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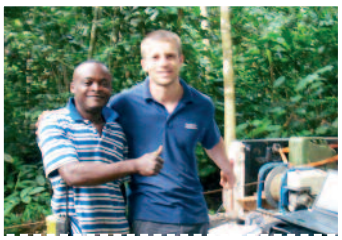

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GLOBAL GEODATA NEWS

ISSUE 05 | SUMMER 2019

Ireland

ROBERTSON GEO'S FLEET of service logging vehicles are fully customised and equipped ready to go whatever the location or application, seen here at a new deep mine development at Boliden Tara Mines.

Logging on location at EUROPE'S BIGGEST ZINC MINE

Tara Mines of Navan, County Meath, Ireland is in the top ten of the world's largest zinc mines.

Image shows borehole camera transmission at 250.68m.

ORE HAS BEEN extracted there since 1977 and it is estimated that more than 85 million tonnes have been mined since this time. Boliden AB the Swedish smelting and mining corporate giant acquired the Tara Mine in 2006.

In 2018 some 2200 ktonnes of ore was processed into metal concentrates containing zinc, lead and silver. In May of the same year a new joint venture was announced with Minco Ireland to extract a new area of deposits, making Tara Mines one of the world's deepest mines with fresh ore located up to 1.9km below the surface.

As part of the development of the new deep mine sector Robertson Geo has been contracted to log a pilot air shaft down to 250m.

The new RGeo-eye 4 core borehole camera has been deployed to investigate borehole integrity at 250m. It has provided excellent visual definition of the shaft. After the camera, probes were deployed to generate a composite log for the structural integrity and continuous diameter of the borehole shaft. The probes used were Acoustic Televiewer (HRAT), 3 Arm Caliper, Triple Sonic and Temperature Conductivity.

The United Utilities facility has four megalitres of processed potable water in a covered reservoir at Kerridge overlooking Macclesfield, Cheshire UK. It is looking to replicate the existing capacity within adjacent land by a further four megalitres.

UK's largest listed water company looks to DOUBLE THE CAPACITY FOR ITS KERRIDGE FACILITY

The initial data acquisition was completed by a Robertson Geo Service team, using the latest addition to its fleet of logging vehicles, a customised Toyota 4x4 Land Cruiser with its installation of mobile data acquisition and winch deployment surface equipment.

ROBERTSON GEO CUSTOMER Geotechnics is conducting the ground investigation on behalf of Mott MacDonald, the global Engineering, Management and Development Company.

Three of the eight boreholes that are scheduled for drilling have been logged to produce a subsurface televiewer survey. One borehole gave excellent optical output from the High Resolution Optical Televiewer (Hi-OPTV) probe and the other two gave excellent data when the Hi-OPTV and the High Resolution Acoustic Televiewer (HRAT) probe data was combined.

The boreholes range from 20m – 30m deep of 146mm diameter and are cased off at between 1 and 2m.

SEATTLE'S TRINITY PARISH Church was established in 1865, it is a historic building and was added to the National Register of Historic Places in 1991.

A major development is taking place in the Church grounds, announced in 2018 by Australian developer Caydon. The historic Church will remain but other buildings on the site will make way for a high-rise 28 storey tower of 200 plus condominiums.

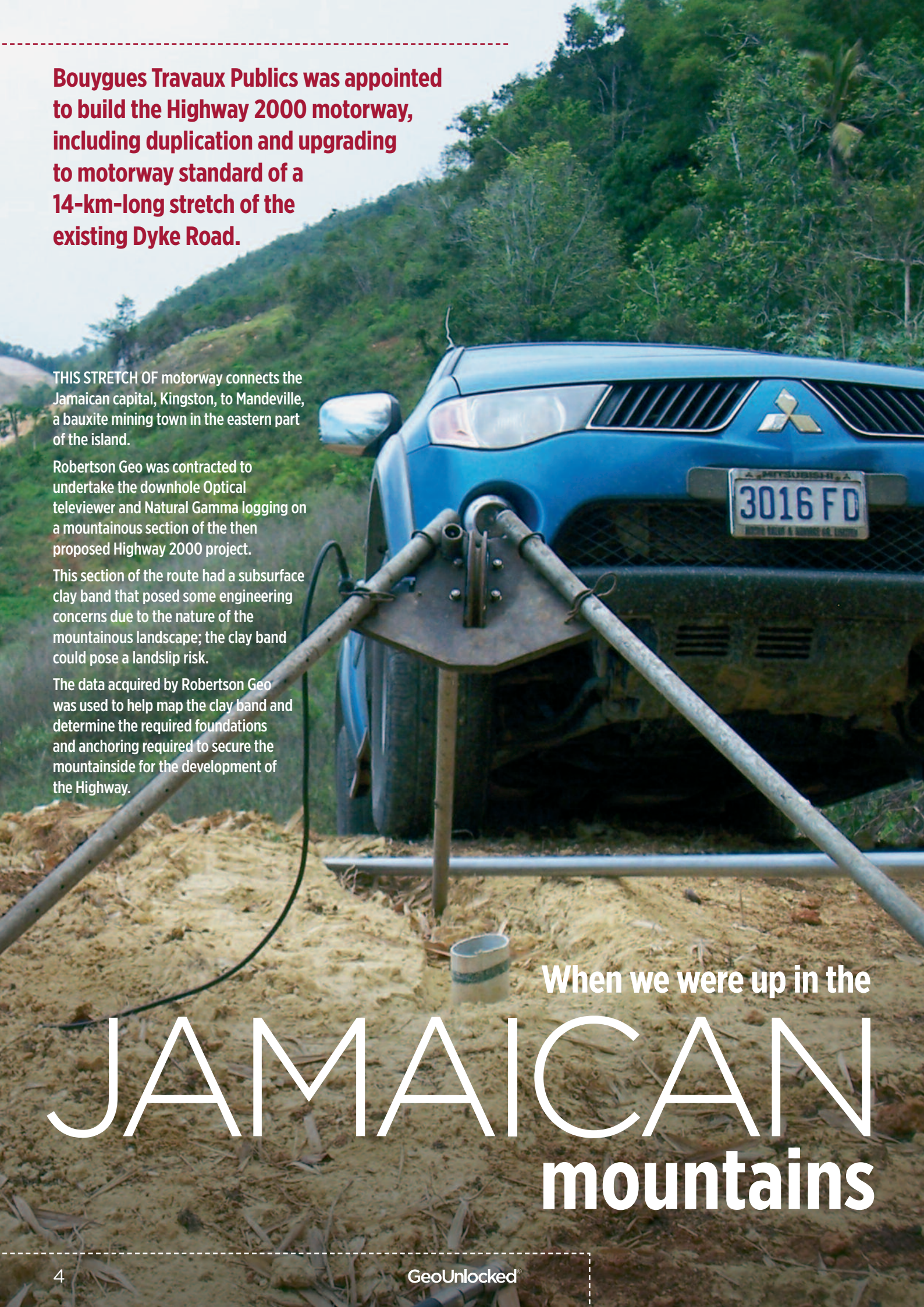
Jorge Ramirez of Robertson Geo Inc and Meron Okbay MS of customer Insitu Engineering of Snohomish, Washington State commissioned a new PS Logger suite of equipment at the 100ft pilot borehole for subsurface investigation in the Trinity Church grounds off 8th Avenue.

The PS Logger was successfully deployed with data acquired from 87ft through 7.5ft. A mini winch (175ft capability) and the Micrologger2 surface interface system, together with Winlogger the MS Windows based operating system was part of the commissioning and training.

PS LOGGER IN SEATTLE

Mr. Meron Okbay MS of Insitu Engineering accessing data from the PS Logger deployed into the pilot borehole at Trinity Parish Church.

Bouygues Travaux Publics was appointed to build the Highway 2000 motorway, including duplication and upgrading to motorway standard of a 14-km-long stretch of the existing Dyke Road.



THIS STRETCH OF motorway connects the Jamaican capital, Kingston, to Mandeville, a bauxite mining town in the eastern part of the island.

Robertson Geo was contracted to undertake the downhole Optical televiewer and Natural Gamma logging on a mountainous section of the then proposed Highway 2000 project.

This section of the route had a subsurface clay band that posed some engineering concerns due to the nature of the mountainous landscape; the clay band could pose a landslip risk.

The data acquired by Robertson Geo was used to help map the clay band and determine the required foundations and anchoring required to secure the mountainside for the development of the Highway.

When we were up in the

JAMAICAN mountains

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SOUND PRACTICE MEANS SOUND ECONOMICS

The Robertson Geo PS Logger Probe

Why do major civil engineering projects routinely deploy the Robertson Geo PS Logger probe for determination of soil and rock strength?

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.

PS Logger probe deployed in an offshore location (Hong Kong).

Cased and ready to go: the PS Logger is proven with data acquired from thousands of boreholes worldwide, often in the harshest of offshore applications

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 and therefore cost effective, especially when compared to alternative methods. When combined with bulk density values (from a density log or from core sample tests) small strain moduli (Young's, Shear and Bulk) can be calculated using simple formulae.

ORIGINALLY DEVELOPED BY Robertson Geo parent company OYO Corporation in the 1970's to provide a full waveform tool that would produce reliable P and S wave velocity measurements in unconsolidated materials and rock formations at depth. The initial application was microzonation, to characterise earthquake prone zones with respect to geological and geophysical characteristics such as ground shaking, liquefaction susceptibility, landslide, rock fall hazard and earthquake-related flooding, so that seismic hazards within the area could be identified.

So successful was the probe that it soon gained acceptance in the civil engineering arena, firstly in Japan and Asia, then USA in the 1980's and subsequently in Europe. The development and manufacture of the probe was continued by Robertson Geo in 2007 where it has remained a market leader, especially in the burgeoning offshore wind farm market.

The PS Logger system is offered worldwide as a turnkey service, for long-term and short-term rental, or for outright purchase. It is also plug compatible with the full range of Robertson Geo slim hole probes, that are calibrated and issued with a conformance certificate prior to mobilisation.

HOW THE PS LOGGER WORKS

The PS Logger is a full waveform acoustic probe, designed to measure compressional and shear wave velocities in soils and rock formations. It operates using indirect excitation rather than mode conversion as in a conventional sonic. It is capable of acquiring high-resolution P and S wave data in borehole depths of up to 600m.

It contains a unique design of powerful hammer source and two receivers, separated by acoustic damping tubes. To acquire data, the probe is stopped at the required depth and the source is fired under surface command. Firing causes a solenoid-operated shuttle aligned across the borehole axis to strike plates on opposite sides of the probe in turn, setting up a pressure doublet in the surrounding fluid. The resultant fluid motion produces a tube wave at the borehole wall with velocity close to the shear velocity of the formation together with a compressional wave. As the waves propagate parallel to the borehole axis, they set up corresponding fluid movements that are detected by the two-receiver combination (neutral-buoyancy 3D hydrophone for P waves and horizontally aligned geophone for S waves), allowing the wave velocities to be directly measured. The facility to stack multiple shots and filter the data as in normal seismic data acquisition is included in the operating software.

KEY BENEFITS

The PS Logger works in a single fluid filled borehole in contrast to cross- hole methods that usually require two or more

specially prepared boreholes. The method works in open or grouted plastic cased boreholes and borehole muds generally do not need to be flushed prior to logging, without compromising borehole stability. The PS Logger is largely unaffected by path affects which can be problematic for cross-hole methods.

With an integral powerful source, energy delivery is constant throughout the extent of the borehole, independent of borehole depth, giving reliable velocity measurement in hard rock and the slowest of formations. The high vertical resolution (0.5m typical) allows for measurement of thin layers and is not affected by high velocity layers above low velocity layers. As no external source is required this makes the system ideal for working offshore on barges, jack-up platforms and drill ships.

As the probe is suspended in the borehole no clamping to the borehole wall is required allowing faster acquisition. The PS logging can be conducted at the end of the drilling alongside any of the full range of conventional logging probes that Robertson Geo offers.

The propagated waves are measured in the vertical plane providing the most useful information in anisotropic formations.

When combined with bulk density values the PS Logger provides a continuous strength profile, especially important when hard layers are encountered and CPT methods 'refuse'.

The relatively high frequency of the source, when compared to other methods, means that good data can usually be obtained in very noisy environments. On drill ships where engines, DP thrusters, generators and ancillary equipment contribute to the ambient noise this is very important. The reversed polarity shear wave measurements provide unambiguous identification of shear wave arrivals.

APPLICATIONS AND ENVIRONMENTS

Robertson Geo has been regularly deploying the PS Logger throughout the world since 2008, especially for offshore projects where alternative methods are impractical. The list of projects includes wind farms, bridges, port extensions, oil and gas sub-surface infrastructure and nuclear power plants.

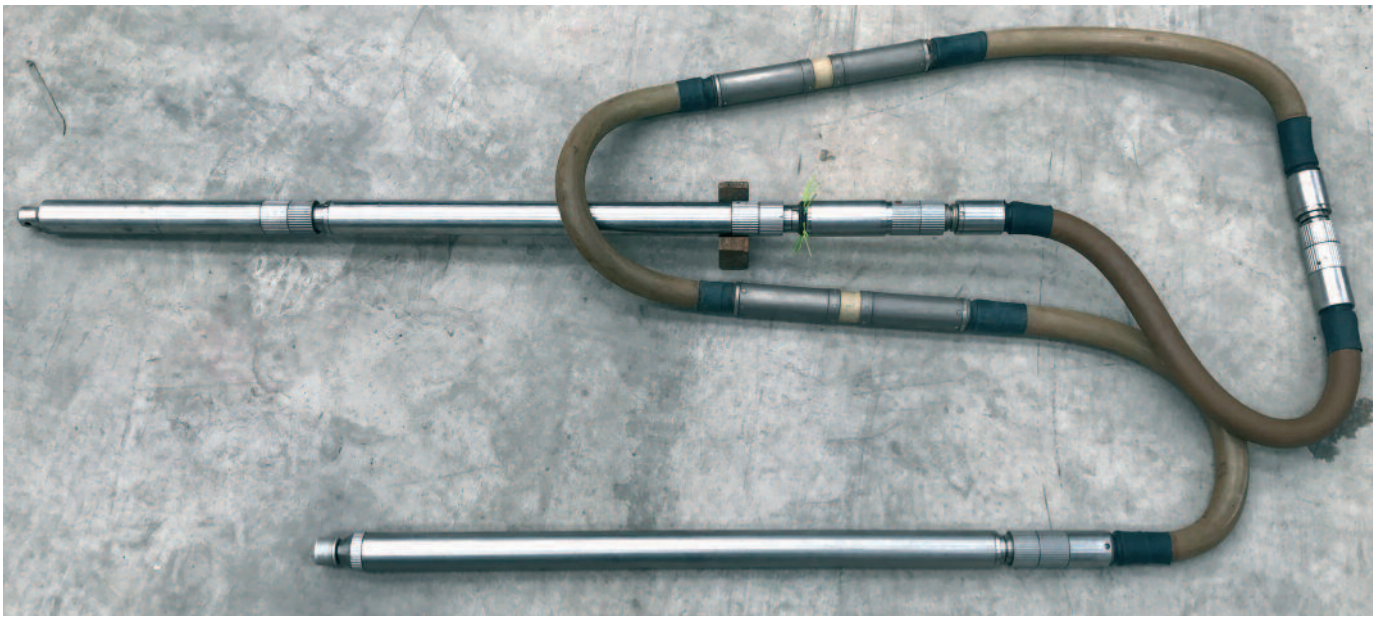
The UK is a world leader in the development of offshore wind farms. Rock strength information is key to engineers designing foundations for the massive structures which support the latest generation of turbines. Operating from jack-up platforms or from drill ships, marine resistant technology developed by Robertson Geo has allowed the PS Logger to be routinely deployed. The list of wind farms is extensive but includes Seagreen, Dudgeon, Hornsea, Moray East and Neart Na Gaoithe in the UK as well as those in Germany, France, Belgium, Denmark and the USA.

PS Loggers have also seen action on many of the UK's largest infrastructure projects including Wylfa, Sizewell B, Oldbury and Bradwell nuclear power stations, HS2, Lower Thames Crossing and A303 Stonehenge bypass, in addition to many other major civil engineering projects. However, the ease of deployment and cost effectiveness of the technology means affordability for even the smallest of projects.

DRILLING MATTERS

Borehole conditions play a big part in data quality and that is where the drilling personnel should be involved. Rotary drilled boreholes always provide the best data (low rugosity). The PS Logger can produce good data in boreholes from 65mm to 400mm with the optimum range being from 75mm to 200mm. Inclined

The assembled probe:
PS logging is unique in offering high resolution seismic measurements from a single borehole up to 600m depth.



boreholes can also be logged providing the tilt is no more than 30° from vertical.

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 potentially unstable 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.

Due to the PS Logger's tolerance to borehole muds, there is little or no preparation required on the borehole. Polymer or Bentonite based muds can be extremely viscous with the limiting factor being the buoyancy of the probe. Where the use of thick mud fails to provide sufficient borehole stability the borehole can be plastic lined and grouted. A specification for the grouting can be supplied.

PROCESSING

Full waveforms are recorded digitally at acquisition time across 6 channels (P wave, S wave left & S wave right at the near and far receivers) at a predetermined sample rate as low as 2.5µsec. The sample rate is carefully selected to be as small as possible to provide the best resolution but high enough to capture the arrivals within the listening window. Low pass filters can be applied at acquisition time and digital filters can be applied during or post acquisition.

Using the acquisition software, the waveforms can be displayed, scaled and filtered to allow for the picking of the first arrivals at each receiver. Automated picking is available but in most cases the arrivals are picked manually by experienced engineers. While the P wave arrivals are generally simple to pick, the S waves with their typically slow onset and possible superposition over the decaying P waves benefit from an experienced eye to avoid 'cycle skipping'. From the receiver separation (1 metre) and the arrival times the velocities are automatically calculated.

Once the arrival times and velocities have been determined, the data is opened in a second program (also supplied with all PS logger systems) that creates and manipulates logs of the data. If a bulk density profile by depth is available it can be combined with velocities to give the small strain moduli, Young's, Shear and Bulk and Poisson's ratio. Finally, all data can be outputted in industry standard LAS format.

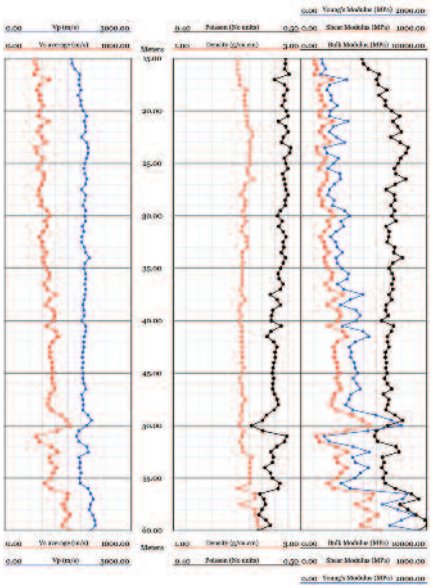
Robertson Geo Logging Services department offer a 3rd party processing service for clients renting or buying systems.

From unconsolidated soils to the hardest of rocks, the PS logger gives proven results.

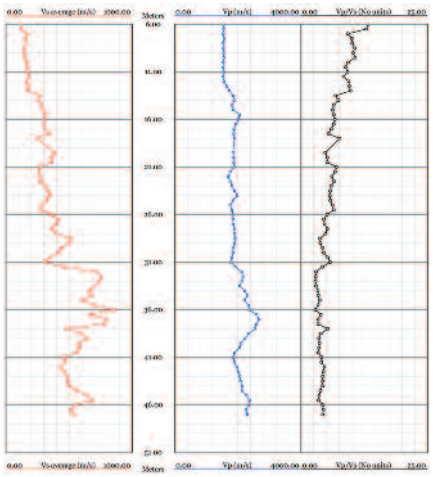
Simplicity of deployment combined with a minimum of borehole preparation and the ability to obtain high quality velocity data in unconsolidated formations and hard rocks make the PS Logger a sound economic choice for Geotechnical and Civil Engineers investigating rock strength.

Graham Comber
Logging Services Manager, Robertson Geo

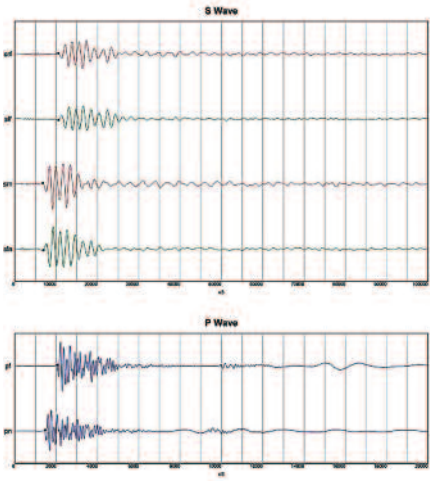
SMALL STRAIN LOGS:



Example of full probe data logs.



Example of basic velocity logs.



Example of single wave trace output.

Thumbs up for problem solving in GABON

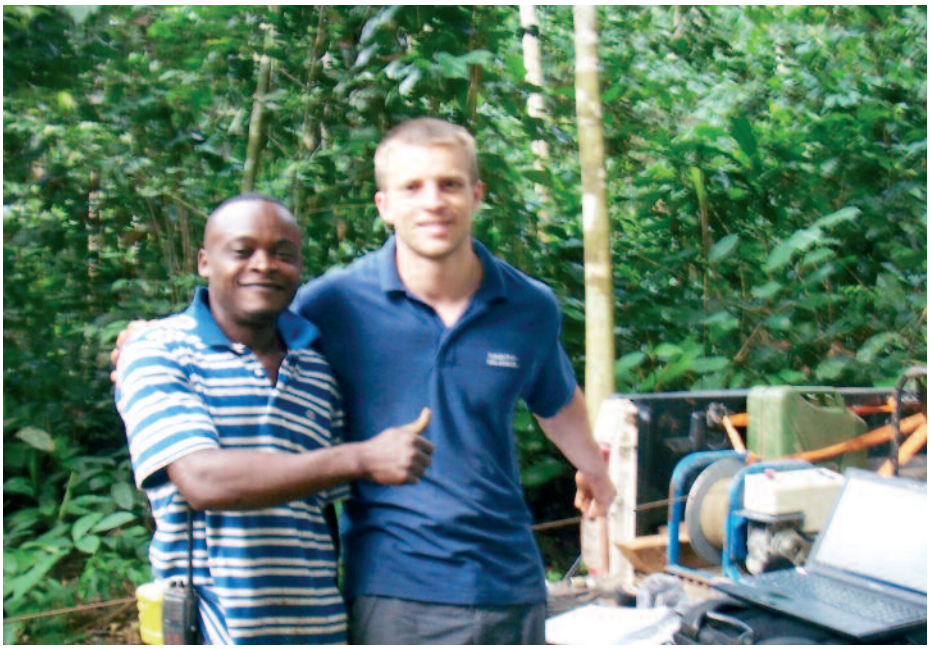
THE 'MABOUMINE' MINING company was preparing an industrial project to open a niobium polymetallic mine near to Lambaréné, in Gabon's Mabounié Valley.

Soil Engineering Geoservices Ltd contracted Robertson Geo to undertake the wireline logging to measure the Natural Gamma Radioactivity of the subsurface down to 50m.

The site was located in an equatorial rain forest and very difficult to access. We also had to overcome the bending effect of the sun scorched 50mm diameter downhole plastic borehole liners. We attempted to use a standard probe of 2.2m length and 42mm diameter but due to the extreme heat the liners had been exposed to, they had bent and were curling in the borehole making hitting target depth with a probe of this size very difficult.

Remarkably, the development and manufacturing departments of Robertson Geo were able to fast track the development and production of a small 0.78m length and 27mm diameter Gamma Probe within a matter of days to provide the solution to this and enable the acquisition of full data coverage to meet the Client requirement.

Aaron Jones
Senior Logging Engineer



Continuing subsurface investigation along the route of the HS2 RAILWAY PROJECT

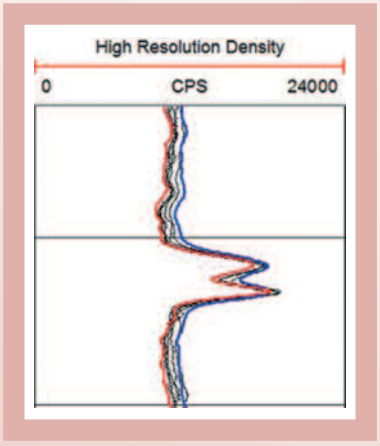
THIS PHASE REQUIRED the logging of 55m deep boreholes for the proposed Colne Valley Tunnel and viaduct section near Chalfont St Peters, South-East Berkshire UK.

Probes deployed were 3-Arm Caliper, Formation Density, PS Logger and High Resolution Optical Televiewer (Hi-OPTV). The data acquired characterised the subsurface properties for soil structure, formation, rock strength and the presence of any fractures or faults.

“Robertson Geo is the only ISO CERTIFIED logging services provider and the only company which comprehensively CALIBRATES all of its logging systems”

“ CALIBRATION IS ONE of the most important aspects of using geophysical equipment but also one of the most easily ignored. A proper calibration routine is vital to maintain the highest standards of data quality.

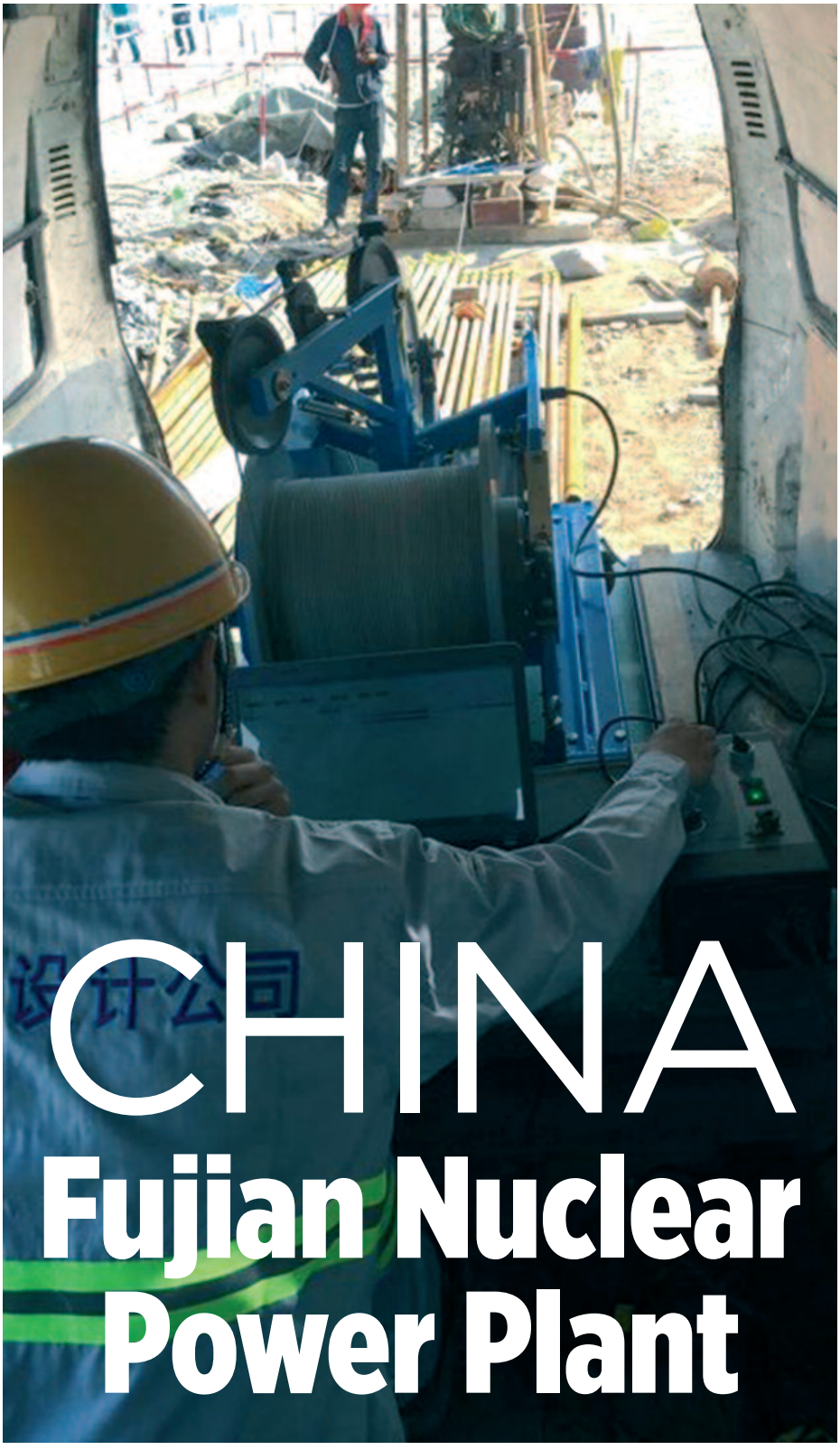
A good example of the importance of calibration is seen in gamma radiation density logs. With time the strength of the radioactive source gradually decreases (2.3% per year for caesium 137) and the efficiency of the sodium iodide detector may decrease.



The log shows the result of this: over the course of three years the raw count rate experienced by the probe drops noticeably. Calibration allows field engineers to maintain reading precision by resetting the clock, achieving high quality results over extended periods.

Robertson Geo provides calibration equipment and support for all of its probes, helping clients achieve optimal results for all future operational needs. ”

Timothy Hamflett
Test Engineer



CHINA
Fujian Nuclear Power Plant

THE CONSTRUCTION OF nuclear power engineering civil works has started in Xiapu County, Fujian Province. It is the first nuclear power project started in China since 2017.

Robertson Geo customer, Changjiang Survey Technology Institute was commissioned by the project department to drill 15 boreholes each with a depth of 200 to 300 meters and an outer diameter of 95mm. The collected data will be used for fracture identification and slope stability analysis.

Over a five day period, the data logging of the 15 boreholes was completed using Robertson Geo High Resolution Acoustic Televiewer (HRAT), Electric Log and Full Wave Triple Sonic probes deployed by a 1000m capacity winch.

Introducing Michael Jones

"My name is Michael Jones and I am the newest addition to the software development team.

I'm from North Wales and thrilled to be back and working with Robertson Geo.

I have a background in earth sciences having completed an MSci degree in Geology and Geophysics from Imperial College London.

When I graduated I entered the mining industry completing an internship as a graduate geologist on a mine site in Utah, USA and gained some valuable experience, but then decided to follow a different path and was employed as a consultant in a hydrology and flood risk consultancy. This role was very enjoyable and multifaceted involving field work across the UK, hydraulic modelling, scientific research and computer programming among other things. As the role progressed it became clear that computer programming was the area which I found most rewarding and stimulating and decided that it was something I wanted to do full time and I joined Robertson Geo.

I have now been here for over six months (where does the time go?), already I'm fully absorbed in Robertson's most recent development project. With my earth science background the role feels like a perfect fit for me. I look forward to combining my experience as a geologist and a software developer with the success of current and future projects."

The Service team are all "*Tough Mudders*"

Robertson Geo Service Teams decided to place their "ready to go anywhere" reputation to the ultimate test by facing the world renowned Tough Mudder endurance event in the grounds of Cholmondeley Castle, Cheshire UK.

The challenge of mud, cold water, teamwork and endurance was embraced with a positive, familiar attitude as each logging job usually involves at least one of these conditions. The ten-mile-long course consisted of a multitude of obstacles ranging from crawling through muddy trenches, wading through rivers and climbing over high vertical walls.

An obvious 'favourite' being the electric shock therapy, where a mad dash from one end to another through dangling electric wires was viewed more as an 'every man for themselves' obstacle, rather than the 'no one gets left behind' mentality the team used throughout the day. Many of the obstacles were impassable without teamwork and the event was a great team building exercise.

See you soon!

Already this year we've exhibited at exhibitions and conferences across Europe, the Americas, the Middle East and Australasia.

See us at these upcoming shows:

Geotechnica 2019
Warwickshire, UK
July 10th - 11th 2019 • Booth 18

AEGC 2019
Perth, Western Australia
September 2nd - 5th 2019

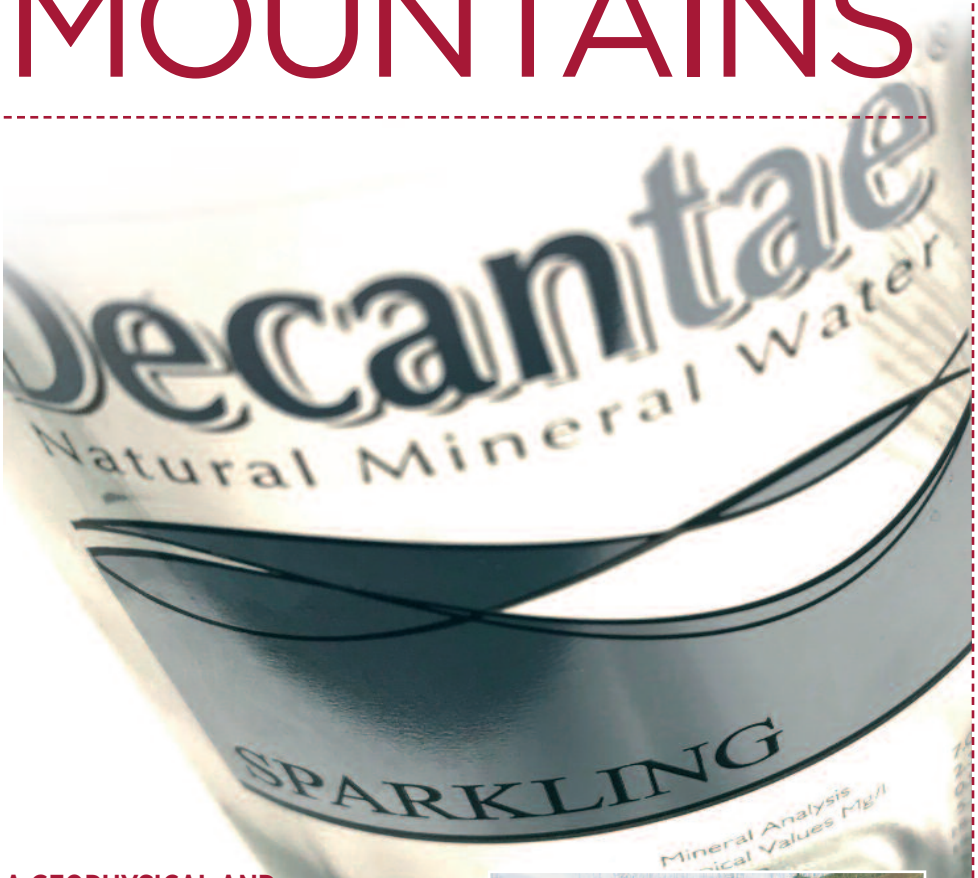
ASDSO Dam Safety 2019
Orlando, Florida, US
September 8th - 12th • Booth 618

Near Surface Geoscience Conference and Exhibition 2019
The Hague, Netherlands
September 8th - 12th 2019 • Booth 35

SEG19
San Antonio, Texas, US
September 15th - 20th 2019

Transport Geotechnics 2019
London, UK
October 2nd - 3rd 2019

Mineral water from the WELSH MOUNTAINS



A GEOPHYSICAL AND camera survey, down to 40m, of two water producing wells has been completed for Decantae Mineral Water in the Snowdonia foothills at Trofarth, North Wales.

The acquired data was used to determine the extent, nature and condition of the water well casing with a view to implementing a plan to increase flow rates whilst maintaining the highest water quality. The geologic target and producing zone was a Silurian mudstone at 40m subsurface. The well site had one borehole in hilly terrain only accessible with a 4WD vehicle.

The logging of the wells was completed in two visits of one day each. Probes deployed included Downhole Camera, 3-Arm Caliper/Natural Gamma, Electric Log, Temperature/Conductivity and Cement Bond Log.

Following initial set up, the Downhole Camera was run into the borehole and a comprehensive inspection of the borehole and casing was performed in real-time with the results saved for later inspection. A Temperature/Conductivity log was then made which provided information on the inflow depths. The 3-Arm Caliper provided quantitative information on the borehole condition and the Natural Gamma and Electric Log helped define the local lithology. Finally, a Cement Bond Log was run to provide additional information on the casing integrity.

The logging was completed in a timely manner minimising any disruption to the water production. Probes were deployed with 100% reliability, and provided invaluable information for future development. Following logging operations, the operator replaced casing from the wells as necessary and the wells were brought back into production.

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40 YEARS 1979 - 2019

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