South Africa
A History of Mineral Wireline Logging

Lowering a probe or ‘sonde’ into a borehole, in order to make measurements of rock properties, is based on geophysics in the sense that it is a remote, non-destructive, technique that does not involve taking rock samples. It is hardly surprising, then, that it was a geophysicist who invented wireline logging. Nor is it surprising that the application was oilfield exploration. Energy has always been a major driver of advances in exploration technology.

In 1927, Conrad Schlumberger, a French geophysicist, was performing surface electrical prospecting work, with his brother Marcel, at the Pechelbronn oilfield near his home in Alsace. The brothers had been working on improving remote sensing to depth and had travelled to several countries, including the Union of South Africa. Their client, the Pechelbronn Oil Company, was struggling to identify a particular stratigraphic boundary from drill chippings and, as a result of an on-site conversation, Conrad thought it might be worth lowering an electrode array into the borehole and moving it up and down instead of along the surface.

Actually, it was not Conrad that captured the first log but his son-in-law, Henri Doll. Henri assembled a four-electrode array, as instructed by Conrad, and lowered the first ever logging tool down well Diefenbach 2905 rig 7 on September 5th 1927. The contraption did not work well at first, mostly due to problems with the wireline (the logger’s most important piece of equipment) but, eventually, Henri and his team were able to make point measurements of formation resistance, every one metre, to a depth of 600 metres. It was then necessary to place the measured values on a long graph and join up the dots in order to generate the first ever wireline log.
The log was a success and, on 28 July 1928, the Schlumberger brothers signed a contract to provide ‘Electrical Coring’ services to the owners of the Pechelbronn site, which was, surprisingly, the only oilfield in France at the time.

The business grew steadily at first and, by 1931, the brothers had discovered SP or spontaneous potential, a natural voltage generated between bedding layers, occurring only as a result of the presence of a borehole (or perhaps a submerged cave). The SP ‘noise’ had been problematic until it was realized that it was a stand-alone log and could help define permeable zones, which are, of course, important in oil exploration. SP was used later in the 1930s to create the first formation dipmeter tool.

Over the next forty years wireline logging, as it became known, grew into a major oilfield service sector. Schlumberger and, later, Halliburton, Baker Hughes and others, developed a wide range of tools, dedicated to the exploration and production of oil and gas resources. New measurements included natural gamma ray, formation density, inductive conductivity, and sonic transit time. Continuous logs plotted on roll paper became available from 1936.

In 1942, Gus Archie, working for Shell, described an empirical relationship between the porosity of sandstone and its resistivity, known as the formation factor. If the resistivity could be predicted based on porosity then deviations from this prediction, on the resistivity high-side, would infer the presence of oil. What was needed was a reliable porosity log. At first, porosity was estimated based on local knowledge or the separation of resistivity logs due to borehole fluid invasion. As density, sonic and neutron-based porosity logs appeared in the 50s and 60s and, with refinements to Archie’s original equations; wireline logging became a quantitative measure of oil in place.

In South Africa, there was little use for wireline logging due to a rather unique lack of oil reserves. From the early 1950s, however, there was an application in uranium logging, using the new gamma ray detectors. Uranium was a growth industry and several companies, notably Mount Sopris from Colorado, USA, sold logging equipment to South African mining companies and technical institutions. Overseas, Century Geophysical, from Tulsa Oklahoma, built a contract logging business around the search for uranium. They pioneered the digitisation of mineral log data. Mineral logging had begun to arrive.

Two events in the 1970s changed the mineral logging industry. In 1973, a global oil crisis resulted in a spike in oilfield prospecting activity but, also, an entry into coal exploration by oil companies such as Shell and BP. There was a perceived need to reduce dependence on one commodity. In 1979, the Three-Mile Island partial meltdown ended the uranium boom and, for many years, U ceased to be a mineral logging target.

In 1972, Dick Reeves, an enthusiastic geologist working for BPB Instruments in the UK, had begun to convert gamma ray tools (gypsum loggers) into a simple wireline logging system for coal exploration. Density was the key; a gamma logger plus a radioactive source. Reeves performed a few trials in the Vale of Belvoir coalfield and results were very well received. He
visited Shell Petroleum to show them the new logging system and they immediately asked for two logging units in South Africa and two in Australia. Global contract logging for coal arrived just in time for the coal exploration boom of the late seventies and early eighties. South Africa had its first contract logging service, based in Pretoria at a BPB plasterboard factory. Within a few years, BPB were operating fifteen logging units in the region. By then, local companies like Trans Natal Coal and Goldfields had embraced the technology. The log below shows a typical coal seam description based on gamma ray, density and caliper.

Wireline logging had become a universal tool for the coal geologist and, inevitably, competition arrived in the form of Century Geophysical who, although only in the country for ten years, made a big impact with their digital logging systems. By the mid eighties both BPB and Century were offering a wide range of log measurements including dipmeter, lateral resistivity and compensated sonic logs. Then, in 1984, the coal boom died and the total number of logging units in Southern Africa dropped to five.

It is remarkable how much has changed in the way companies approach this type of exploration since the 1980s. In those days the logger would operate alone, in the middle of the night if necessary, often in shorts and flip-flops. He had a Spitfire pilot mentality. Nowadays, the industry is much more formalized and safety conscious. Jumbo Jet pilots with copilot, protective clothing and safety manual are the norm. Heavy drinking and the trashing of hotel bars are now frowned upon.

The BPB logging system was originally designed to log coal exploration boreholes. In 1985 there was not much coal logging to do in South Africa but the horizon was dotted with big drilling rigs. The Witwatersrand deep gold exploration boom had begun, and it continued for ten years. Gold mineralisation could not be detected by the wireline logs but they were able to describe the complex structure intersected in Central and West Rand sediments. The dipmeter, redesigned to cope with resistive non-porous rocks, proved to be the key to the gold logging market. JCI, Anglo American and Goldfields were the main users of wireline technology, mostly along the Welkom-Bothaville-Potchefstroom arc. These companies extended their required tool suite to include a range of measurements including gamma, density, magnetic susceptibility, sonic and neutron-neutron.

The deepest (actually longest would be a better word, given the deviation from vertical) borehole logged by a mineral logging system was 5115 metres in 1991. The log above shows a typical dipmeter display with a gamma log, on the left, describing uranium deposits associated with reef conglomerates.
Century failed to enter the gold logging market and left South Africa in 1990. BPB became Reeves Wireline Services after a management buy-out. Then the gold boom ended in 1995 and things went quiet for a while. During this period there was much experimentation, mostly encouraged by Anglo American, in the logging of different minerals using whatever new technology could be found. Reeves introduced the first slimline televiever to South Africa in 1993. They also introduced photo-electric absorption, spectral gamma, flowmeter, fluid conductivity and full waveform sonic logging services during that decade. Wireline logging was employed to support exploration for coalbed methane, diamonds, platinum, iron ore, copper and other base metals.

Platinum has never offered the same potential as gold and coal for the logging companies. Geologically and structurally the Bushveld setting is not sufficiently complex for logs to be used in primary exploration. They have been used extensively in seismic calibration work and in mine shaft geotechnical studies. A new player in the market, Quiklog Geophysics has made a significant contribution in these services over the last decade. Quiklog offers a comprehensive range of tooling from global suppliers like Auslog and Robertson Geologging. The latter claims to be a world leader in supplied technology of this kind but they are one of many and, indeed, South Africa has its own supplier of mineral logging systems in Geotron, based in Potchefstroom.

From a tooling perspective, the Acoustic Televiewer has made a very big impact since Reeves ran the first log in the Barberton goldfield in 1993. A slimmer, more effective, design has since been offered by ALT of Luxembourg. All the South African logging companies, including Reeves, have switched to this design which, supported by its famous WellCAD software, has proved to be perfect for slim-hole logging conditions.

Reeves were bought out by Precision Energy Services in 2004 and they in turn were purchased by global oilfield services giant, Weatherford in 2006.

Since that change in ownership there has been another energy crisis and, coal, despite fears of global warming, is reasserting itself as the main user of wireline logging technology in Southern Africa. Local companies like Weatherford, Quiklog and Geoline, a small player targeting the coal market specifically, are all busy again. The range of technologies available to the exploration industry is wider than ever before and the future looks very exciting for the logging engineer.