SPE Society of Petroleum Engineers

SPE International

Italian Section

Poste Italiane S.p.A. - Spedizione in Abbonamento Postale- 70%-DCB Milano

Over **30 years** of technological leadership in Surface Logging

With a presence in over 45 countries, GEOLOG is the largest **independent** service company in the world focused exclusively on surface logging. GEOLOG stands today as the leader in advanced technologies applied for **drilling optimization and reservoir evaluation and characterization**.

Besides providing highly reliable and field-proven technologies such as Cutting Volume Monitoring or Formation Fracture Detection, GEOLOG contributes to enhance the **safety** on drilling rigs with highly qualified personnel and advanced sensors.

GEOLOG, thanks to in-house developed instruments and proprietary innovative technologies, is able to cover a wide spectrum of analysis and integrated services.

Very accurate quantifications of gases and light hydrocarbons up to C7 and of **thermal desorbed hydrocarbons** from cuttings, integrated by **isotopic** analysis of gas, enable clients to have premium information while drilling related to pay zones, fluid contacts and cap rock efficiency.

GEOLOG also runs a number of complementary services, integrating **geochemical** analysis of fluids and rocks and focused on **unconventional** reservoirs, in particular on sweet spot identification in shale gas. The same services can be very valuable even with conventional reservoirs for different purposes, for example, **geosteering** in horizontal wells.

Surface Logging Services

To **reduce** drilling times and costs
To **improve** rig safety
To **characterize** reservoirs

Operations, Sales and Administration
Geolog International B.V.
De Entree 242
1101 EE Amsterdam Zuid-Oost - The Netherlands
Tel: + 31 (0) 20 3420 620 - Fax: + 31 (0) 20 3420 645
geolog@geologinternational.com

Technical, Production and R&D
Geolog S.r.l
Via Monte Nero, 30
20098 San Giuliano Milanese - Milano - Italy
Tel: +39 02 9825 21 - Fax: +39 02 9825 2328
geolog.italy@geologinternational.com

DNV

www.geologinternational.com

Enhanced Real-Time Formation Evaluation at wellsite with advanced surface logging solutions

by Gionata Ferroni, Luis Alvaro Fernandez - Geolog International - Presented at SPE Atyrau Section Monthly Technical Presentation, Feb 6th 2014 - River Palace Hotel - Atyrau, Kazakhstan

Introduction

Surface logging data have historically been utilized, while drilling, as a basic drilling safety surveillance tool. For decades, these Real-Time measurements have been considered intrinsically too qualitative and not sufficiently consistent to be utilized for any Formation Evaluation task.
Nevertheless, the surface logging (aka mudlogging) data are the only direct measurements done on site on the rock formation being drilled and on the fluids that it liberates. What has been done to make the most of such data? Mainly, it is the natural result of technology development. Things have changed. With time, many of the sensing technologies utilized in surface logging have become increasingly reliable, consistent, repeatable and quantitative, to the point that now Formation Evaluation can be strongly supported in Real-Time with information that once was only available from remote laboratories, months after the wells were drilled.
This article will summarize some of the main results obtained and the technology utilized for such scope.

Identification of Formation Fluid

Modern, advanced gas extraction and detection systems are designed to eliminate or compensate for the main disturbance factors which alter the measurement of the formation fluid in its difficult trip from the rock, in which it is contained, to the detector's sensing head, passing through the destruction of the rock matrix by the drilling bit, crawling up the well's annular space transported by the drilling fluid, reaching the rig's flow line, being beaten out of the mud by an agitator and sucked into a sampling line by the pumping device which injects it into a chromatographic column. Changes in temperature, pressure, solubility, together with the instability of the drilling mud flow are all factors that are now being taken into account via the utilization of constant

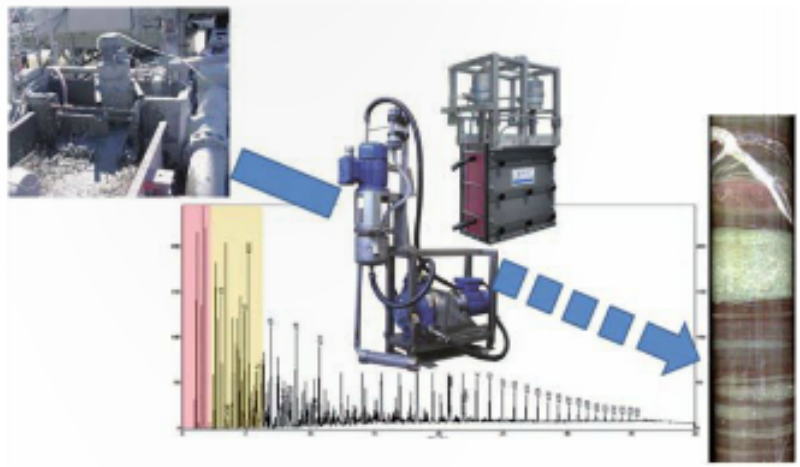


Fig.1: The ultimate aim of gas detection is to reconstruct the fluid content of the cylinder of rock being excavated

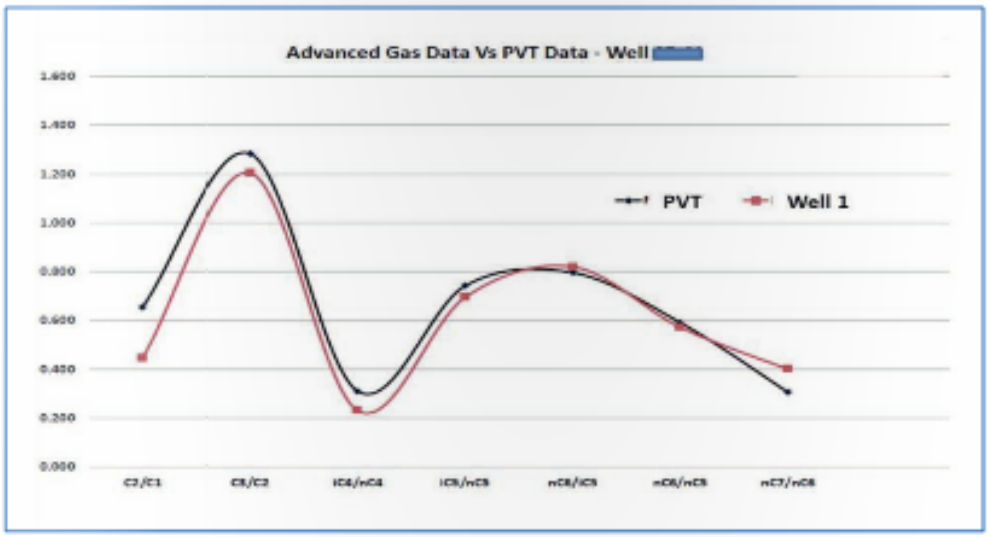


Fig. 2: Advanced gas detection can match the PVT fluid composition as shown in the case above

volume gas extractors, mud heating systems, controlled flow distribution devices, and detectors capable of measuring sub-ppm concentrations of gas. New, dedicated operating procedures enable now to quality-control continuously the gas extraction procedure.

The results? Three, mainly: first, a deep-spectrum identification of the components of the formation fluid. Such composition, once compared with fluid samples taken from MDT or DST systems, can match them with a tolerance of few percentiles. Such fluid analysis extends nowadays from methane, the lightest and most abundant hydrocarbon, to 7-carbon species and up to n-octane. These light components are very informative also on the liquid part of the formation fluid.

Second, the possibility of obtaining an early indication of the changes in the formation fluid composition, to the point that, by the end of the drilling phase of a well, the main potential targets are locked, and the expected fluid, be it gas, condensate, oil, or even water, are predicted with a limited margin of error.

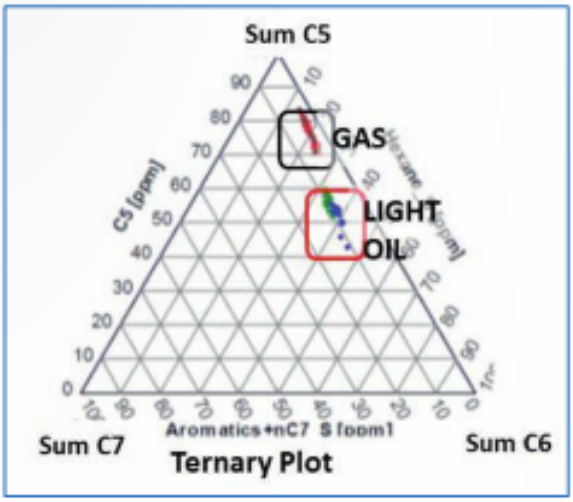


Fig. 3: Heavy gases help to identify different formation fluids while drilling

The ternary compositional chart above is an example of how it is possible to identify two different fluids, gas and light oil in this case, from their compositional differences. This analysis enables to place accurately the Gas-

Oil contact in the reservoir zone, and to support planning of the formation testing points.
The third main result is the utilization of technologies, previously never brought to the field, which permit not only to identify the fluid's composition, but also to characterize its carbon isotopic signature.
In most operations, drilled gas isotope measurements are mostly performed off-line. Spot samples are sent to a remote laboratory for analysis and results are available in weeks or months.
Isotope analysis on the field provides immediate, continuous carbon isotopic marking that can be fed in the interpretative models for isotope ratio variations.
$\delta^{13}C1$ ratio enables to recognize biogenic, mixed and thermogenic origin of methane. It can give indications of the approaching of a reservoir and provide information about the status of the seal.
C1 and C2 isotopes ratio enable to assess origin and migration of the gas.
Isotopic ratios also provide indication of maturation of the organic matter. Mud Gas Isotope Logging, therefore, enables to assess the lateral and vertical extent of a reservoir or the communication between formations. With regards to reservoir and source rock description, the known standard field analysis is constituted by visual qualitative microscopic identification of rocks, qualitative fluorescence and calcimetry. Anything deeper, or more accurate, was until recently destined to later (much later sometimes!) laboratory analysis. However, data are often needed while drilling or in Near-Real Time. Geochemical cuttings analysis on site today enables to do a few more things:

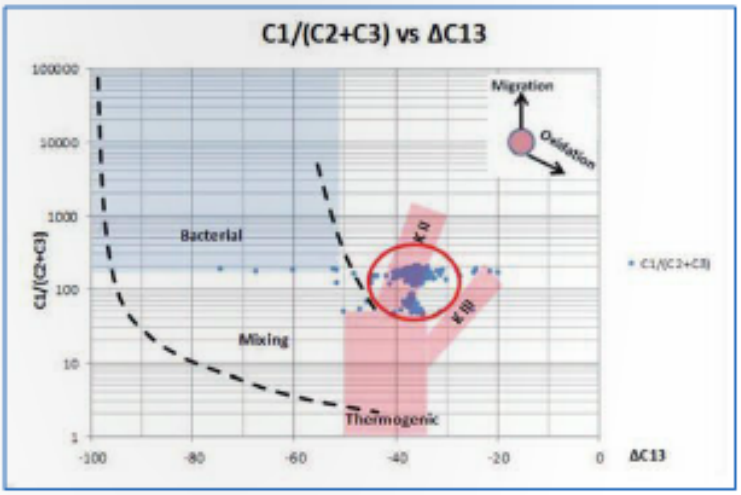


Fig.4: Carbon Isotopic ratio indicates clearly the kerogen type generating the gas

- Mineralogical quantification of clay minerals and reservoir mineral associations.
- Identification of elemental stratigraphic markers.
- Quantification of Total Organic Carbon in source rocks and shales.
- Measurement of source rock maturity and quantification of kerogenes.

X-ray diffractometry and compact pyrolyzers are now a reality. A number of successful field deployments have been documented by technical papers published with the industry most authoritative organizations (SPE, SPWLA).
A project in Poland in 2011 first validated the data and implemented the work process. During this ENI-led campaign, for the first time a complete geochemical laboratory was deployed on site, permitting to save significant time and money. In fact, having data available in Real-Time contributed to optimize coring programs, calibrate wireline with directly-measured TOC and added new depth to the geomechanical characterization of the rock,

TOC & PYROLISIS ANALYZERS

XRD & XRF ANALYZERS

Fig. 5: Equipment used in field geochemical labs comprises X-ray diffractometers, X-ray fluoroscopes, portable pyrolyzers and oxydizers

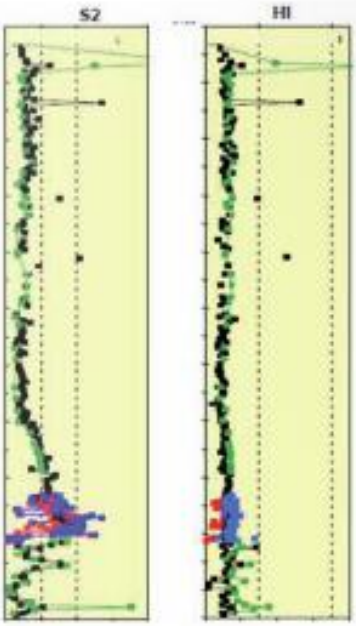


Fig. 6: This chart shows a very good match between the pyrolysis readings obtained on site and the laboratory post-mortem data

since the brittleness index was measured directly, generating a map of which sections of the well were the most adapt for a possible hydraulic stimulation. Such experience was documented with a paper presented last year at the IPTC in Beijing.
Another paper presented in 2013 at the Offshore Technology Conference in Houston, the largest in the world, document the successful utilization by the Kuwaiti Company KOC of X-ray measured rock cutting chemical composition, with the scope of supporting the geosteering (chemosteering) of a horizontal drain in a sandstone reservoir through fault zones.
Such analysis provided data which were incorporated in the operator's workflow. This is crucial to make the most of any new dataset. If it is not correctly utilized, at the right time, it loses most of its value.
A series of 20+ wells drilled in a shallow potential shale gas play in Portugal has been logged with the help of a geochemical field laboratory system. It has enabled to characterize the mineralogy and organic matter distribution in the shale play in Real-Time.

Ultimately, such geochemical characterization tools were initially developed to help mainly unconventional reservoir investigations, but found significant applications also in the more

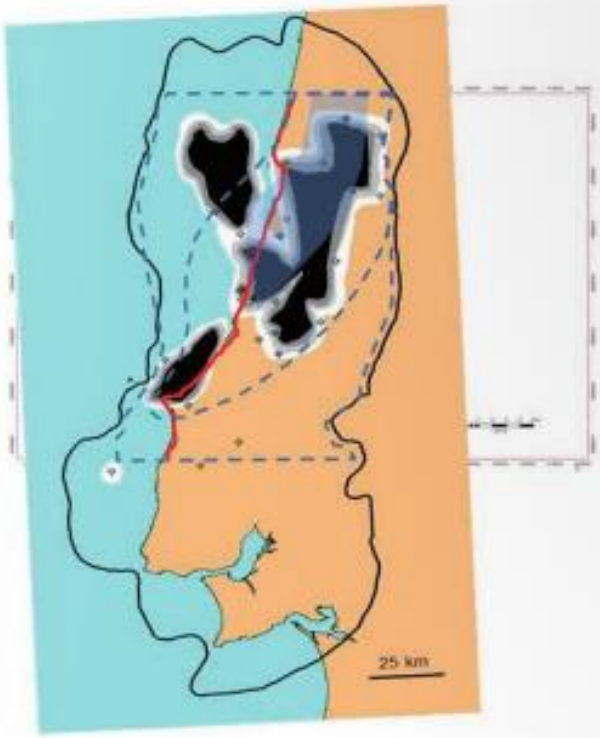


Fig.7: This coastal section of Portugal has been characterized for Total Organic Carbon with an on-site geochemical laboratory

conventional reservoir explorations.
The oil industry is traditionally slow at picking up new technologies and novelty in general. But advanced mudlogging systems are already utilized in dozens of high-profile operations, in ultra-deep waters, in HPHT operations, in exploration wells, to maximize the geological and petrophysical data collected while drilling. The applications presented here are today available from several vendors, they have become common place in several regions and with those oil companies more agile in trying new or advanced technologies. Some of them are now testimony of the new role of surface logging:

"Advanced Mud Logging [...] is moving towards continuous, real time determination of rock and fluid parameters from drill cuttings, drilling parameters and mud (gas) returns, in aid of well evaluation and reserves calculation." (Loermans, Kanj, Bradford, Saudi Aramco, 2005 – SPE 106324)

"Mudlogging has turned mud gas measurements [...] to a sufficient level of reliability to consider the C1 to C5 (C6) surface gas compositions as a reliable picture of the hydrocarbon fluid content of the mud. [...] a real continuous fluid composition log along the well."

Caroli, Lafaurie, Barraud, Segalini, Total, 2013 – SPE 166246

Surface logging strives to the ultimate aim of reconstructing, from the gas liberated at the shakers and from the rock cuttings, the composition and amount of hydrocarbons contained in the reservoir rock being drilled.

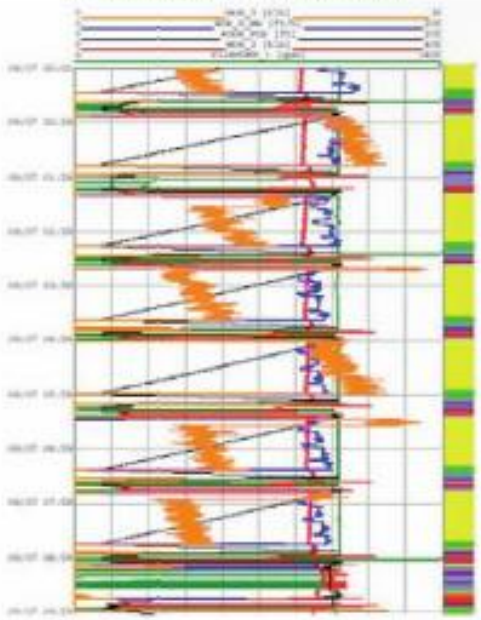
Technology Applications

by Vincenzo Pozzi - Editorial Committee Member

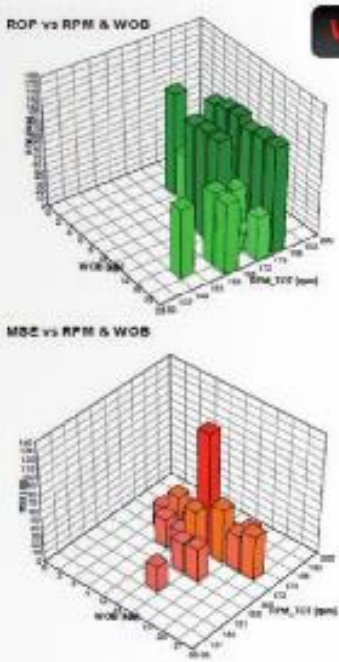
Optimizing drilling performance and operations

Non-Productive Time, or NPT, is the main enemy of all drilling operations. It dents a well budget, possibly cutting short the well original scope. No stone must be left unturned to maximize an operation's potential and make the most of an oil company investment. This was the driver behind the development of Geolog International's Workbench Service. Such drilling support service, carried out by dedicated specialists working alongside an oil company's drilling engineering team on site, is designed to make the most of the vast amount of data recorded while drilling by a mudlogging system. Intelligent logic operators and algorithms in the hands of experts in drilling parameters interpretation sift through the mass of data extracting information. This can be used immediately, to correct inefficient drilling procedures, or can be applied to subsequent wells, in a development campaign, granting large s avings proportional to the scale of the operation.

Drilling Parameters
(WOB, ROP, pumps, hook position)



A day's drilling, viewed from the mudlogging recorded parameters. In reality, over the 24 hrs, the bit was on bottom only 60% of the time. This hidden NPT can now be studied.



WORKBENCH™

GEOLOG

Workbench operators quality-control the drilling data and plot all the relevant parameters to recognize important data. In this case, Weight on Bit (WOB) and RPM are being optimized for Rate of Penetration (ROP) and Mechanic Specific Energy (MSE) respectively.

Operational and drilling performance analysis is normally done based on the IADC report, which has a 30 minutes data density at best. The mudlogging database is recording data as frequently as each 5-seconds, and in certain cases with a 30 Htz frequency. It has therefore a resolution 360 times better than traditional information. It is therefore possible to identify *invisible NPT*, or problems which the operator may not even be aware of, in the lack of advanced data recording and filtering. The system couples advanced computing and sound mudlogging and drilling engineering. This "recepy" has made it very versatile and is enabling constant development of new applications to this service; from the monitoring of wellbore stability, to the in-depth analysis of gas composition, from rig crew performance evaluation to innovative techniques for filtering dat,a removing otherwise blinding background noise, a very useful help when monitoring close-to-balance wells.

For more info contact us at www.geologinternational.com or email at technology@geologinternational.com