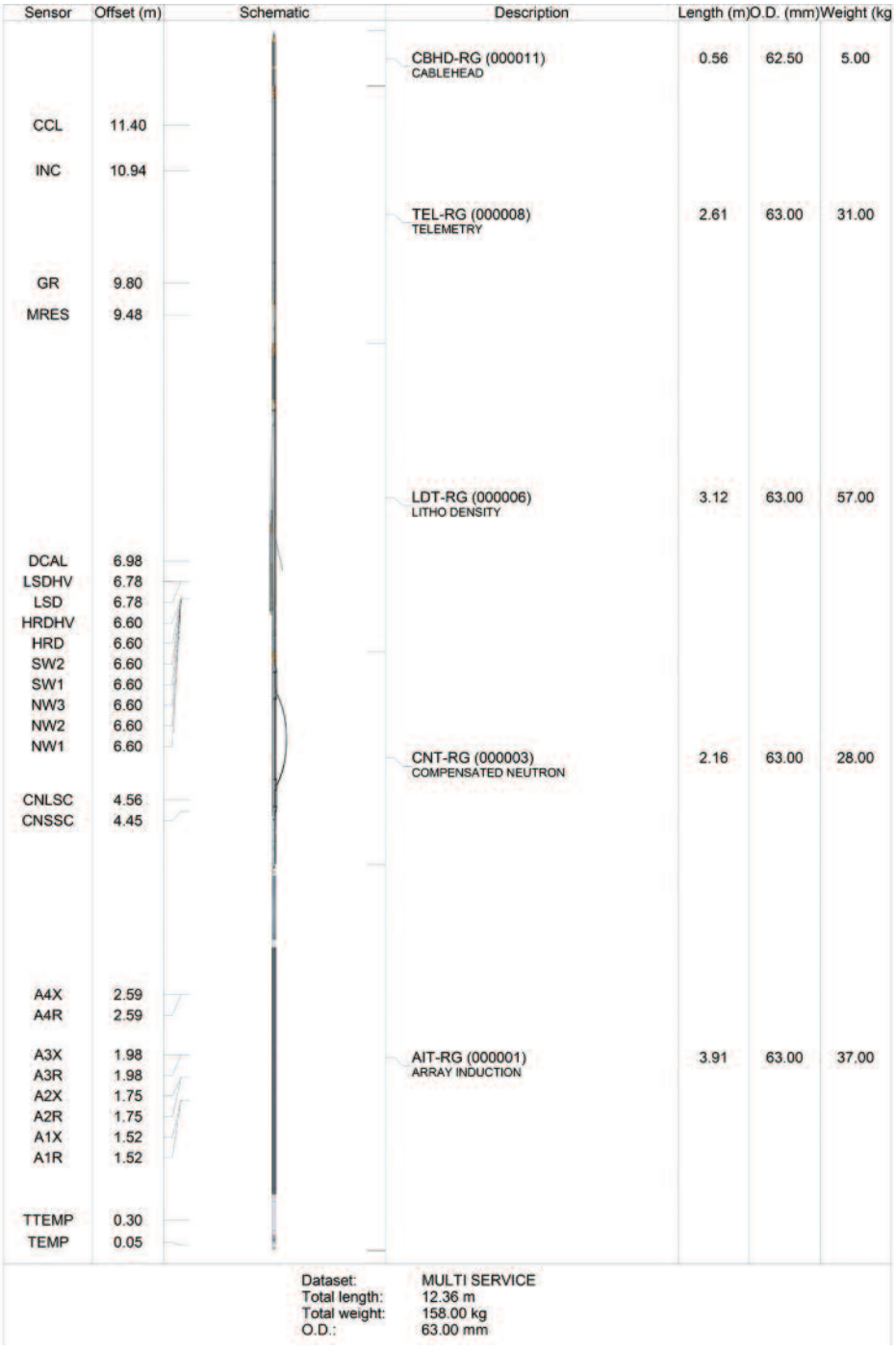


Figure 2. *The tool string, as depicted in the industry standard Warrior acquisition software.*

Timescale

The partners agreed a project schedule that included initially delivering one

working prototype system providing all the petrophysical measurements required of an Air Quad, in a modular suite, within two years.

Measurements were to match the accuracy, repeatability, and resolution of existing major wireline logging systems, within specific working limits.

Pressure and temperature specifications were to be sufficient for most mid-tier oil and gas logging operations worldwide (Figure 2).

The development would also include all system accessories necessary for a complete logging solution. This included cablehead adapters, radioactive source holders, centralisers/decentralisers, calibration hardware, and knuckle joints, necessary to calibrate and deploy the system across various well applications.

For data acquisition, Robertson Geo chose to implement the widely-used Warrior™ Acquisition software in conjunction with its own surface acquisition system and telemetry protocol. The use of acquisition software widely adopted across the industry would minimise the need for additional user training and provide a familiar, proven system interface.

Engineering and development

The tight timeline was the most challenging aspect. Design, testing, and manufacture all had to be accomplished within the agreed schedule. Robertson Geo possessed much of the expertise and knowledge in-house. However, the most demanding technical hurdles were in developing the UGD and array induction, both new to the company. The air-filled borehole posed other significant challenges as it greatly affected known tool responses from density and porosity measurements.

Most of the theoretical work and characterisation could be completed in the UK. However, the project also called for multiple trips to Pennsylvania to acquire the data in the specified air-filled environment and to verify functionality with the customer's truck, wireline cable, head, and acquisition systems. Measurement data acquired in the UK and in the Pennsylvania test well then required extensive Monte Carlo numeric processing to fully characterise the tool output. This work was undertaken by an industry expert

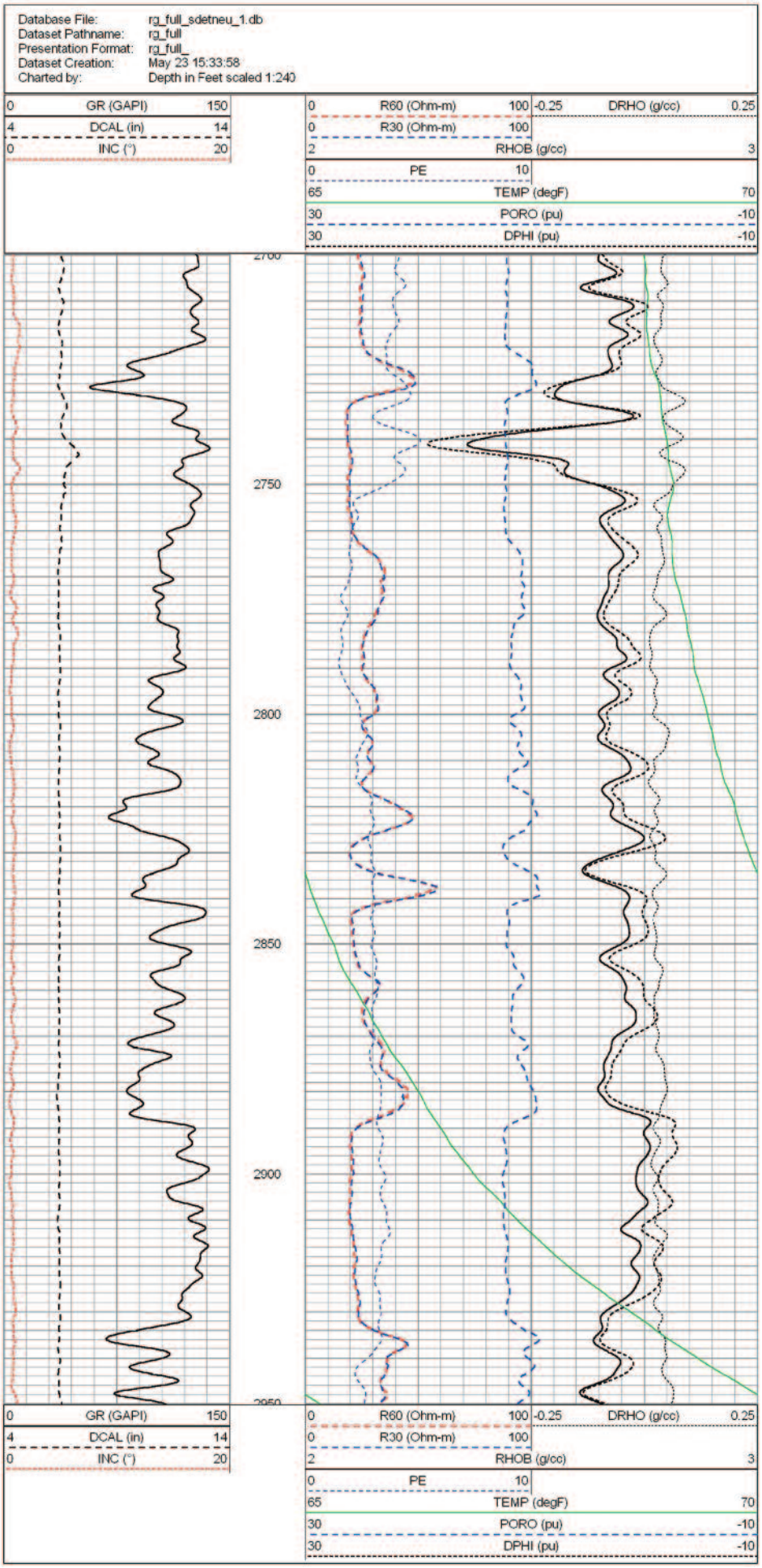


Figure 3. *Data acquired from the Marcellus Shale Formation, Indiana County, Pennsylvania.*

in specialist nuclear modelling, to generate and refine the final calibration algorithms. The Warrior software uses these algorithms to negate the need for traditional spine and rib plotting for the calculation of density and environmental corrections.

Once the physics of density and porosity measurements were established, the design and engineering of the modules could start.

The neutron porosity module was initially designed and tested with one thermal and one epithermal detector. However, the epithermal formation salinity correction proved to be complex to model and became challenging to incorporate into the Warrior software. As a result, the final version of the module contained two thermal detectors.

A challenge posed by the UGD arose from the Robertson Geo team's unfamiliarity with this measurement. It was required to detect the 'noise' of gas entry into the empty borehole through a fracture. The solution was to use two ultrasonic detectors and measure the differential – which also helped reject 'noise' from the tool itself in the empty environment.

Lithodensity (PE) measurements were also new to the company's project engineers so posed design challenges. An iterative process of development was pursued to understand the complexities of mechanical packaging and energy calibration requirements. Once again, the PE required further field trials to validate the Monte-Carlo derived output algorithms before acceptance of the design could be agreed.

One surprising aspect of the engineering design involved the array induction module. The air-filled hole allowed for a build-up of static electricity on the insulated section of the tool, which led to data spiking from electrostatic discharge. This was observed in the Pennsylvania test well, necessitating major design modifications.

This testing and improvement process continued until all the technical obstacles had been overcome, final designs confirmed, and a prototype manufactured.

Figure 4. *A complete GeoKey Logging system.*

The final stage of project was to carry out extensive field trials with multiple customers in Pennsylvania, in air filled, open-hole conditions. Field trial results fed a process of continuous refinement of the suite's design, and enhancement of calibration performance until both partners were satisfied the Air Quad suite met all of the original design objectives.

Commercialisation

With the original system objectives achieved, the final design concepts were approved by both parties and manufacture of the Air Quad system commenced. The development partner purchased and deployed multiple suites of logging tools in the USA. Regular field use proved the system delivered on its brief of reliability and repeatability in an air environment. Known today as the GeoKey logging suite, the Air Quad collaboration has allowed Robertson Geo to make available to the industry a suite of value delivering logging technologies that were traditionally the reserve of the large integrated service companies.

Figure 4 shows a complete GeoKey Logging system.

Continuous improvement

Based upon customer feedback, further support and modifications were implemented as field performance informed product refinements. An example of this was a redesigned UGD to facilitate field replacement of the ultrasonic detectors. Robertson Geo also revised the tool designs to operate in fluid-filled boreholes. Using similar engineering methodology, and with the addition of dual laterolog, full wave sonic, microresistivity, and formation imagers, a complete fluid or air-filled well logging system is now available.

Opportunities to participate in field trials with major operators in Uganda and the Canadian oil sands led to further design refinements and vital performance benchmarking. The decades old logging cablehead, which had its origins in the original partner's equipment, required a complete re-design. A downhole tension measurement was added, and radioactive source strength in some environments required increasing to meet measurement specifications. Furthermore, refinements to measurements were implemented across both software and hardware to hone GeoKey system performance, to satisfy the benchmarks expected by the major operators. Critical to this success and ongoing development was having the proper licensing and experience to package, calibrate and deliver radioactive sources to customers. Subsequently, numerous systems have been deployed globally to a range of clients and in varied applications, proving credibility and adaptability of the GeoKey technology suite.

The end result of this major collaborative technology development is a family of slim open hole oil and gas logging technologies openly available to the global oil and gas markets.

Conclusion

GeoKey offers independent wireline logging companies technology solutions that provide a genuine alternative in the competitive marketplace in 2018. Access to top quality equipment is necessary for independent wireline logging entities if they are to keep pace with shrinking technological development cycles and compete for market share with the major service companies.

Logging in ANTARCTICA

The British Antarctic Survey have two Robertson Geo 1000/2000m winches which have been used extensively both in the Antarctic and the Arctic for a range of down hole instrument deployments.

THE SHELF SEAS component of the Polar Oceans Group specialises in accessing the oceanic and sedimentary regimes located beneath floating ice shelves and grounded ice streams with the aim of collecting data to help understand the oceans effect on ice shelves and ice stream dynamics.

This is achieved utilising the technique of hot water drilling in which large quantities of snow are melted, heated to 95°C and pumped at a rate of up to 150l/min through a hose being slowly lowered into the ice. The technique allows the creation of 300mm diameter access holes through up to 2300m of ice in less than 24hrs.

Typical recent projects have created multiple access holes through the 900m+ thick ice of the Filchner and Ronne Ice Shelves in Antarctica.

Once drilling is complete the hole will begin to start freezing up meaning time is of the essence and work doesn't stop for poor weather. Robertson Geo winches need to operate in conditions as cold as -30°C with blowing snow often covering the drum.

Copy and image supplied by Paul Anker of British Antarctic Survey.

SUBSURFACE SOIL STABILITY ANALYSIS

for a major San Francisco construction project

A construction project is estimated at over 10m US Dollars to renovate the Levon Hagop Nishkian Bascule Bridge.

POPULARLY KNOWN AS the 3rd Street Drawbridge the new bridge is needed to accommodate the ever increasing flow of vehicles and with rising tide conditions the Nishklan Bridge will also require elevating above its current height.

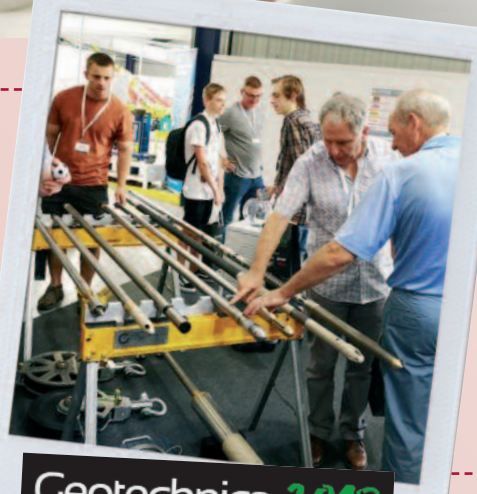
The City of San Francisco recognized the need to improve the bridge due to its age and structural stability. With on average, 50,000 cars crossing the bridge every day as well as transit trains, the increased weight of cargo trucks and the number of daily passenger vehicles has led to the decision to improve the 1945 built bridge.

Robertson Geo customer Norcal Geophysical Consultants Inc (a Terracon company) has a wide-ranging portfolio of services including geotechnical, environmental and infrastructure solutions. It commissioned the use of the PS Logger probe and surface equipment to analyse the shear-wave and compressional velocity data for subsurface soil stability for the new construction foundations that will be required, with consideration that the foundations for the new improved bridge could be set as deep as 200ft.

ONE FINE DAY IN THE MIDDLE OF THE DESSERT

Caliper logging at a residential and commercial development near the Grand Mosque, Rawdhat, Abu Dhabi UAE.

*"Good to see old friends and new at the **Geotechnica** exhibition in July... it's a focused show for our industry and gives us the opportunity to showcase our products and services, we'll be back next year!"*



Welcome to Robertson Geo, Joanne!

My name is Joanne van Aardt, I was born in Zimbabwe and grew up in Lusaka, Zambia.

Having lived in Africa my whole life and obtaining my Bachelor's Degree (Geology and Environmental Science) at Rhodes University in South Africa, I wanted to broaden my global horizons and head over to the northern hemisphere.

After I got my Masters in Applied Environmental Geology from Cardiff University, I was determined to work and explore as much of the UK as possible.

My new role as a Geophysical Logging Engineer at Robertson Geo has allowed me to achieve both of these goals with my first job on site occurring in a field right across from the majestic Stonehenge.

Currently I am an engineer-in-training, with aims of working on many more projects across the whole of the UK, and even the possibility of working offshore.

Professor Hubbard wins our Photo competition!

*The winner of the Robertson Geo customer photo competition is **Professor Bryn Hubbard** from the Dept. of Geography at Aberystwyth University.*

His outstanding photo of his research team conducting logging operations through the sea ice using Robertson Geo equipment was taken on the King Baudouin Ice Shelf in East Antarctica.

We featured it on the front cover of our first magazine earlier this year (pictured left).

Professor Bryn Hubbard (left) receiving the winning prize an iPad from Gavin Rowlands, our Business Development Manager.

"We explored the tunnels and marvelled at the engineering skills of the Victorian engineers and miners."

Great Orme - Llandudno

"A group of our Employees were hosted by the Great Orme Exploration Society on a private, guided visit to the Ty Gwyn copper mines, deep below the Great Orme in Llandudno, North Wales.

Access was through a manhole cover near the pier entrance, then down a 17ft vertical shaft to the main tunnel. The group explored the tunnels and marvelled at the engineering skills of the Victorian engineers and miners that exploited the high grade copper ore.

The mine operated from 1835 to the early 1850s and copper ore was shipped to Parys Mountain on Anglesey, to improve the overall grade of the ore being smelted at nearby Amlwch.

The fine brickwork lining some of the shafts and tunnels remains to this day, along with remnants of pumping equipment in the main Ty Gwyn shaft."

Since 2007 Intilog has been established to provide specialist contract geophysical and geotechnical logging services and geophysical equipment sales and service in Indonesia and the South East Asian region. Intilog's expertise is drawn from a team of key personnel with a combined total of 25 years experience in the region and a proven and valued close association with Robertson Geo.

A MUTUALLY ENJOYED PARTNERSHIP OVER A GOOD MANY YEARS

AS WELL AS running a successful logging company Intilog represent Robertson Geo as exclusive agents in Indonesia. It's been a working relationship, long established and together a host of logging systems and services has been provided to some of the largest mining houses, service logging providers and government organisations throughout the region.

Available are 13 geophysical logging systems in total and all reflect state-of-the-art Robertson Geo technologies. Excellent back-up facilities are offered with well-equipped workshops, technicians and a comprehensive inventory of spares ensuring downtime is minimal in the event of a breakdown. A feature of the business all will appreciate is the ability to fulfil customer requirements if equipment is requested outside of the current inventory.

A comprehensive operational and radiation safety management plan has been developed and approved by the Nuclear Energy Regulatory Agency (BAPETEN). Intilog's key personnel are holders of radiation protection licences (Petugas, Proteksi, and Radiasi) with new employees are given thorough training on the safe operation of equipment with special emphasis on the handling of radioactive material.

Operational and radiation safety management a must for Intilog personnel.

ROBERTSON GEO®
Unlocking Your GeoData

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

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

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