

Slimline Capabilities









Evaluation



Completion



Production



Intervention

Better mineral logging starts with better technology. Weatherford provides a full range of high-resolution slimline logging services on a proven, lightweight, low-cost platform. Our advanced technologies include the mining industry's most advanced density logging tool, the slimmest dipmeter tool with the highest available contrast, a sonic tool quiet enough to differentiate first arrivals in even the hardest rocks, and advanced compensation algorithms that can overcome the most challenging borehole problems. All of these tools can be easily transported in Weatherford's compact logging vehicle with high-quality, on-site processing, analysis and presentation.

Why Weatherford Slimline

For more than 30 years, Weatherford has led the industry with our Slimline services. We sell data and interpretation—not tools—and we are continually at work to improve those results for clients. Our Petroleum Consulting teams use one of the most comprehensive and advanced software suites available. Their wealth of experience ranges over virtually all types of logging. In addition, Weatherford researches and develops new tools and methods to meet client requirements. Our tools are developed and manufactured in-house to exacting oilfield standards to ensure economy and quality. Slimline tools are smaller, lighter, less expensive and easier to handle than other tools on the market, enhancing operational efficiency and reducing risk.

Weatherford offers Slimline services in 103 countries, operating out of 48 bases to provide exceptional logistical responsiveness; for example, we visited a Brazilian client at the end of October, signed a contract in mid-November, and had equipment on-site by the end of December—and this was our first job in that country. Weatherford global support includes data processing facilities around the world for multiple applications, plus a knowledge base built up over 30 years. The Slimline services group has worked in coal, oil, gas, tar sands, gold, platinum, copper, uranium and other metals and in countries that include South Africa, Botswana, Angola, Mozambique, Australia, New Zealand, China, Mongolia, Indonesia, Canada, Colombia, Mexico, Peru, Argentina, British Guiana and Brazil.

Slimline services operate from a truck or an air-lifted skid.

Initial data is available within minutes.





Complete Evaluation Services

We design the 'physics' of lithological evaluation into our Slimline tools, sizing down proven Weatherford oilfield technology to lower pressure and temperature requirements. Because our tools are based on oilfield standards, they provide very high resolution. We can capture amazingly accurate data within a few hours, provide qualitative results almost immediately, and complete a thorough geoscientific analysis.

Slimline services can show:

- Top and base of zones of interest
- Bulk density of seams and overburden
- Strength of overburden and foundation for mine design
- Fault delineation, formation dip and azimuth
- Stress orientations and presence of "breakout"
- Formation analysis, rock mechanics and rock properties
- Water levels, flow and well temperature
- Background radiation levels
- Line of oxidation
- Hardness—compression and shear wave
- Coal quality (sills and dikes, coked [burnt] coal)
- 3D acoustic images plus optical televiewer images
- Borehole deviation and diameter





Dual Density Sonde – DD Series

The **Dual Density** tool provides essential lithology and porosity information in boreholes as small as 76 mm (3.0 in.) in diameter. The DD sonde is a dual detector density tool which uses the same advanced processing as our full size tools. The near and far measurements are characterised and calibrated independently, and then combined in a model-based algorithm which automatically corrects for hole size and mud density variations, as well as mudcake effects. This results in a Compensated Density field log which needs no further corrections. Optional VECTAR[®] processing of the compensated density produces a log with the spatial resolution of the short spaced log. The upper log example depicts a typical coal, shale and sandstone sequence logged with a DD Series sonde. Thin bed analysis uses higher sampling rates and lower logging speeds. The lower logging speeds ensure acceptable counting statistics. The lower example shows a detailed scale presentation over a 3 metre coal bearing interval using data sampled every 0.01 metre.

Measurements

- Near and Far Spaced Densities
- Compensated Density
- Degree of Compensation
- Caliper and Hole Volume
- Gamma Ray

- Coal Identification
- Coal Quality
- Porosity/Lithology
- Enhanced resolution logging
- Gas detection







Dual Neutron Sonde - NN Series

Dual Neutron logs are sensitive to variations in rock type and porosity. NN series tools operate in boreholes as small as 63 mm (2.5 in.) in diameter. They measure the flux of thermal neutrons at two detectors; the count rate ratio produces a Compensated Porosity log that has greater immunity to variations in borehole size and borehole fluid salinity than single detector designs. Logs are presented in porosity units, and are calibrated to give true porosities in clean, water-filled limestone formations. The combination of density and neutron porosity allows the simultaneous determination of porosity and lithology (including clay content), and is sensitive to the presence of gas. An integral Gamma Ray is used for correlation with the Gamma Ray on DD Series (Dual Density Sonde) tools and provides an evaluation of clay content.

Measurements

- Near and Far Spaced count rates
- Compensated Neutron Porosity
- Limestone and Sandstone matrix apparent porosities
- Gamma Ray

- Porosity
- Lithology
- Gas detection
- Empirical correlations with rock strength in sand and shale





Multi-Channel Compensated Sonic - MS Series

The Multi-Channel Compensated Sonic measures compressional (P-wave) slowness (inverse of velocity) for porosity, lithology and mechanical properties applications. Cement Bond Log (CBL) and Full Waveform Sonic (FWS) variants also record waveform data. The tool contains one transmitter and four receivers, giving four transit times. In compressional slowness (Δt) mode, pairs of first arrivals are combined to eliminate the fluid path and provide formation Δt measurements at spacings from 24 in. to 48 in. (60 cm to 120 cm) from the transmitter. The recorded curves are a high resolution 20 cm curve, a 40 cm curve, a long 60 cm which provides better estimates of in-situ velocities in the presence of near wellbore damage and an un-despiked 20 cm curve which can indicate formation fracturing. Borehole caving effects are reduced using a depth derived compensation system. P-wave and S-wave velocities (measured by an SS Series Sidewall Sonic sonde or derived from Christensen's Equation) are combined to compute Poisson's Ratio. Shear, Bulk and Young's Moduli are calculated with the addition of density data. In CBL and FWS modes, Δt and peak amplitude come from the 120 cm spacing curve, and a VDL log from the 120 cm waveform.





Measurements

- Compensated compressional Δt
- 20 cm resolution curves
- Integrated transit times
- Waveforms (CBL only)
- Default presentations of 20,40,60cm and un-despiked 20cm

- Porosity
- Fracture detection
- Seismic time to depth conversion
- Mechanical properties
- Fracture height analysis
- Cement bond quality (CBL only)

Acoustic Scanner

The **Acoustic Scanner** gives high resolution formation images in wells as small as 76 mm (3.0 in.) in diameter. Amplitude and Transit Time images are constructed whilst recording data from a rotating acoustic transducer. A special windowless housing enhances resolution and gives an excellent signal-to-noise ratio. Analysis of the images reveals bed boundaries, fractures and other discontinuities in the rock, and borehole enlargements related to rock mechanical properties and earth stresses.





Acoustic Scanner Continued

Measurements

- Oriented and normalised Amplitude image
- Oriented and Transit Time (borehole diameter) image
- 360 degree caliper
- Borehole trajectory Gamma Ray

- Fracture identification and orientation
- Stress orientation from breakout
- Bed boundary orientation
- Sedimentological and structural studies





Slim Dipmeter – DV or SQD Series

The **Slim Dipmeter** is designed for operations in wells as small as 76 mm (3.0 in.) in diameter. It provides three or four focussed microresistivity measurements and tool orientation data - these are used to compute formation dips and wellbore trajectory. Analysis of patterns generated by successive dips provides important information about depositional and structural environments. The microresistivity measurements are made by small electrodes embedded in the pads on caliper arms. These are correlated to produce formation dips.

Measurements

- Microresistivity traces
- Sonde navigation data (from the navigation sub)
- Gamma Ray
- Caliper (X and Y for SQD)
- Borehole trajectory

- Formation dip and azimuth
- Sedimentological studies
- Palaeoenvironment studies
- Structural studies
- TVD analysis
- Breakout analysis (SQD only)





Borehole Verticality Sonde - VO Series

The **Borehole Verticality Sonde** is designed for operations in wells as small as 76 mm (3.0 in.) in diameter. It may be logged as a standalone tool (for borehole navigation data only) or in combination with either DV or SQD Series slim dipmeters (for formation dip and azimuth). Its five component navigation system provides continuous directional data in open hole or plastic cased environments. Variants are available that can measure from the vertical to the horizontal. Standard output includes graphical presentations of cross section (polar position plot) for up to 10 depth levels, vertical sections and depth correction (True Vertical Depth) analysis. Additionally, all data is presented in a tabular format that includes lateral and polar co-ordinates.





Measurements

- X, Y and Z magnetometers
- X and Y tilt measurements
- Sonde navigation data
- Borehole trajectory

- Borehole tilt and azimuth
- Orientation of dip data from DV and SQD Series dipmeters
- TVD analysis
- Tabular presentations of borehole co-ordinates at all depths
- Field magnitude log for detection of magnetically anomalous zones



Gyroscopic Verticality Sonde - GYR Series

The **Gyroscopic Verticality Sonde** provides highly accurate positional information in boreholes as small as 76 mm (3.0 in.) in diameter. It is designed to operate in steel cased boreholes where conventional magnetometer-based verticality tools cannot function. The tool operates on the principle that the spin axis of a rotating gyroscope maintains a fixed position with respect to the earth, regardless of the orientation of the outer casing. By measuring the relative positions of the casing and the spin axis, the tool orientation can be deduced. Standard output (identical to that from the VO Series Verticality tools) includes graphical presentations of cross section (polar position plot) for up to 10 depth levels, vertical sections and depth correction (True Vertical Depth) analysis. Additionally, all data is presented in a tabular format that includes lateral and polar co-ordinates. Differences between inertial and magnetic azimuths (from VO series) can indicate magnetically anomalous zones.



Measurements

- Azimuth from gyroscopic inertia
- X and Y tilt measurements
- Sonde navigation data
- Borehole trajectory

- Borehole tilt and azimuth in open-hole or steel cased slim holes
- TVD analysis
- Tabular presentations of Borehole co-ordinates at all depths



Dual Focused Resistivity Sonde - RR Series

The Dual Focused Resistivity tools are ultra-slim laterologs for resistivity determinations in small diameter boreholes containing conductive fluids. RR Series tools simultaneously record Deep and Shallow Focused Resistivity curves, both of which have the same high vertical resolution. Deep and shallow curves are standardised for a 4 inch diameter well where the ratio of Apparent Resistivity to Mud Resistivity is 20. Gamma Ray and/or Temperature options are available on some variants of tools.



Measurements

- Deep Resistivity
- Shallow Resistivity
- Gamma Ray (some variants only)
- Temperature (some variants only)

- Resistivity in water-filled holes
- Water saturation
- Coal Rank
- Fracture identification



Miscellaneous Services

The table below lists additional sondes for specialist applications.

Availability is limited - please refer to your local Reeves representative.

Series	Sonde Name	Measurements	Applications
ΟΤV	Optical Televiewer	Optical image	Casing Inspection Dry Hole Structural Analysis
СО	3-Arm Caliper	3-Arm Caliper	Borehole diameter Hole volume
GC	Gamma Ray 3-Arm Caliper Casing Collar Locator	Gamma Ray 3-Arm Caliper CCL	Correlation Borehole diameter Hole volume Drill rod or casing joint locator
SG	Spectral Gamma Sonde	Gamma Ray Potassium % Thorium % Uranium %	Correlation Clay mineral type Clay volume
тт	Temperature Sonde	Temperature - Absolute - Difference - Differential	Temperature profiles Ingress of fluid or gas into a borehole



Petroleum Consulting

Besides the routine log processing done historically, **Petroleum Consulting**, our new product line, expands into the advanced formation evaluation services for both Coal and Oilfield Weatherford clients. Weatherford is capable of providing a full range if interpretation services: from basic petrophysics to advanced borehole seismic interpretation.

Petroleum consulting offers a wide range of services including Slimline services related to wellbore image analysis, mostly applicable for coal mining formation evaluation.

A typical structural interpretation study:

- Detailed image data in electronic format (DLIS, LAS, PDF, PPMGZ)
- Presentation of borehole profiles
- Structural information as dip azimuth and dip strike direction of major features
- Bedding and coal bedding orientation
- Major structures (Fractures, Faults and coal based features)
- Statistical analysis, such as depth indexed image plots and stereograms that illustrate the categorization undertaken.
- Cleat and fracture frequency
- In-situ stress analysis (based on breakout and induced fractures)







Safety First

Weatherford operates an extensive Health and Safety program which is integral with the basic management of the company.

In all of our operations, Weatherford's most important mission is to pursue the highest possible standards to maximise our Quality, Health, Safety, and Environmental performance. In order to achieve this goal, the effective implementations of our policies on these issues are the top priority for all employees. By maintaining compliance with all applicable laws and regulations within the areas of our operation and by conducting all operations in a manner that promotes safe work practices and avoids risk to our employees, our neighbours, and the environment, we can optimise the value created for our customers.

Our objectives are straightforward:

- Assure the quality and technical integrity of our products and services so that they are fit for purpose and that their functional specifications match the customer's application in all instances.
- Conduct our operations with zero risk to personnel or the environment.
- Seek continuous improvement.
- Consult regularly with employees, and others, with regards to Quality, Health, Safety and the Environment.

Contacts

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