Surface Logging Services

to reduce drilling time and costs

to improve rig safety

to characterize reservoirs
Mission Statement

Our Mission

To help our clients make quantified, informed, substantial improvements in their drilling efficiency, hydrocarbon detection and reservoir characterization.

To constantly build a leading edge service company that attracts, develops and retains exceptional people.

To respect and improve the highest safety and environmental standards whilst actively participating in the development and know-how of the countries in which we operate.

@2017 GEOLOG. All rights Reserved
Company Overview
The leading independent surface logging company

**GEOLOG International** ("GEOLOG") is a leading global oilfield services company that provides surface logging services to a substantial and diversified client base. Founded in 1982 in Milan, Italy, the firm maintains offices in most major oil producing countries. GEOLOG operates at the forefront of technology and its services are focused on the optimization of the overall drilling process and reduction in costs of each well in addition to the acquisition of quality data for formation characterization.

GEOLOG services national and international oil companies and integrated service providers, both onshore and offshore across more than 45 countries and is presently involved in exploration, development, deep and ultra deep water offshore, HP/HT, geothermal and unconventional reservoir wells. GEOLOG’s significant growth since its inception 35 years ago is to be attributed to, amongst others, its technological leadership in surface logging and its strong focus on proprietary research and development. As such, GEOLOG invests heavily in R&D (up to 5% of annual turnover) with a target to produce a new patent, on average, every six months. In line with its strategy to be the leading global supplier of choice, GEOLOG is already a leading supplier for highly technological surface logging services to the energy industry, where its leadership and innovation is recognized to bring value and reduce drilling costs. These projects typically include deep-water, HP-HT operations, horizontal/extended reach and / or extensive development drilling as well as drilling in areas with complex reservoirs. In particular, GEOLOG is now a world leader in hydrocarbon characterization through its gas extraction, analysis and interpretation from drilling mud thanks to its advanced technologies in integrated rock and fluid characterization.

GEOLOG’s products and services are focused on 3 key industry requirements:

- To reduce overall drilling costs
- To improve rig safety
- To characterize reservoirs

GEOLOG is the largest independent international surface logging company in the world and presents itself as the only solution to clients seeking an independent surface logging company versus one of the integrated service providers.

GEOLOG’s surface logging services provide answers which are critical for the drilling, geology and reservoir teams of our clients. GEOLOG delivers services which include the acquisition, analysis and interpretation of (i) Geological data obtained by physical evaluation of cuttings; (ii) hydrocarbons data obtained from analysis of gases in and out and (iii) drilling data (including mechanical, hydraulic and engineering variables) obtained using technologically advanced sensors and enhanced real time analysis. GEOLOG provides key information to evaluate the well in terms of hydrocarbon content and origin, pressure balances and relative positions of its lithological layers. GEOLOG’s services also provide early notification and analysis of events to ensure well integrity, safety and to prevent formation damage for optimum data acquisition and field productivity.
GEOLOG was founded in Italy in 1982 to provide mud logging services to AGIP on geothermal, oil and gas wells. From its early years, GEOLOG’s strong technological and R&D culture led to the development of a number of innovative solutions and highly technological patents in the mud logging arena. The Italian crisis of 1994, during which the company moved abroad, opening bases in Tunisia, Congo and Venezuela, servicing AGIP’s international operations, acted as a catalyst for the company’s international expansion. Current management acquired the company in 2001 and has been able to develop its innovative solutions and technological patents into commercial products and services, thereby significantly growing the customer base across not only international oil companies but also across national oil companies worldwide. Whilst retaining its R&D and production facilities in Milan, Italy, in 2016 the company reorganized its corporate structure under GEOLOG Surface Logging DMCC, based in Dubai, UAE.

Under current management, GEOLOG has consistently grown organically by delivering value, expanding its operations from its established footholds in Europe, North and West Africa and Central America and by opening new bases in the Middle and Far East, South America, the North Sea, USA and Australasia. Today, GEOLOG remains privately owned and has grown to become the largest international independent mud logging company in the world.
GEOLOG’s experience covers over 5,000 wells globally and includes national and international oil companies across multiple continents. Our services are in demand with traditional oil & gas operators and extend to small and large integrated service providers.

Our services have been performed both onshore and offshore for:

- Exploration Wells
- Development Wells
- Geothermal Wells
- Unconventional Reservoirs
- Extended Reach Drilling
- Narrow Mud Weight Windows
- Underbalanced-Managed Pressure Drilling

GEOLOG has logged over 500 wells in Deep and Ultra-Deep Water operations in:

- Angola
- Australia
- Brazil
- Congo
- Egypt
- Ghana
- Gulf of Mexico
- Guyana
- India
- Italy
- Malaysia
- Mauritania
- Mozambique
- Namibia
- Sri Lanka
- Tanzania
- Timor Leste
- Togo
- Trinidad
- Tunisia
- Turkey
- Venezuela

HP/HT Well Experience includes:

- Argentina
- Austria
- Bolivia
- Brazil
- China
- Ghana
- Italy
- Kurdistan
- Kuwait
- Mexico
- Mozambique
- Netherlands
- Norway
- Romania
- Sri Lanka
- Turkey

Extreme Weather Environments:

North Africa +55°C   Arctic -50°C

International Oil Companies include:

- ADDAX PETROLEUM
- Anadarko
- iol
- bhpbilliton
- bp
- CAIN
- CEPSA
- Chevron
- ConocoPhillips
- dana petroleun
- devon
- ecopetrol
- eni
- enel
- ExxonMobil
- HESS
- Lukoil
- Marathon Oil Corporation
- Murphy Oil Corporation
- Oil Search
- Petro-Canada
- Perneco
- pluspetrol
- REPSOL
- RWE
- Santos
- Shell
- Statoil
- Total
- Tullow Oil
- wintershall

National Oil Companies include:

- ENAP
- Gazprom
- INAGAZ
- PEMEX
- PERTAMINA
- PDVSA
- Petrobras
- Petronas
- PTTEP

Integrated Service Providers include:

- Baker Hughes
- Senergy
- Halliburton
- Weatherford
GEOLOG's R&D collaboration with its clients often starts at the early stage of conceptual design and follows through into the field deployment and solution validation. This is to ensure that the research work is entirely focused on meeting the client expectations and solving the challenges arising continuously in our oilfield industry.

The following is a list of some of the technical papers GEOLOG has written in collaboration with its clients over recent years:

**Thermo-Desorption on Cutting Samples: a Real Case Study of Hydrocarbon Identification while Drilling. IMOG-2017-P184** (IMOG, Florence, September 2017)

This paper reports the application of the G9+ service at wellsite during an exploration well and the favourable comparison of G9+ results with post-mortem GC-MS analysis from a geochemistry laboratory. The wellsite analysis was also able to deliver real-time results when downhole evaluation tools failed.


This paper shows how real-time while drilling assessment with Surface Logging technologies has contributed to optimizing well completions, helps define the petrophysical facies, to aid geo-steering and to address hydraulic fracturing in three different unconventional wells in the Anadarko Basin.


This paper illustrates the application of helium detection at wellsite, ranging from instrumental performance to interpretation. Case studies show the potential use of helium as a tracer of fractures and the good match with the light hydrocarbon concentrations and lithologic changes.

**Cost-Effective Reservoir Characterization from Advanced Surface Logging Technologies in Unconventional Reservoirs. URTEC-2460893-MS** (URTeC, San Antonio, August 2016)

This paper has been written in collaboration with Southwestern Energy to evaluate a number of cost effective services that can be used to understand the vertical and horizontal heterogeneity in organic tight rock formations. These early, real-time measurements can then be used to characterize the reservoir rocks for optimizing and designing completions.

**The Application of Well-Site Isotopic Analysis for Reservoir Evaluation. SPWLA-2016-VVVV** (SPWLA Annual Symposium, Reykjavik, June 2016)

Joint paper written with Kuwait Oil Company which demonstrates the applications and benefits of Geolotopes and shows how the carbon isotopic ratio analysis performed on site, while drilling, is a technique that generates an unprecedented isotopic data density across reservoir and source rock intervals.


Joint paper prepared with Repsol shows how an accurate Mud Flow Measurement is able to identify and evaluate in real time an open fracture while drilling. The paper summarizes that monitoring while drilling of micro-losses associated to fractures provides important data to characterize fractured reservoirs, to identify pay zones and to support testing decisions.
The Application of Mud Gas Analysis in the Evaluation of a Complex Carbonate Reservoir. SPWLA-2014-EEE (SPWLA Annual Symposium, Abu Dhabi, May 2014)

Joint paper written with Chevron describes how GEOLOG has performed characterization and evaluation of formation fluids while drilling with its advanced gas detection system. The technique provided solutions for fluid characterisation, reservoir zonation, fluid contacts identification and validation of potential vertical flow barriers. It also found a positive impact in geosteering of drain holes. Additionally, the comparison with PVT sample data obtained post-mortem confirmed the reliability of GEOLOG’s advanced gas detection system as a fluid character indicator.

High Resolution ChemoSteering in Drilling Horizontal Wells. SPE-164385-MS (MEOS, Bahrain, March 2013)

Joint paper prepared with KOC summarizing how KOC Geosteered successfully smart level-4 multilateral well with dual stacked lateral in Sandstone Reservoir with OBM utilizing GEOLOG’s advanced geochemical system. Resulted in successful placing the wells with maximum reservoir contact, isolation of potential trouble zones, optimization of nozzle sizes of the ICDs.

Innovative Geosteering Technology Utilized in Drilling Smart Multi-lateral Wells. OTC-24002 (OTC, Houston, May 2013)

Joint paper with KOC summarizing how KOC was capable to drill successfully a horizontal well in Sandstone Reservoir with OBM utilizing GEOLOG’s advanced geochemical system. Such system enabled drilling a reservoir having vertically stacked channel sands, fault network connected to the aquifer and hydrocarbon viscosity of about 40 cP.

Real Time Advanced Flow Analysis for Early Kick/Loss Detection & Identification of Open Fractures. SPE-167335 (KOGS, Kuwait, October 2013)

Joint paper prepared with KOC summarizing how KOC was able to drill safely an HPHT well with OBM utilizing GEOLOG’s advanced mud flowmeter. Such system ensures safe drilling by early detection of minor well kicks and mud-losses occurring in subsurface. The importance of such system becomes greater due to presence of naturally open fractures and narrow pressure margins.

Advanced Mud Gas Detection System Improves Formation Fluid Characterization While Drilling In Challenging Indonesia Deepwater: A Case History. (IPA Annual Convention & Exhibition, Jakarta, May 2012)

GEOLOG teamed up with ENI in choosing the optimal mud gas extraction and detection system to support the evaluation of the Jangkrik reservoir fluids, in Indonesia deepwater.

Innovative In-house Geosteering Utilizes Gas-While-Drilling Data for Deep Jurassic High Angle Well Placement. SPE-163368-MS (KIPCE, Kuwait, October 2012)

Joint paper prepared with KOC summarizing how KOC was capable to perform in house geosteering independently from directional drilling companies. Besides, this workflow successfully tested innovative use of advance gas data in conjunction with the LWD data for well placement. Indispensable in the complex short-radius drain--holes/slim well bores where conventional logging/LWD is not possible.

Cutting Weight Sensors to Improve Drilling Efficiency: Field Results Onshore South Italy. (IADC, Dallas, March 2004)

Joint paper prepared with ENI summarizing how ENI was able to solve serious problems drilling deviated wells by utilising GEOLOG’s cutting weight sensors. The data displayed while drilling, enable to identifying lack of borehole cleaning and borehole instability problems and to undertake remedial action improving drilling efficiency and reducing not productive time.
HSE & Quality

Health, safety, the environment and quality are fundamental to everything we do.

HSE Capabilities

Our vision at GEOLOG is to ensure we meet or exceed all health, safety and environmental (“HSE”) expectations of our stakeholders and strive to improve our H, S & E performance on a continuous basis.

GEOLOG HSE Management System is certified under the international standards ISO 14001:2015 (Environmental Management System) and OHSAS 18001:2007 (Occupational Health and Safety Management System) by DNV-GL for its main locations in Amsterdam and Dubai (headquarters), Luanda (main operational base of Sub-Saharan Africa) and Ijmuiden (operational base for North Sea region). These certifications are integrated by the ISO 9001:2015 (Quality Management System) both for office/base and rig site activities. This demonstrates that GEOLOG operations are managed safely and responsibly, providing reliable services to our clients free of risks associated with HSE matters.

Executive Management is fully committed to our HSE vision through constant personal involvement, including review meetings, audits and the provision/assignment of resources.

The GEOLOG corporate HSE policy statement is issued directly by the President of the Company, Mr. Antonio Calleri. The HSE function within GEOLOG has grown significantly to maintain pace with the increased expectations of customers and regulatory bodies globally as operations have expanded.

To comply with international standards and clients’ requirements, GEOLOG constantly monitors and evaluates the effectiveness of its HSE system targets. For this reason, many KPIs are evaluated and regularly reported to senior management, such as, the man-hours worked, the number of lost time injuries\(^1\) (LTI), the LTI frequency rate\(^2\) (LTIFR), the total recordable incident rate (TRIR) \(^3\) and all statistics related to minor incidents and environmental spills. In 2016, GEOLOG worked approximately 2 million man-hours worked with zero fatalities, zero lost time injuries, and zero environmental spills.

GEOLOG is registered in many Achilles communities, such as FPAL, Connexio Achilles JQS, and Repro. This is a further confirmation of GEOLOG’s commitment and adherence to standards. Some of the major benefits of having an integrated certified system worldwide are:

- To provide effective and consistent operational service to our clients.
- To provide efficient and consistent support to our rig site operations.
- To have standardized planning and procedures worldwide, enabling GEOLOG to work consistently at the highest standards.
- To involve and encourage the participation of both office and rig site personnel.
- To have an active system for continuous improvement.

Quality Capabilities

GEOLOG’s Quality Management System, certified to ISO 9001:2015, is founded on the belief that continuous improvement of the quality of our services must be pursued. GEOLOG involves all its employees in this process, from field staff to senior management.

The integrated certification of the QHSE Management System (ISO 9001:2015, ISO 14001:2015 and OHSAS 18001:2007) guides the company in achieving excellence in QHSE performance and ensures that GEOLOG’s operations are managed efficiently and responsibly, providing reliable, safe and environmentally respectful services to its clients.

To ensure the QHSE Management System is in place in the certified bases, GEOLOG uses a team of internal auditors trained in the ISO & OHSAS standards.

Our integrated management system has been internally reviewed against the API Q2 standard and a comprehensive GAP analysis performed to ensure compliance.

In addition to its ISO & OHSAS certificates, the GEOLOG QHSE Management System is also verified and approved as per Achilles requirements, a system used by major organisations to qualify suppliers and consequently reduce the risks in the supply chain.

Achilles

<table>
<thead>
<tr>
<th>Stop/Observation cards, Safety meetings, Unsafe Act/Condition reports</th>
<th>26,302 (30,485)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical Treatment Cases</td>
<td>5 (10)</td>
</tr>
<tr>
<td>First Aid Cases</td>
<td>6 (4)</td>
</tr>
<tr>
<td>Near Misses</td>
<td>235 (258)</td>
</tr>
<tr>
<td>Lost Time Injuries</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Fatalities</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

2016 (2015)

\[1\] A Lost Time Injury (LTI) is a work-related injury occurred to an employee in which a physician or licensed health care professional recommends day(s) away from work.

\[2\] The Lost Time Injury Frequency Rate (LTIFR) is calculated as the number of Lost Time Injuries per million hours worked in the period analyzed.

\[3\] The Total Recordable Incident Rate (TRIR) is calculated as the number of Fatalities, Lost Time Injuries and Medical Treatment Cases per million hours worked in the period analyzed.
Satisfy customers with superior quality, value and services

Maintaining outstanding QHSE Performance that follows the ISO & OHSAS standards is a core value of GEOLOG. Our successful QHSE performance has been made possible through the leadership and teamwork of all employees and all managers. GEOLOG’s QHSE Standards are based on the continual improvement of the QHSE Management system:

Corporate Responsibility

GEOLOG is committed to advancing its policies and systems to ensure it addresses all aspects of social responsibility that are relevant to its business.

For these reasons GEOLOG is an active member of the United Nations Global Compact (UNGC) - a strategic policy initiative for businesses that are committed to aligning their operations and strategies with ten universally accepted principles in the areas of human rights, labour, environment and anti-corruption, as detailed here:

1. Businesses should support and respect the protection of internationally proclaimed human rights and make sure that they are not complicit in human rights abuses.

2. Businesses should uphold the freedom of association and the effective recognition of the right to collective bargaining, the elimination of all forms of forced and compulsory labour, the effective abolition of child labour, the elimination of discrimination in respect of employment and occupation.

3. Businesses should support a precautionary approach to environmental challenges, undertake initiatives to promote greater environmental responsibility and encourage the development and diffusion of environmentally friendly technologies.

4. Businesses should work against corruption in all its forms, including extortion and bribery.

GEOLOG publishes its annual COP (Communication on Progress) report in May of each year. The latest copy of which is available on GEOLOG’s as well as the UNGC’s website.

GEOLOG supports local charitable initiatives and actively participate in projects that benefit communities around the world.
GEOLOG’s services help to reduce drilling costs through the use of low risk surface methods, improve safety by monitoring and analysing drilling processes that identify harmful gases and fluid movements and assist in the rapid characterization of formations, including source, reservoir and their contents. We have a range of services that are applicable to many drilling operations, including BitLife, our patented near real-time bit wear monitoring service, and DrillBest and NRG@Bit, which are easily implemented software solutions that can analyse drilling activities to improve drilling efficiency in real-time, and also analyse operational activities to identify invisible lost time and non-productive time, thus reducing the costs of operations.

Our KickAlarm and DrillClean services are also focused on reducing specific aspects of non-productive time through the rapid identification of fluid losses and influxes, analysing the return of cuttings to ensure the borehole is being adequately circulated clean and that borehole instability does not lead to potential pack-offs. Our GeoPressure services are used in areas where moderate to severe formation pressures require careful evaluation to help for example; avoid unnecessary casing strings, or NPT through dealing with additional unplanned well-control procedures. The RheoDrill service delivers continuous high resolution drilling fluid viscosity, density and temperature monitoring, ensuring that drilling fluid rheology changes caused by reactive clay formations or water influxes are identified easily.

Our formation evaluation suite of services such as G5, G8, Geolsotopes, G9+, GeoSource and GeoRox provide the most detailed analysis of all aspects of the formations drilled, and their contents.

<table>
<thead>
<tr>
<th>Drilling Challenge</th>
<th>Essential</th>
<th>Value Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reducing Non-Productive Time and Costs</td>
<td>KickAlarm, DrillBest, BitLife</td>
<td>DrillClean, GeoFracture</td>
</tr>
<tr>
<td>Measure, Monitor and Improve Drilling Efficiency/Drilling Optimization</td>
<td>DrillBest, NRG@Bit, BitLife</td>
<td>DrillClean, RheoDrill</td>
</tr>
<tr>
<td>Mitigating Fluid Influxes and Losses for Improved Safety</td>
<td>KickAlarm</td>
<td>GeoPressure, GeoFracture</td>
</tr>
<tr>
<td>Minimizing Drilling Costs</td>
<td>DrillBest</td>
<td>NRG@Bit, BitLife</td>
</tr>
<tr>
<td>Optimizing Wireline and LWD Evaluation Programs</td>
<td>G5, G8, GeoROX</td>
<td>Geolsotopes, G9+</td>
</tr>
<tr>
<td>Real-Time Geological and Reservoir Answers</td>
<td>Wellcoms</td>
<td>GeoWITSML</td>
</tr>
</tbody>
</table>
Deep and Ultra-deep Water

Drilling in deep and ultra-deep water poses many formation evaluation challenges for operators including increased costs, remote locations, complex formation pressures which in turn may lead to borehole instability and unplanned well-control situations and drilling muds cooled by long riser sections. Use of services such as KickAlarm help mitigate non-productive time by carefully identifying only true fluid influxes and losses. The DrillClean service provides accurate assessment of the volumes of returned cuttings, identifies borehole instability and monitors hole cleaning efficiency in real-time. Inclusion of the RheoDrill service can provide an early identification of reactive clays. Our GeoPressure services help identify, monitor and analyse the presence of formation overpressures and assist in the drilling of wells with narrow safe-drilling margins. Our G5, G8, G9+ and Geolsotopes services provide the broadest range of data analyses available to analyse the hydrocarbon composition and origin in real-time at the wellsite. This allows the optimal use of other techniques such as wireline formation testing and sampling that require specific use of extended periods of rig-time.

<table>
<thead>
<tr>
<th>Drilling Challenge</th>
<th>Essential</th>
<th>Value Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifying and Quantifying Borehole Instability</td>
<td>DrillClean</td>
<td>GeoPressure</td>
</tr>
<tr>
<td>Drilling in Narrow Pore Pressure Margin Environment</td>
<td>GeoPressure</td>
<td>DrillClean</td>
</tr>
<tr>
<td>Early Reservoir Characterization</td>
<td>G5</td>
<td>G8</td>
</tr>
<tr>
<td></td>
<td>GeIsotopes</td>
<td>G9+</td>
</tr>
</tbody>
</table>

High Pressure and/or High Temperature

By using only surface data analysis and interpretation techniques such as G5, G8, Geolsotopes, G9+, GeoSource and GeoRox we are not constrained by down-hole temperature and pressure limitations of our tools and are able to evaluate data from any temperature or pressure regime. Our NRG@Bit, BitLife, DrillVibe, DrillClean, RheoDrill and GeoPressure services are able to assist in the efficient drilling of wells in these complex environments.

<table>
<thead>
<tr>
<th>Drilling Challenge</th>
<th>Essential</th>
<th>Value Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifying and Quantifying Borehole Instability</td>
<td>DrillClean</td>
<td>GeoPressure</td>
</tr>
<tr>
<td>Drilling in Narrow Pore Pressure Margin Environment</td>
<td>GeoPressure</td>
<td>DrillClean</td>
</tr>
<tr>
<td>Minimizing Downtime from Downhole Tool Failures</td>
<td>GeoROX</td>
<td>DrillVibe</td>
</tr>
<tr>
<td></td>
<td>G5</td>
<td>GeoIsotopes</td>
</tr>
<tr>
<td></td>
<td>G8</td>
<td></td>
</tr>
<tr>
<td>Accurate Reservoir Hydrocarbon Description</td>
<td>G5</td>
<td>GeIsotopes</td>
</tr>
<tr>
<td></td>
<td>G8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GeoIsotopes</td>
<td>G9+</td>
</tr>
<tr>
<td>Accurate Reservoir Hydrocarbon Description</td>
<td>DrillClean</td>
<td></td>
</tr>
</tbody>
</table>
Unconventionals

Our range of services tailored to the drilling of unconventional gas and oil wells, such as GeoRox, G5 and G8 enable cost effective geosteering to allow accurate well-placement in extended horizontal and high angle wells and develop a better understanding of the geology through chemostratigraphic interpretation and correlation. Our GeoRox, GeoSource, G5, G8, G9+ and GeoFracture services identify “sweet spots” for stimulation and the composition of the hydrocarbon types present. The real time availability of these services at the wellsite means that lengthy delays waiting on laboratory turn-around are completely removed and timely decisions on how to complete wells can be made effectively and in a far more cost effective manner. By using GeIsotopes and G9+ we are able to provide a laboratory quality service, at the well-site to identify hydrocarbon origin and maturity and help rapidly build up a more complete understanding of the results from the wells.

<table>
<thead>
<tr>
<th>Challenges &amp; Solutions</th>
<th>Essential</th>
<th>Value Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic Fracture Placement</td>
<td>GeoRox</td>
<td>GeoIsotopes</td>
</tr>
<tr>
<td>Finding Source Rock Sweet Spots</td>
<td>GeoSource</td>
<td>GeoFracture</td>
</tr>
<tr>
<td>Hydrocarbon Fluids Typing (Composition)</td>
<td>GeoRox</td>
<td>GeoSource</td>
</tr>
<tr>
<td>Stratigraphic Interpretation &amp; Correlation</td>
<td>GeoRox</td>
<td></td>
</tr>
<tr>
<td>Commercial and Production Potential</td>
<td>G8</td>
<td></td>
</tr>
<tr>
<td>Onsite Lab Results for Improved Turn-Around Time</td>
<td>GeoRox</td>
<td>GeIsotopes</td>
</tr>
<tr>
<td>Hydrocarbon Origin and Maturity</td>
<td>GeIsotopes</td>
<td></td>
</tr>
</tbody>
</table>
Exploration drilling comprises a whole range of challenges, the primary of which is obtaining the maximum amount of information from the well in a cost effective and safe manner. By utilising our suite of formation evaluation services, G5, G8, G9+, Geolsotopes, GeoSource and GeoROX, we are able to acquire the maximum amount of data possible, with no risk of loss, or later availability. These services cover the entire range of likely exploration scenarios from biogenic to thermogenic gas, condensate to heavy oil, clastic, carbonate or even granitic basement reservoirs. Our drilling related services, KickAlarm, DrillClean, DrillBest, RheoDrill and BitLife will help deliver a safe and economic well.

<table>
<thead>
<tr>
<th>Challenges &amp; Solutions</th>
<th>Essential</th>
<th>Value Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real-Time Geological &amp; Reservoir Content Answers</td>
<td>G5</td>
<td>G9+</td>
</tr>
<tr>
<td>Minimizing Evaluation Risk</td>
<td>GeoROX</td>
<td>GeoFracture</td>
</tr>
<tr>
<td>Onsite Lab results for improved turn-around time</td>
<td>GeoROX</td>
<td>G9+</td>
</tr>
<tr>
<td>Commercial and Production Potential</td>
<td>G8</td>
<td>G9+</td>
</tr>
<tr>
<td>Hydrocarbon Origin and Maturity</td>
<td>GeoIsotopes</td>
<td></td>
</tr>
<tr>
<td>Drilling in Narrow Pore Pressure Margin Environment</td>
<td>GeoPressure</td>
<td>DrillClean</td>
</tr>
<tr>
<td>Stuck pipe from Cuttings Accumulation</td>
<td>DrillClean</td>
<td>RheoDrill</td>
</tr>
</tbody>
</table>
Development

Development wells require the optimization of formation evaluation, improved drilling efficiency and the ability to identify all pay effectively. The combination of G5, G8, G9+ and GeoROX gives operators the opportunity to optimize their LWD and wireline evaluation programs effectively using surface data analyses and interpretations to help reduce costs across multiple wells and still acquire excellent formation and fluid characterization. The combination of G8 and GeoIsotopes enables hydrocarbon origin to be determined, and assist in evaluating complex reservoirs with multiple different geologic compartments. Complex structural and stratigraphic correlations are enabled by performing detailed chemostratigraphic analysis at the wellsite, ensuring that results and the geological model are understood. The DrillBest, DrillClean, BitLife, RheoDrill and KickAlarm services all enable optimal safe drilling practices.

<table>
<thead>
<tr>
<th>Challenges &amp; Solutions</th>
<th>Essential</th>
<th>Value Added</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Unlocking Additional Reserves</td>
<td>G8, G9+, GeoIsotopes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stratigraphic Interpretation &amp; Correlation</td>
<td>GeoROX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrocarbon Origin and Identification of Compartmentalization</td>
<td>G8, GeoIsotopes, GeoROX</td>
<td>GeoROX</td>
<td></td>
</tr>
<tr>
<td>Stuck Pipe from Cuttings Accumulation</td>
<td>DrillClean, RheoDrill</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimizing Costly Downhole Tool for Fluids Characterization</td>
<td>G8, G9+</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Horizontal and Extended Reach

Our experience in horizontal and extended reach drilling in both conventional and unconventional wells has enabled GEOLOG to be a leading provider of surface logging solutions in these wells. The G5, G8, G9+, GeoIsotopes and GeoROX services help determine hydrocarbon types and origins, stratigraphic position for effective well-placement and identify geologic sweet spots and potential barriers to production along the well-path. By using a combination of surface drilling data we are able to optimize the use of more problematic LWD and Wireline services. Drillbest, NRG@Bit, BitLife, RheoDrill and DrillClean all assist in improving drilling and hole cleaning efficiency.
Geothermal

The drilling of geothermal wells introduces a different range of challenges but, by utilising GeoFracture and GeoROX we are able to identify natural fracture patterns and characterise complex mineralogy and make stratigraphic correlations. Our KickAlarm and DrillBest services enable the implementation of performance drilling, NPT reduction and the careful monitoring of losses and micro-losses for both safety and potential reservoir identification. The measurement of hazardous non-hydrocarbon gases is performed using specific technologies for a range of gases, which may include H2S or CO.

<table>
<thead>
<tr>
<th>Challenges &amp; Solutions</th>
<th>Essential</th>
<th>Value Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Fracture Identification</td>
<td>GeoFracture</td>
<td>GeoROX</td>
</tr>
<tr>
<td>Stratigraphic Interpretation &amp; Correlation</td>
<td>GeoROX</td>
<td>DrillClean</td>
</tr>
<tr>
<td>Characterizing Mineral Alterations</td>
<td>GeoROX</td>
<td>DrillVibe</td>
</tr>
</tbody>
</table>
Technology Innovation @ GEOLOG
Continuous investment in R&D

• Widespread culture of innovation at all company levels
• Continuous efforts to improve our technologies
• Significant investments in Research and Development (5% of revenue)

The continuous improvement of our technologies and our technical capabilities is a common target pursued by all at GEOLOG. Innovation is part of GEOLOG’s DNA as shown by the important results and solutions developed and achieved year after year. At GEOLOG, we believe our development is never complete and we therefore continuously strive towards the improvement of our systems, equipment and processes. We usually develop our innovations in response to our clients’ needs, working together, testing at site and analyzing results, but increasingly, we try to anticipate clients’ needs and future technological challenges, working at introducing innovative solutions independently.

Reliability and accuracy of the whole process strictly depends on quality and validation of each step.
Approach to Research and Development

• To develop proprietary analytical instruments
• Data integration and interpretation
• Competence and multidisciplinary innovation
• Cooperation with oil companies, technology providers and universities

The majority of the sophisticated instrumentation, used in our mobile laboratories, has been developed in house and is the result of our internal innovation and development process. We have designed, tested and commercialized our instruments to guarantee the highest reliability and accuracy associated with easy and fast maintenance.

In our daily activities we acquire a huge amount of data and our aim is to extract the maximum value from this for our clients. Data analysis, integration and accurate interpretation are the key drivers of our technological innovation process. Thanks to this activity, we are no longer merely a data provider, but as a partner able to actively support our clients in the making of key decisions in a timely and efficient manner.

Our team comprises geologists, petrophysicists, physicists, chemists, mechanical, electronic and robotic engineers from a wide variety of educational and cultural backgrounds. The complexity of our solutions requires many different competences and skills, for this reason, GEOLOG has developed a group of highly skilled professionals with different backgrounds to nurture a multidisciplinary approach.

At the same time, we are working together with clients to solve specific issues, with different technological partners particularly qualified in key technological areas and we are actively collaborating with universities by means of Masters and Doctoral theses.
Recent R&D Results

GEOLOG has achieved significant innovative results over its 35 year history. Some results achieved in recent years include:

- First company to run full spectrum (C1-C3) of real time isotopic analyses at well site
- First company to run thermal extraction-Gas Chromatography (G9+) at well site
- Unique company to entirely build its units operating at well site
- Technology for characterization of fractured reservoirs by using mud delta flow
- First company to deliver a near real-time drill bit-wear monitoring service
- Patent portfolio continuously increasing

Research activities have always been very prolific and effective, contributing to improve our existing services or establishing new technologies and services. The time from product inception to commercialization is very short, thanks to the collaboration with our clients, offering us the opportunity to quickly test products and compare the results against those obtained in the laboratory. Thanks to the successes achieved, GEOLOG has become a technological leader in the field of surface logging, pioneering new technologies at well site.
**Innovation Focus**

Main targets of innovation activity are to dynamically support our clients with:

- Cost reduction in each phase of upstream activity
- Reducing time from discovery to first oil/gas/energy production
- Reducing risk by sharply decreasing uncertainties in all data, analyses and interpretations

The consequent technical targets we pursue are:

- Reduction of Non-Productive Time
- Well Construction Optimization
- Integrated Reservoir Characterization (rock + fluids)
- Contaminant Gas origin and distribution in reservoir
- Safety, Health and Environmental protection
GEOLOG prides itself on manufacturing all of its Advanced Surface Logging Equipment and mobile laboratories at its production facility in Milan. By taking ownership of the entire manufacturing process in-house, GEOLOG is the only global surface logging supplier to provide the complete surface logging process to its clients from design of equipment through to interpreting the results of service provision. From design to physical assembly, full control and accountability is maintained for the quality and the highest standards being implemented for all cabins, computing hardware, gas acquisition and detection equipment, advanced geochemical analytical tools and specialist drilling technologies. By providing hardware of the highest possible standard, our field engineers and crews are able to focus on providing an exemplary service, acquiring, analysing and interpreting data, communicating results and delivering as much value from the wellsite as possible. Component selection is based upon technical features as well as customer and internal user feedback, ensuring that lessons learned in the field are incorporated into future production and operational technical support processes.

Complete control over the entire manufacturing process sets GEOLOG equipment apart, in terms of quality of material, performance, reliability and traceability. Designs are modular, with acquisition and analytical components being suitable for all mobile laboratories. Through this process, GEOLOG is able to offer standard and optional extended warranties for its equipment, supported by a global 24/7 network of technical support from its production and operations teams. GEOLOG has in place a dedicated network of operational support bases with qualified, competent resources to provide local technical assistance. It is through this network and with assistance from our Milan Manufacturing Centre that we are also able to provide thorough installation and commissioning of all of our products and services and guarantee the availability of spare parts and upgrades to avoid obsolescence. Frequent and regular refurbishment and upgrading occurs to ensure continued reliability in the field and for our crews to be able to maintain their focus on performing their services. Comprehensive training is also provided for local technical support personnel to ensure that assistance is available in as timely a manner as possible.

Our manufacturing and design teams are able to provide detailed drawings, plans and certification to a variety of standards, addressing all customer concerns about the specifications of our units. Our mobile laboratories can be built according to various international standards, and in a variety of configurations, summarized in the following table:
As a global Surface Logging Service provider, we have extensive experience in developing, building and using equipment in harsh high temperature and extremely low temperature environments. We offer “winterized” components and systems proven to operate consistently in temperatures below -20 degrees C. In hot climates we provide dual air-conditioning units to ensure redundancy. Our full range of equipment and services have been tried and tested in temperatures up to 50 degrees C. We are also able to provide a range of specialty service cabins, including “Advanced Service” cabins designed to be used alongside other surface logging companies providing only standard services (deployed for example in Brazil for Petrobras, in Senegal for Cairn Energy and in Tanzania for Statoil) and “Combination Service” cabins (designed to accommodate GEOLOG’s Surface Logging Services and third party services such as Logging While Drilling (LWD), or Measurement While Drilling (MWD) services in one cabin. For certain land operations, GEOLOG has trailer mounted units, capable of being towed easily between locations.

In addition to our various service provision cabins, GEOLOG also provides suitable certified small toolbox/support containers, commonly used in more remote environments to house additional spares, tools and consumables to ensure continued, uninterrupted service no matter where operations may be occurring.

GEOLOG Surface Logging Equipment Characteristics:

- All equipment manufactured in our Milan facility
- Fully certified equipment by Det Norske Veritas (DNV)
- Customized equipment according to customer/project needs
- Equipment quality independent of 3rd party suppliers
- Fully modular and upgradeable Surface Logging Unit & Equipment
- Efficient and fast implementation of upgrades

With our equipment GEOLOG:

- Guarantees the availability of spare parts
- Offers Global Support 24/7
- Provides commissioning and start-up
- Provides a wide network of locations with support personnel and equipment
- Provides Manuals, Drawings, Certification and other critical production information