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Ultrasonic Scan Imaging Tool-V (USI-V)

Dodeca Segmented Bond Tool (DSB)

Hexapod Resistivity Imaging Tool-OBM (RIT-OBM)

Slim Resistivity Imaging Tool (SRI)

Ultrasonic Scan Imaging Tool (USI)

Nuclear Magnetic Resonance (NMR-M)

Array Laterolog Tool (ALT)

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Ultrasonic Scan Imaging Tool-V (USI-V)

Introduction

USI-V provides a wealth of information about your well in both open and cased holes. In open hole, the USI-V provides complete borehole imaging for accurate, precise formation evaluation. In cased hole, ultrasonic pipe inspection and cement evaluation can now be obtained simultaneously. Operating over a wide range of downhole environments, the USI-V offers a full 360^{o} profile of the borehole that can be presented in a variety of two- and three-dimensional formats. Powerful, yet user friendly imaging analysis software is available to process images, histograms, and curve-type data from this advanced logging device.

Primary applications include:

- Casing Inspection (both Thickness and Diameter)
- Ultrasonic Cement Evaluation / Imaging
- Openhole Borehole Imaging
- Fracture Detection

Ultrasonic Scan Imaging Tool-V (USI-V)

The tool contains two ultrasonic transducers, each acting as both a transmitter and receiver.

- **The fixed transducer has the fixed distance to target, it can be used to measure the slowness of the down-hole fluid.**
- The rotating transducer shoots 100 times to the casing every scan.

The Ultrasonic tool is working on Pulse-Echo mode.

The echo wave is detected for borehole/pipe wall imaging.

The reverberation wave is collected and analyzed for:

1. Pipe thickness calculation.

2. Acoustic impedance to evaluate the cement bonding.

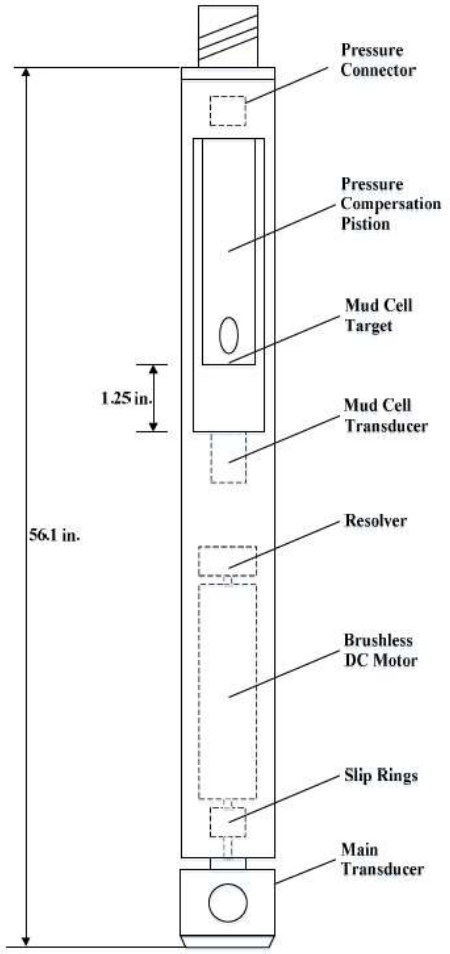

Figure 3-2 USI-V Scanner

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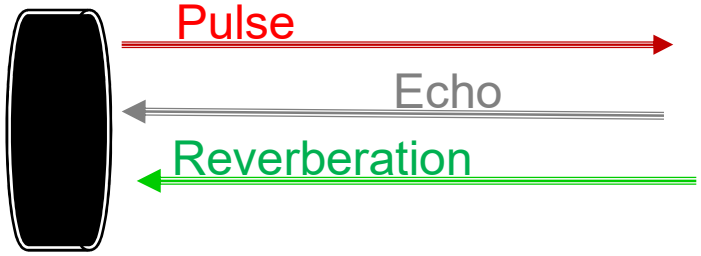
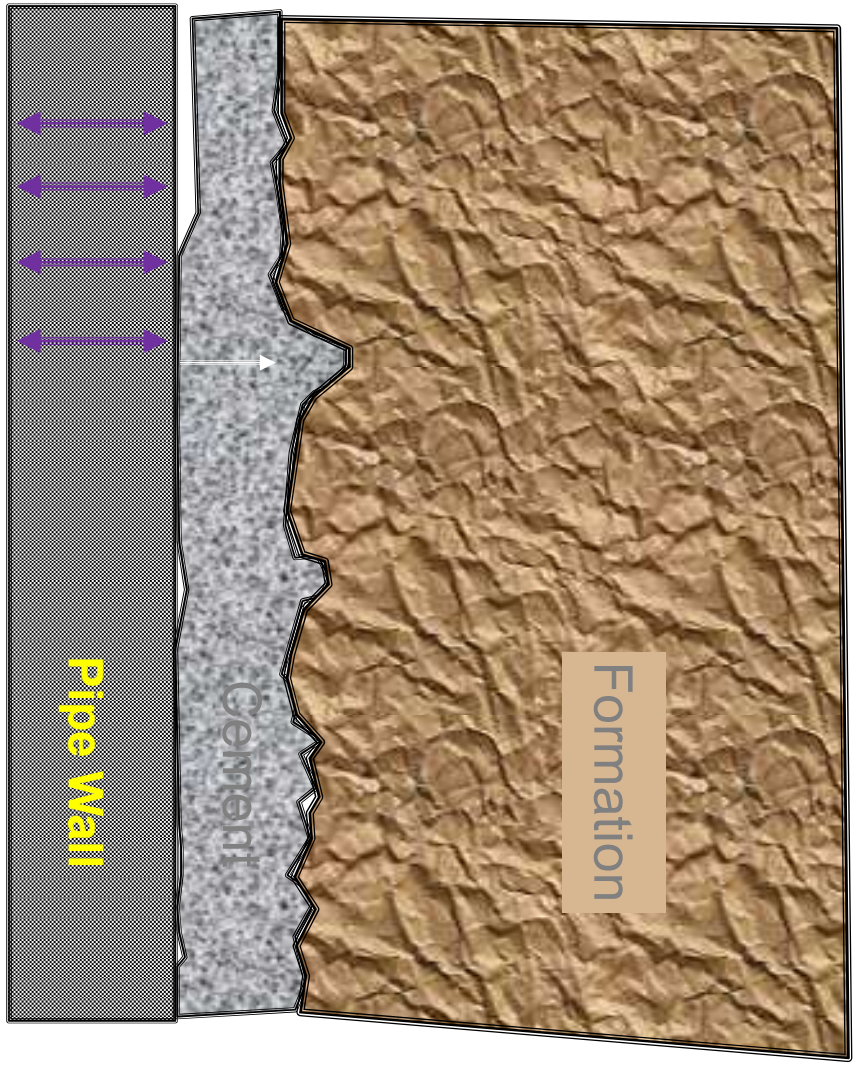
Ultrasonic Scan Imaging Tool-V (USI-V)

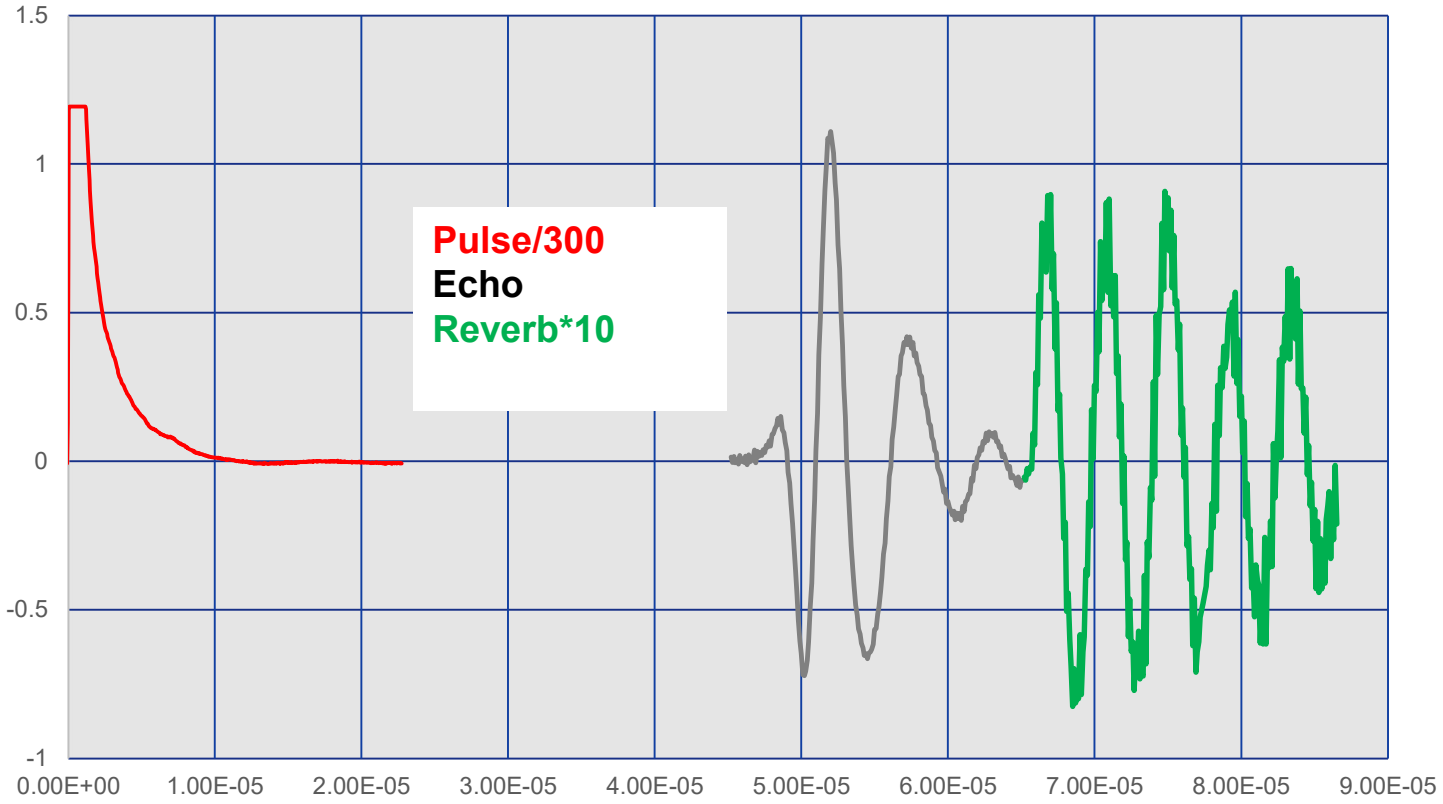


The transducer is excited by the firing pulse, The ultrasonic wave interacts with the pipe wall, the rebounded wave is collected. Part of the sonic energy is transmitted into the Wall, result in resonance, the reverberation Wave is also collected for further analysis.



Ultrasonic Pulse,Echo,Reverb

USI-V measures characteristics of the casing using a high-frequency pressure pulse. During operation, transmitted ultrasonic pulses interact with the borehole wall in a way that causes pressure waves to travel back to the tool. The transducer used to transmit the original pulse then converts these pressure variations to a voltage waveform. The digitized values of this waveform are the basis for all USI-V images and curves in cased boreholes.



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USI-V Specifications

Maximum temperature	350°F (175 °C)
Maximum Operating Pressure	20,000 psi (137.9 MPa)
Make-up Length	23.2 ft. (5.81 m)
Weight	316 lbs. (143 kg)
Diameter	3.625 in. (92 mm)
Power Requirements	180 Vac 120 MA
Motor Power	150 Vdc, <1.5 A
Firing Rate (shots/scan)	100
Vertical Scan Rate	4 scans/ft. at 3.0 in. sampling
Principle	Ultrasonic Pulse Echo and time of flight
Vertical Sampling(Software)	6.0, 3.0, or 1.0 in.
Logging Speed	60, 30 or 10 ft./min (Depending on sampling rate)
Primary Curves	Reflected Amplitude, Radius Acoustic Impedance, Casing Wall Thickness
Secondary Curves	Relative Bearing, Deviation, Fluid TT, Compressive Strength, Mud Impedance
Minimum Diameter Hole	4.276 in. (108 mm)
Maximum Diameter Hole	13 in. (330 mm)
Wireline Requirements	7 Conductor Cable

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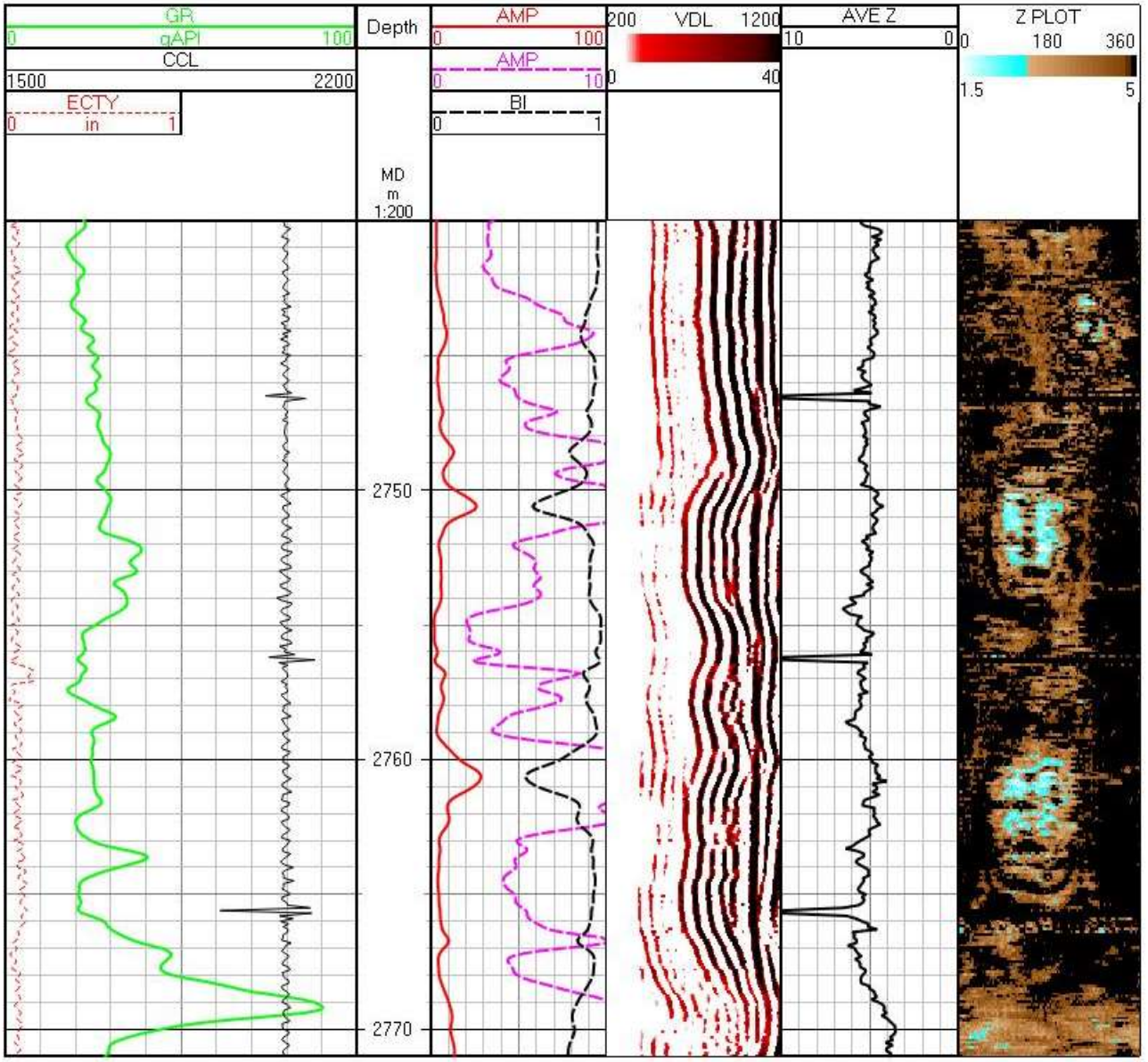
Cement Bond Evaluation



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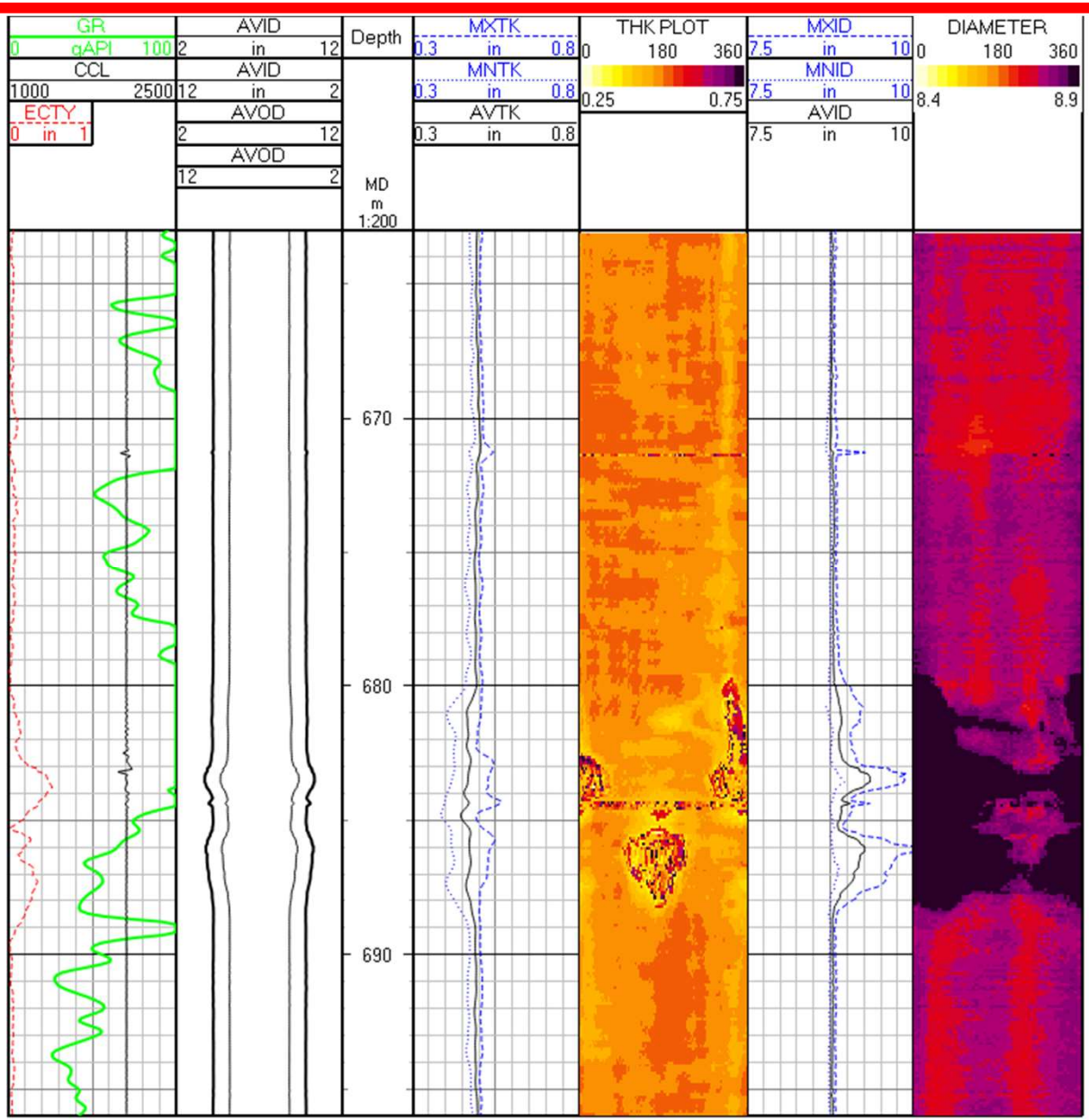
Casing Corrosion Evaluation



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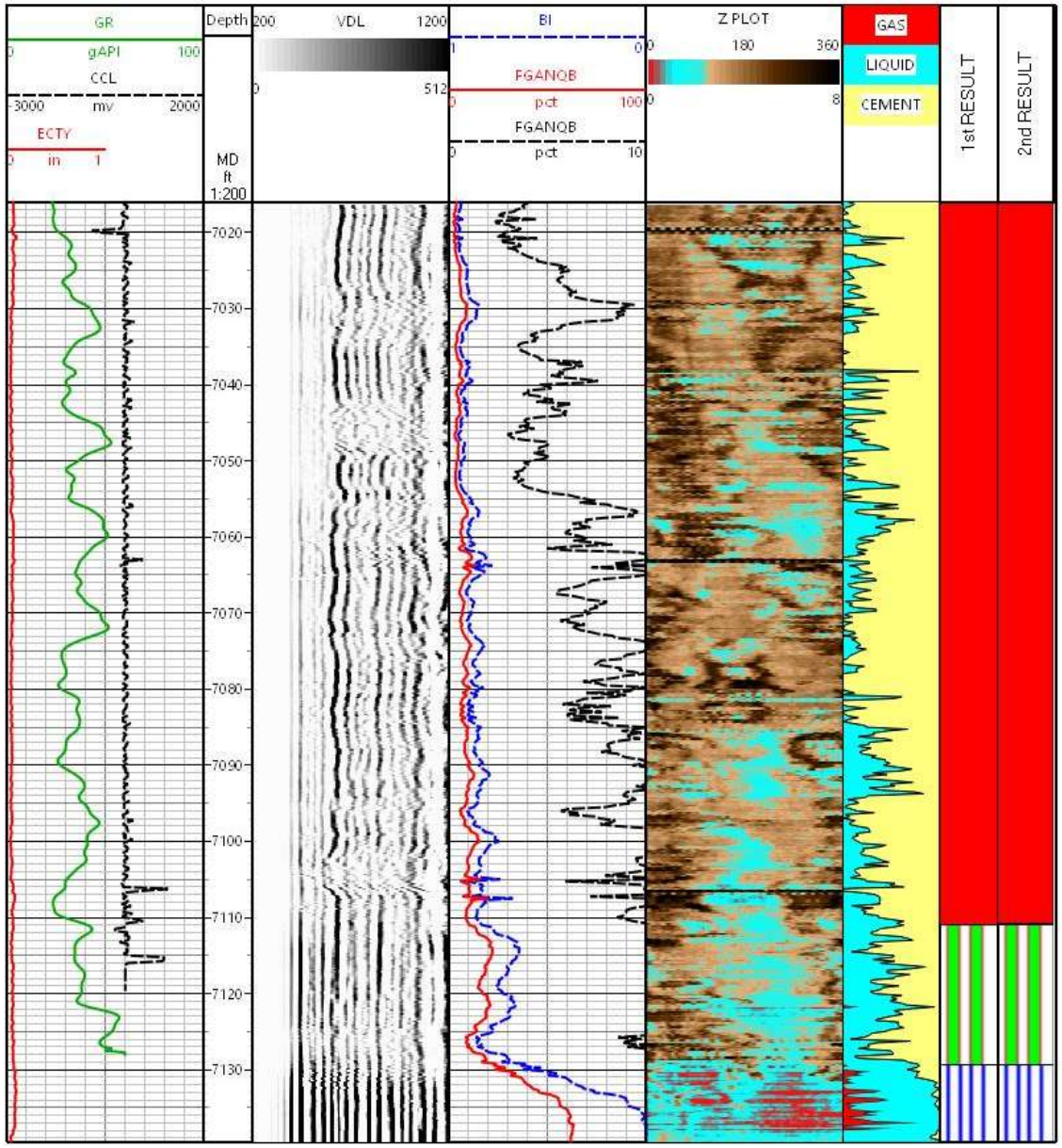
Casing Corrosion Evaluation



DEoRC Dodeca Segmented Bond Tool (DSB)

Introduction

DSB is a twelve sectors acoustic logging tool to evaluate the cement bond integrity. In addition, it measures the amplitude of sonic signal that passing along the casing, the DSB radial receiver generates a map of the cement.

The DSB adds sectors in general CBL/VDL tool that is equipped with one transmitter and three sensors constructed of piezo-electric crystals.

The radial receiver, located 2 feet from the transmitter is constructed of a 12-sector radial receiver. Each sector provides bond data covering a 30^{o} section of casing. The 3 feet receiver, generates a cement bond logging (AMP 3ft).The far receiver, located 5 feet from the transmitter, generates a Variable Density Log (VDL).

Application:

· Cement Bond Evaluation
· Location of free-pipe and cement top

Features & Benefits :

· 360^{o} cement bond imaging view
· Combinable with ultrasonic Ultrasonic Scan Imaging Tool-V (USI-V).

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DSB Specifications

Maximum temperature	350°F (175 °C)
Maximum Operating Pressure	20,000 psi (137.9 MPa)
Make-up Length	13.12 ft. (4.00 m)
Weight	231.48 lb (105 kg)
Diameter	3.5 in. (89 mm)
Maximum Logging Speed	100 ft./min (30 m/min)
Transducer Type	Piezoelectric
Receiver (2 ft.)	12 segments
Receiver (3 ft.)	Monopole
Receiver (5 ft.)	Monopole
Transmitter	Piezoelectric (Monopole)
Recommended Casing Range	
Minimum Casing OD	5.00 in. (127 mm)
Maximum Casing OD	13.375 in. (340 mm)
Wireline Requirements	7 Conductor
Power Requirements	180 Vac

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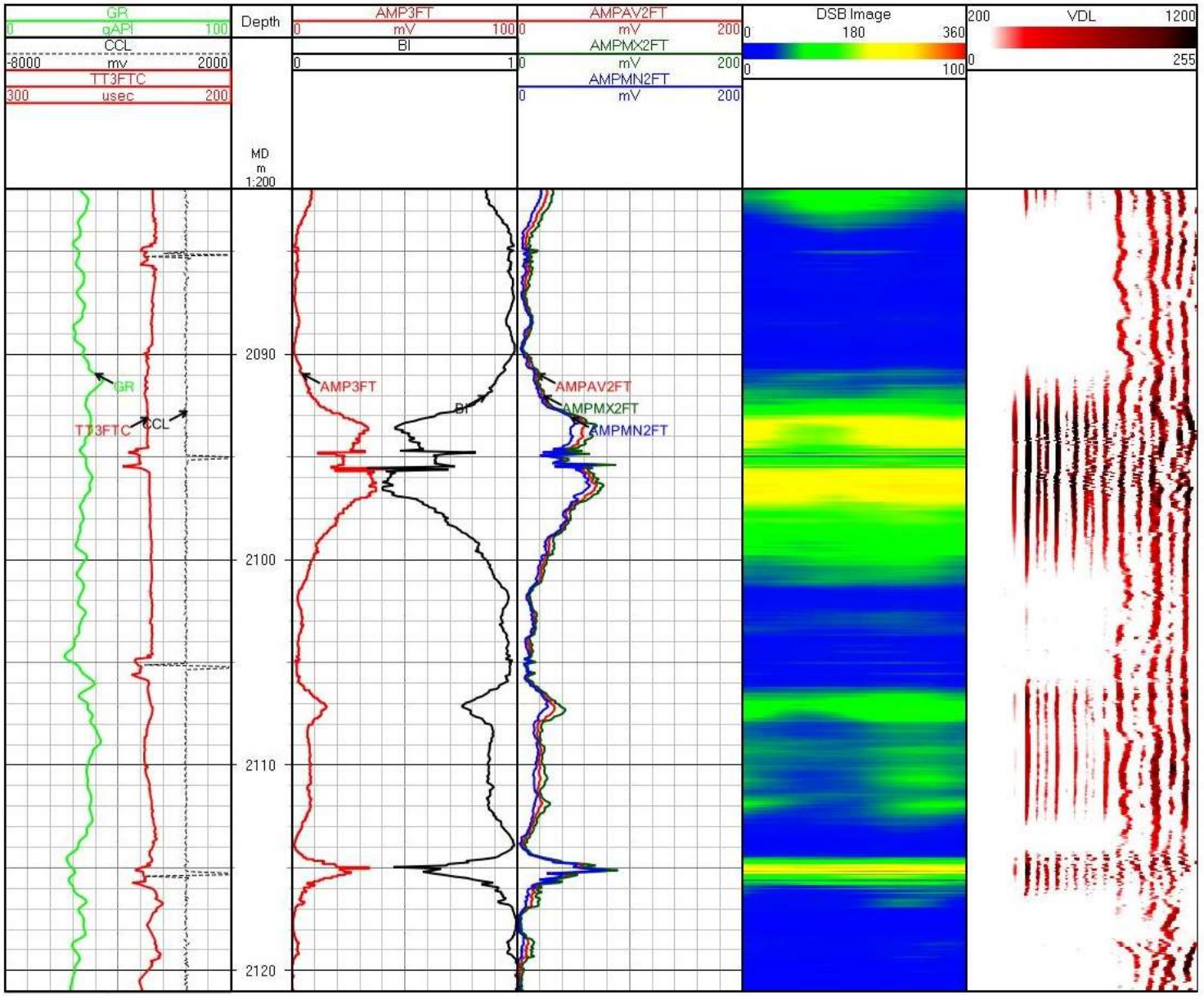
DSB Logging data



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RIT-OBM Introduction

Introduction

The Hexapod Resistivity Imaging Tool-OBM (RIT-OBM) is a micro-conductivity–based service used for imaging boreholes in wells drilled with electrically non-conducting mud systems. The instrument measures the conductivity of the formation it traverses. The data is presented as high resolution images from which geological information is derived such as fractures, bedding, stratigraphy, dip information, depositional environments, etc. The instrument also provides the best geometric definition of the borehole, derived from six independent mechanical calipers.

Application:

· Structural analysis
· Detailed stratigraphic and sedimentological analysis
· Dip and strike determination
· Fracture identification and characterization
· Thin bed analysis
· Fault mapping
· Seismic upscale and verification of a seismically derived structural model

Features & Benefits :

· Provides high-resolution images
· Combinable with acoustic and ultrasonic imaging services

RIT-OBM
(oil based mud)

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RIT-OBM Specifications

Maximum temperature	350° F (177 ℃)
Maximum pressure	20,000 psi (137.9 MPa)
Make-up Length	30.6 ft. (9.35 m)
Weight	600 lbs. (272.4 kg)
Maximum Tool Diameter	5.25 in. (133.4 mm) with pads
Minimum Hole Diameter	6.0 in. (152.4 mm)
Maximum Hole Diameter	16.0 in.(406.4 mm)
Hole deviation	Vertical to horizontal
Arms	6 independent
Pad Force	5-55 lbf (2.3-25 kgf)(Adjustable)
Borehole Coverage	66.7% in. 7-7/8 in. diameter borehole
Caliper Range Diameter	5.0 in. to 21 in. (127-533 mm)
Pad Articulation	± 10 degrees (Radially)
Operating Power (using PAS)	420 Vac/0.5 A
Motor Power	115 Vdc<1.0 Amps
Imaging Mode (High resolution)	120 samples/ft.
Wireline Requirements	7 Conductor
Number of Pads	6
Number of Sensors Per Pad	8 (OBM)

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RIT-OBM Specifications

System capabilities.

Data Recorded	RAD 1 through RAD 6 Radius measure from tool axis to each pad Gains (Bucker ,Pad ,Guard) BTN1-BTN8 Button currents for each of six pads in OBM mode
Measuring Range	Caliper RAD1 through RAD6 as allowed by mandrel 5.5 in. to 21 in. Oil based mud (OBM) BTN1 through BTN8 Resistance 1200 Ohms to 1,200 MOhms Formation Resistivity 0.1 to 10 kOhm-m

Orientation Sensor Type	Orientation obtained from TGO
Tensile Load Capacity	36,000 lbf (16,329 kg)
Compressive Load Capacity	29,000 lbf (13,154 kg)

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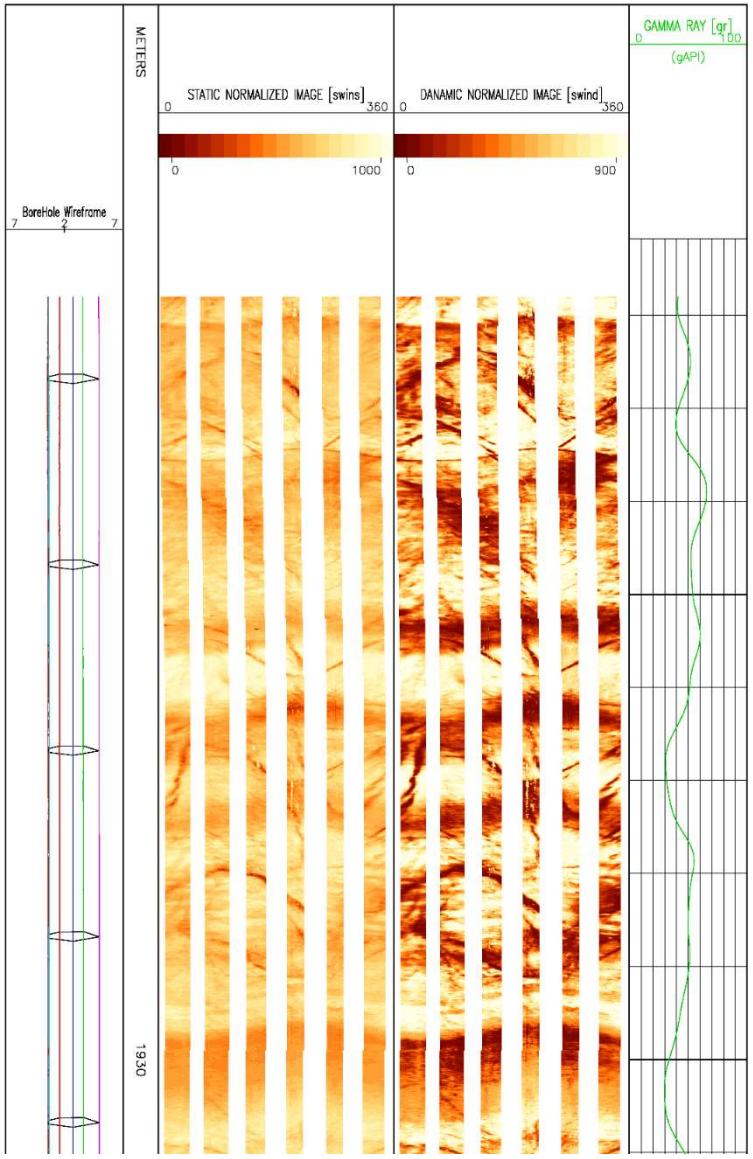
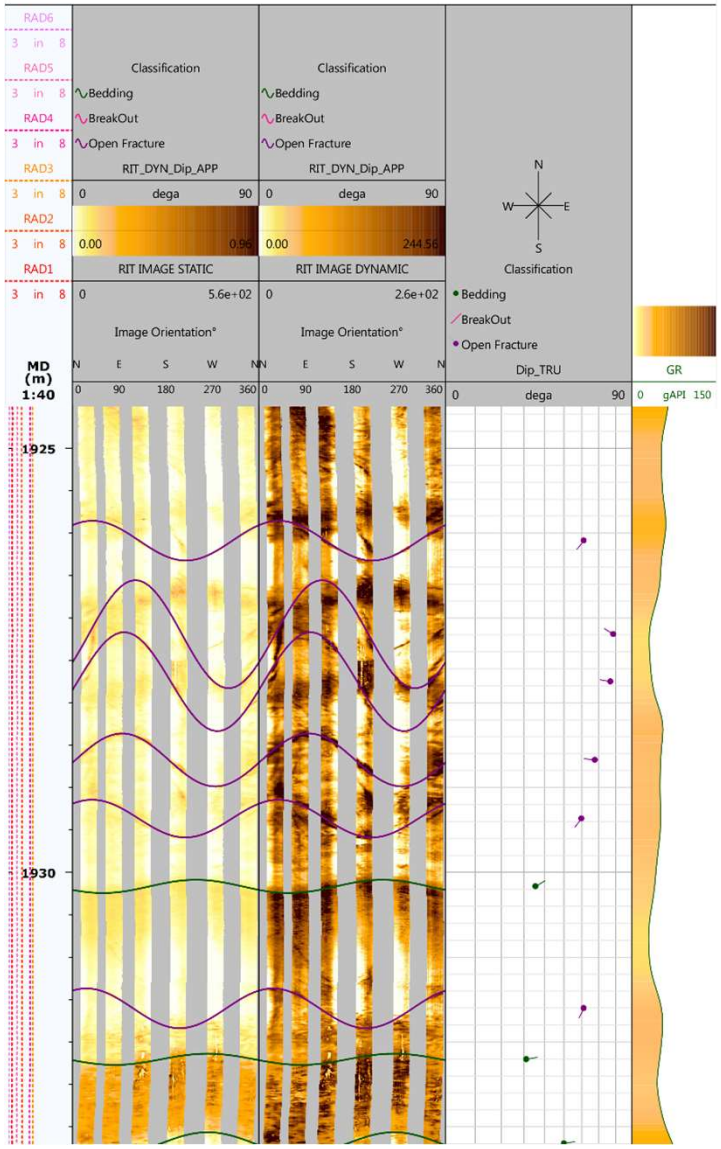
RIT-OBM Logging Data



Field Data



Processed Data

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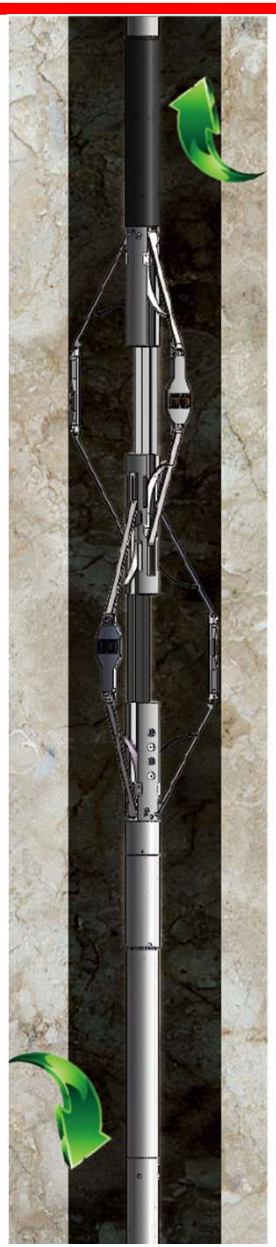
SRI Introduction

Introduction

The Slim Resistivity Imaging Tool (SRI) is a micro-conductivity–based tool used for imaging boreholes in wells. The instrument measures the conductivity of the formation it traverses. The data is presented as high resolution images from which geological information is derived such as fractures, bedding, stratigraphy, dip information, depositional environments, etc.

Conveniently new designed to obtain superior quality images in WBM or OBM by changing PADs.
Separated Pads designed reduce the tool diameter, that allows tool logging in small size borehole.
Dual SRI combination provides high coverage of borehole image.
Unique memory/real time technique offers higher logging speed without compromised quality.
Flexible combination of single/dual mode and other tools on WAP platform.



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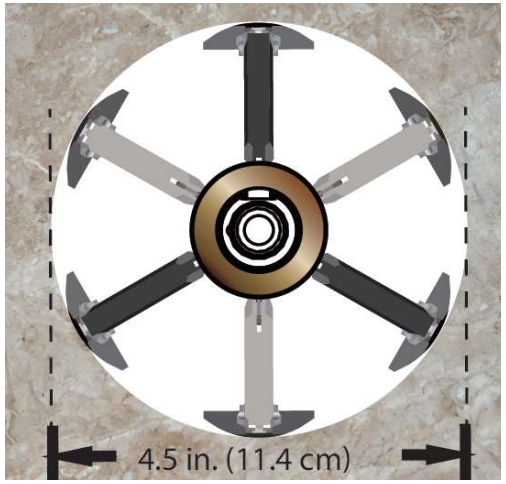
SRI Introduction

Application:

- High-resolution imaging in
- ✓ Slimhole wells
- ✓ Deviated and horizontal wells
- ✓ Irregular and rugose boreholes
- Structural analysis
- Detailed stratigraphic and sedimentological analysis
- Dip and strike determination
- Fracture identification and characterization
- Thin bed analysis
- Fault mapping
- Seismic upscale and verification of a seismically derived structural model

Features & Benefits :

- Dual SRI combination provides high coverage of borehole image with 12 Pad.
  100% coverage in ≤ 10.5 in. diameter borehole
- Provides high-resolution images
- Combinable with acoustic and ultrasonic imaging services
- Logging down is available



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SRI Specifications

Maximum temperature	350° F (175 ℃)
Maximum pressure	15,000 psi (103 MPa)
Make-up Length	29.7 ft. (9.04 m)
Weight	565 lbs. (256.8 kg)
Maximum Tool Diameter	3.85 in. (98 mm) with pads
Minimum Hole Diameter	4.5 in. (114 mm)
Maximum Hole Diameter	16.0 in. (406.4 mm)
Hole deviation	Vertical to horizontal
Arms	6 independent
Tool Positioning	Centralized
Data Recorded (Min):	RAD1～RAD6 Radius measure from tool axis to each pad BTN1-BTN24 currents for each pad in WBM mode BTN1-BTN8 currents for each pad in OBM mode
Imaging Mode (High resolution)	120 samples/ft.
Wireline Requirements	7 Conductor
Number of Sensors Per Pad	8 (OBM) / 25(WBM)
Orientation Sensor Type	Orientation obtained from TGO
Tensile Load Capacity	36,000 lbf (16,329 kg)
Compressive Load Capacity	29,000 lbf (13,154 kg)

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USI Introduction

Introduction

The Ultrasonic Scan Imaging Tool is an acoustic device designed to produce detailed images of the wellbore wall (or casing). The USI pulse-echo transducer emits a high frequency acoustic pulse and measures the amplitude and the time of flight of the reflected wave. The amplitude of the reflected wave is affected by variations in the borehole surface.

The travel time is indicative of the distance from the transducer to the wellbore wall. The acoustic transducer is mounted on a rotating section, allowing the USI to scan the full 360 degrees of the wellbore producing two images or maps.

Application:

· Structural and bedding analysis
· Completing detailed fracture studies
· Dip and strike determination
· Determining high-resolution borehole shape
· Stress analysis and borehole stability studies

Features & Benefits:

· Provides high-resolution images
· Full 360° coverage of the borehole with images containing up to 256 data samples
· Reliably operates in any mud type
· Combinable with Hexapod Resistivity Imaging Tool RIT

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USI Specifications

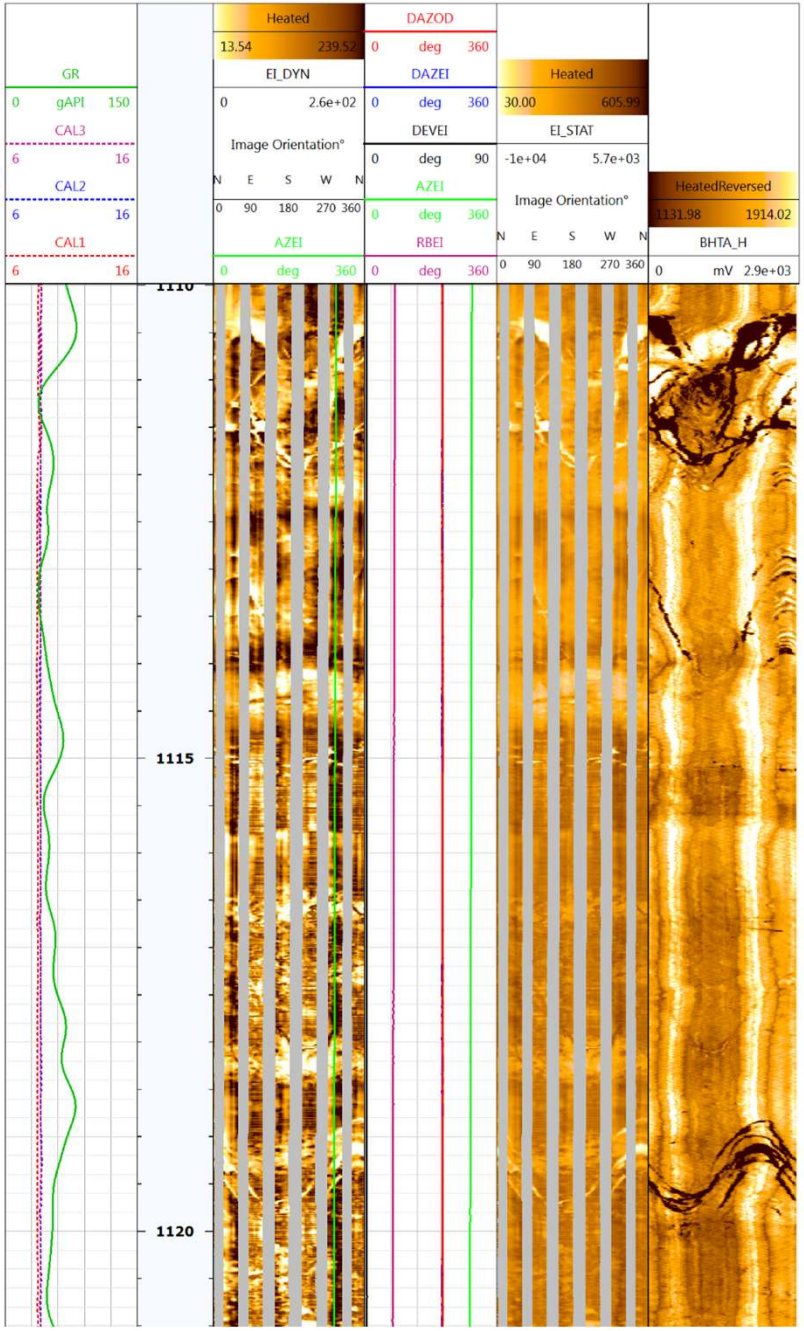
Maximum temperature	400° F (200 ℃) for 6 hours
Maximum pressure	20,000 psi (137.9 MPa)
Tool Diameter	3.625 in. (92 mm)
Make-up Length	15ft.-6.4in.(4.71 m)
Weight	270 lb (122.4 kg)
Power Requirement	180 Vac, 60 Hz, 0.6 Ampere, nominal
Samples per Scan	250/125
Hole coverage	**100%**
Scan Speed	11 scans per second, nominal
Minimum Hole Diameter	5.5 in. (139.7 mm)
Maximum Hole Diameter	16.0 in (406.4 mm)
Hole deviation	Vertical to horizontal
Logging Speed	10 ft./min.(3.05 m/min), 60 scans per foot (s.p.f.) 20 ft./min. (6.10 m/min) @ 30 s.p.f.
Imaging Transducers	
Quantity	2
Size/type	1.5 in., and 2.0 in. (50.8 mm) focused, ceramic
Frequency of Operation	250 kHz
Wireline Requirements	7 Conductor
Maximum Tensile Force	17,500 lbf
Maximum Compressive Force	4,000 lbf

DEoRC Logging Data

The RIT-OBM is combinable with the USI acoustic borehole imager to form a complete borehole imaging service.

Hence, the Full Imaging Capability service for (RIT-USI) simultaneously measures two distinct physical properties of the formation being traversed: acoustic impedance and electrical conductivity.

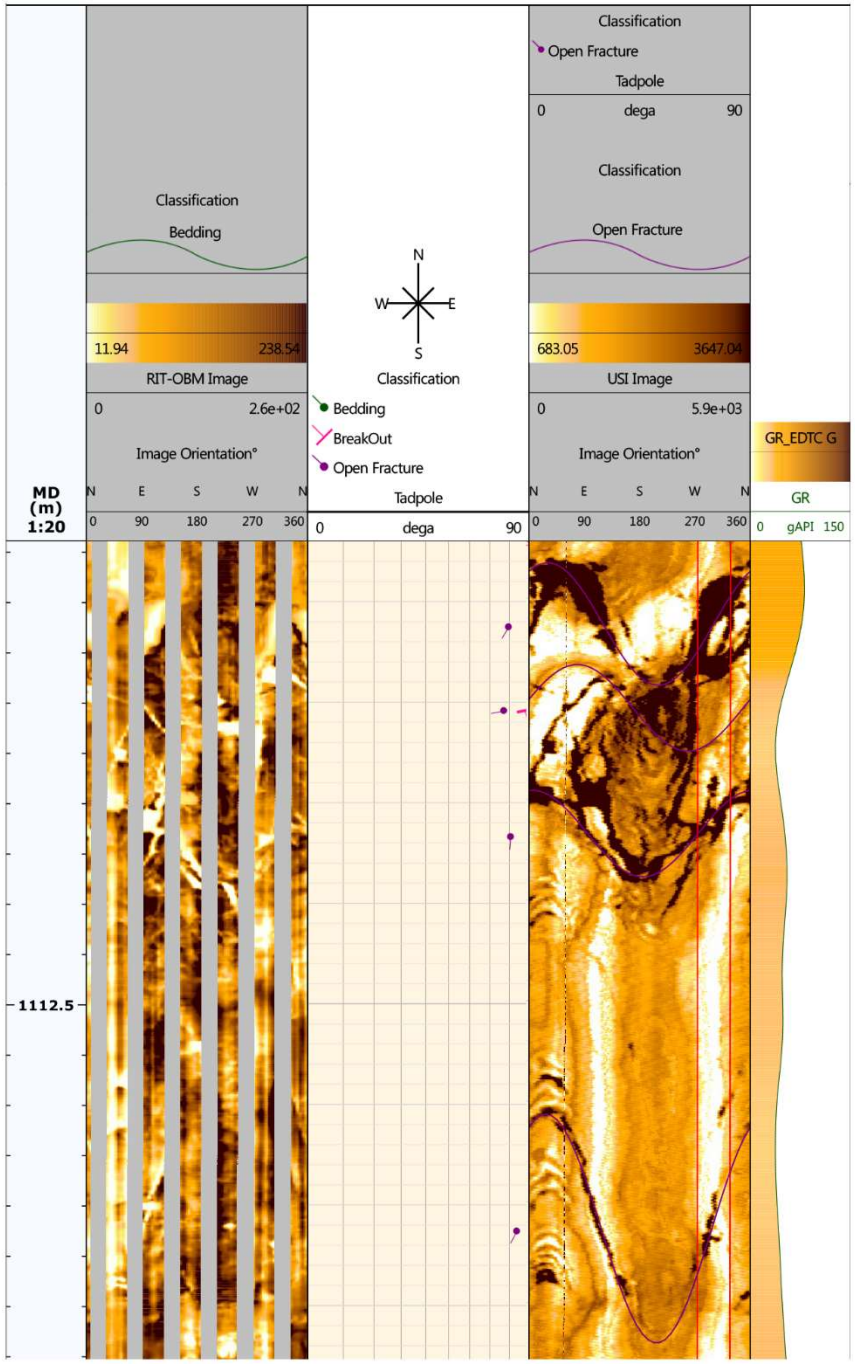
Additionally, a detailed quality control log and image processing was created to provide a better image log.



RIT/USI- Field Data

DEoRC Processed Data

The data is presented as high-resolution images from which geological information is derived, such as fractures, bedding, stratigraphy, dip information, depositional environments, etc.



RIT/USI- Processed Data

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NMR-M Introduction

Introduction

The NMR-M tool measures hydrogen for porosity and relaxation rates of protons. This tool is primarily a digital device. NMR experiments are a measurement of time required for protons to either align with an external magnetic field or for processing protons to de-phase, or relax (T_2 measurement).

Application:

· Reveal different properties of the formation fluid and pore size distribution
  Effective and total porosity
  Movable water and bound water
  Permeability
  Pore size, microporosity and vugs

· Hydrocarbon Typing and Quantification Low-R, low-contrast pay
  Water, gas, oil saturations or flushed zone saturations
  Oil viscosity
  Characterizing unconventional
  Reservoirs such as gas shale, tar and heavy oil

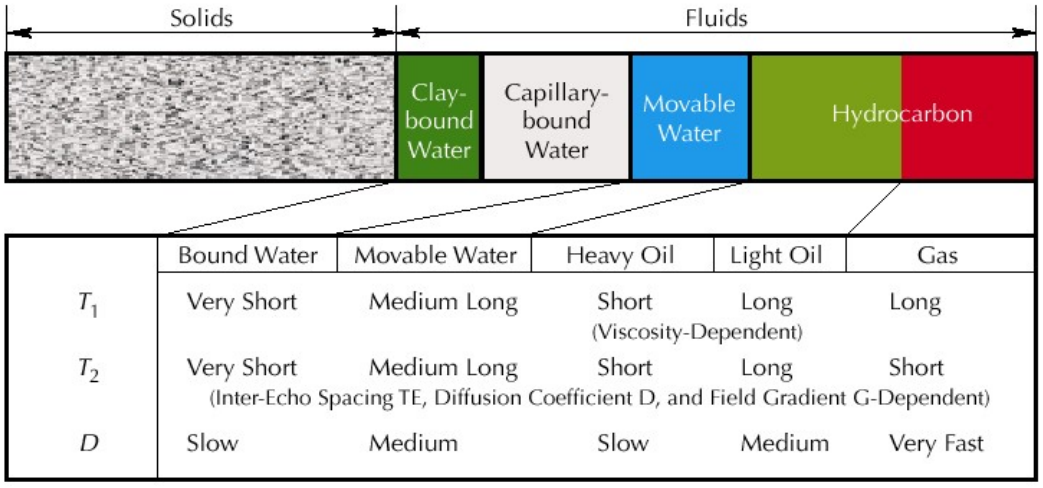
NMR-M Introduction

Benefits:

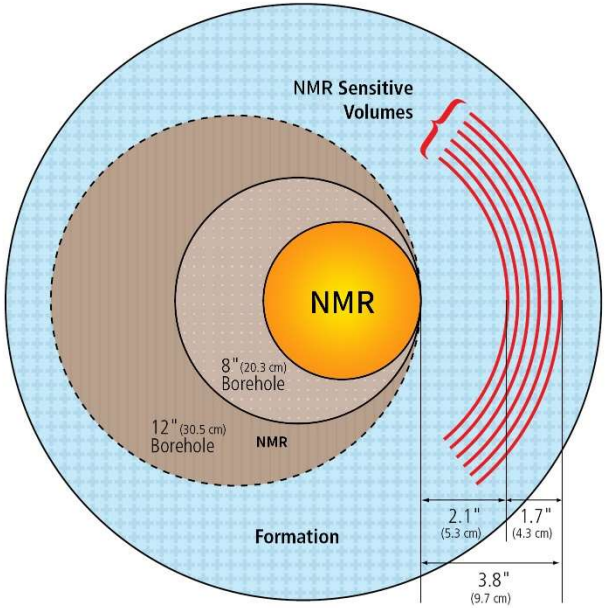
·Improved reservoir quality estimate (permeability, pore size distribution)
·Reduction of rig time through improved logging speed and tool combinability
·Accurate reserves determination with minimal uncertainty

Features:

·Multi-frequency, multi-investigation depth measurements
·Side-looking data acquisition expands operating envelope
·Direct measurement of lithology independent effective porosity, free fluid and capillary bound porosity, bound water
·Accurate measurements utilizing fully recovered wait time



	Bound Water	Movable Water	Heavy Oil	Light Oil	Gas
T_1	Very Short	Medium Long	Short (Viscosity-Dependent)	Long	Long
T_2	Very Short	Medium Long	Short	Long	Short
	(Inter-Echo Spacing TE, Diffusion Coefficient D, and Field Gradient G-Dependent)				
D	Slow	Medium	Slow	Medium	Very Fast



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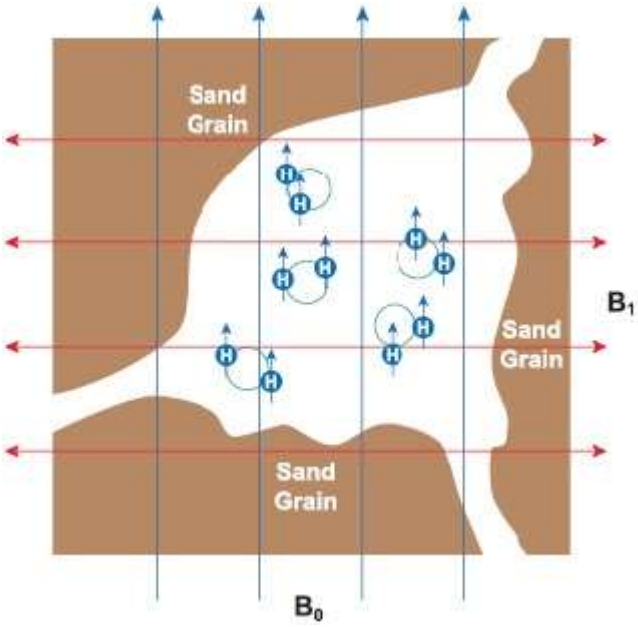
NMR-M Introduction

Principle

NMR-M nuclear magnetic resonance Logging service uses the principle of nuclear magnetic relaxation to provide formation evaluation of petrophysical data including effective porosity, irreducible water saturation, permeability and pore-size distribution, etc.

NMR-M investigates the freedom space with which hydrogen nuclei (proton) can move within the formation. In bulk water a proton which is set in motion will continue unrestrained for some considerable time. The same proton in motion in a rock pore will come into contact with the pore walls and its motion will be damped. The time taken for the motion to die away will be directly related to the ratio between the volume of water in which the hydrogen is moving and the area of the surrounding rock matrix which damps its motion.

The NMR tool responds to hydrogen nuclei in the pore fluids present in the formation. The NMR-M instrument uses static and pulsed radio frequency (RF) magnetic fields to make downhole spin-echo magnetic resonance measurements. Initially, the NMR-M instrument aligns, or polarizes, the hydrogen protons in the formation fluid to its static magnetic field, B0.



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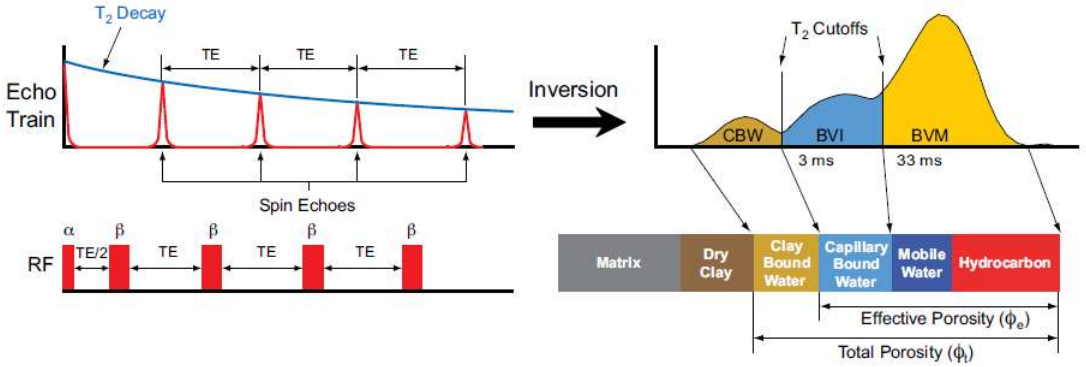
NMR-M Introduction

Principle

Then the NMR-M tool applies an RF magnetic field to rotate or “tip” the protons. The polarizing, or A, pulse “tips” the protons perpendicular to the static field. The instrument then applies rephasing, or B, pulses to rephase the protons, generating a measurable signal called a spin-echo at a time designated as TE. The NMR-M tool continues to apply a series of rephasing pulses at equal time intervals, with each pulse generating a spin-echo. The important information measured by the NMR-M instrument is contained in the echoes. The amplitude of each echo and the time at which the echo was generated is measured and recorded. The initial amplitude of the train of echoes is related to the volume of fluid present in the formation and is used to determine formation porosity. The echo amplitudes decrease, or decay, with time. The decay rate of the echo train, T_2 (see Fig below), provides information about pore sizes and the types of fluid present in the pores.



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NMR-M Specifications

Maximum temperature	350°F (175 °C) for 2 hours
Maximum Pressure	20,000 psi (137.9 MPa)
Make-up Length	24 ft.-5 in. (7.44 m)
Weight	644 lbs. (292.1 kg)
Maximum Diameter	5.06 in. (127 mm)
Minimum Hole Diameter	5.8 in. (147 mm)

Logging speed (typical):
hole diameter = 8 in BHT = 150° F, Rxo > 2 ohm.m., standard resolution 4 spf

Formation Evaluation (TW ≤ 2.1 s)	5 ft/min (4.6 m/min) Rm > 0.1 ohm.m
	4.9 ft/min (1.5 m/min) Rm = 0.02 ohm.m
Fluid-typing (TW ≤ 11 s)	10.8 ft/min (3.3 m/min Rm > 0.1 ohm.m
	2.7 ft/min (0.8 m/min) Rm = 0.02 ohm.m
Bound Water logging	24 ft/min (7.3 m/min) Rm > 0.1 ohm.m
	8.1 ft/min (2.5 m/min) Rm = 0.02 ohm.m
	(Stationary Measurements possible)

Number of frequencies	12
Number of acquisition modes	7
Measurement range	0 - 100 pu
Minimum TE	0.4 ms
Measurement accuracy	2 pu

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NMR-M Specifications

Depth of investigation beyond borehole wall	2.2 – 4.0 in. (56 – 102 mm)
Sensitive volume	
Aperture	18 in. (457 mm)
Arc length	~120°
Shell thickness	1.1 - 2.3 mm
Volume (7 freqs)	1.3 L
Static field gradient	14 - 39 gauss/cm
Power Requirements:	
Minimum instrument voltage	185 Vac
AC Power Operating Voltage & current	190 Vac, 240 mA
DC Power Operating Voltage & current	600 Vdc, <700 mA
Wireline Requirements	7 conductor cable
Operating Position	Decentralized
Hole Deviation	Vertical to horizontal
Tensile Strength	46,000 lbs (205 kN)
Compressive Strength	
6" hole:	30,000 lbs (133 kN)
8" hole:	10,000 lbs (44 kN)
14" hole:	3,300 lbs (15 kN)

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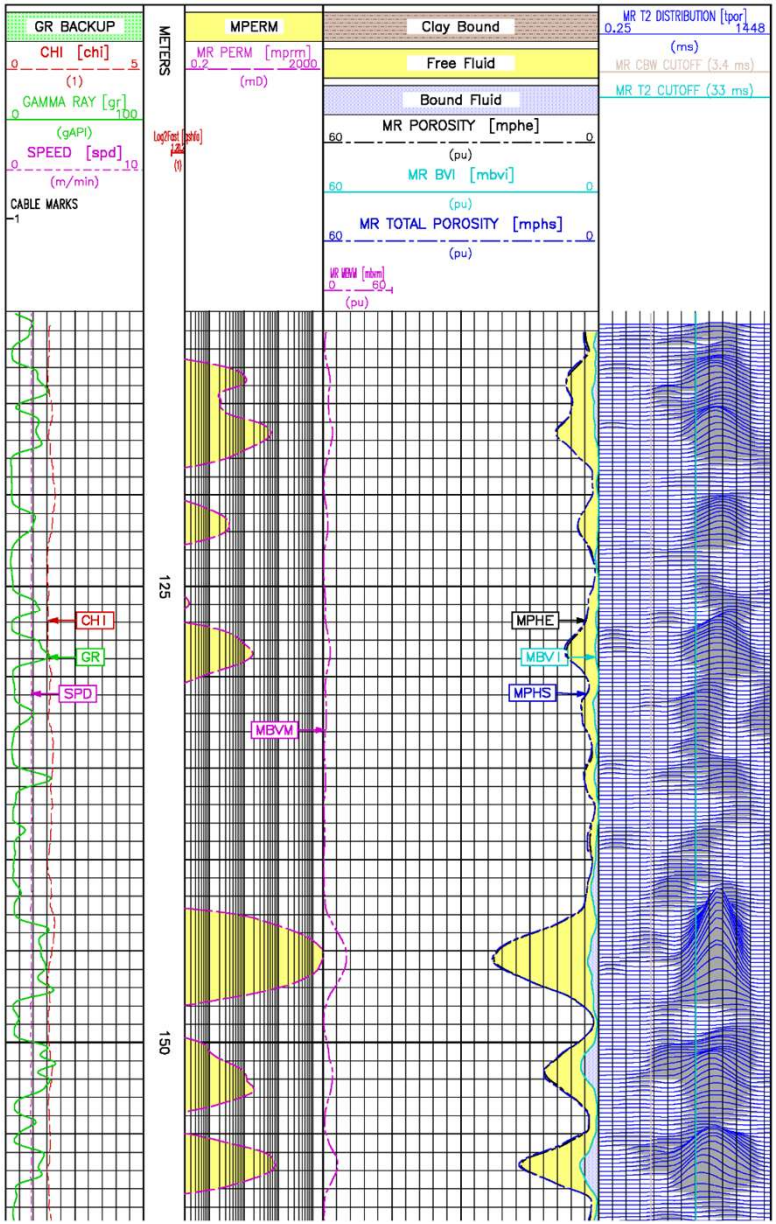
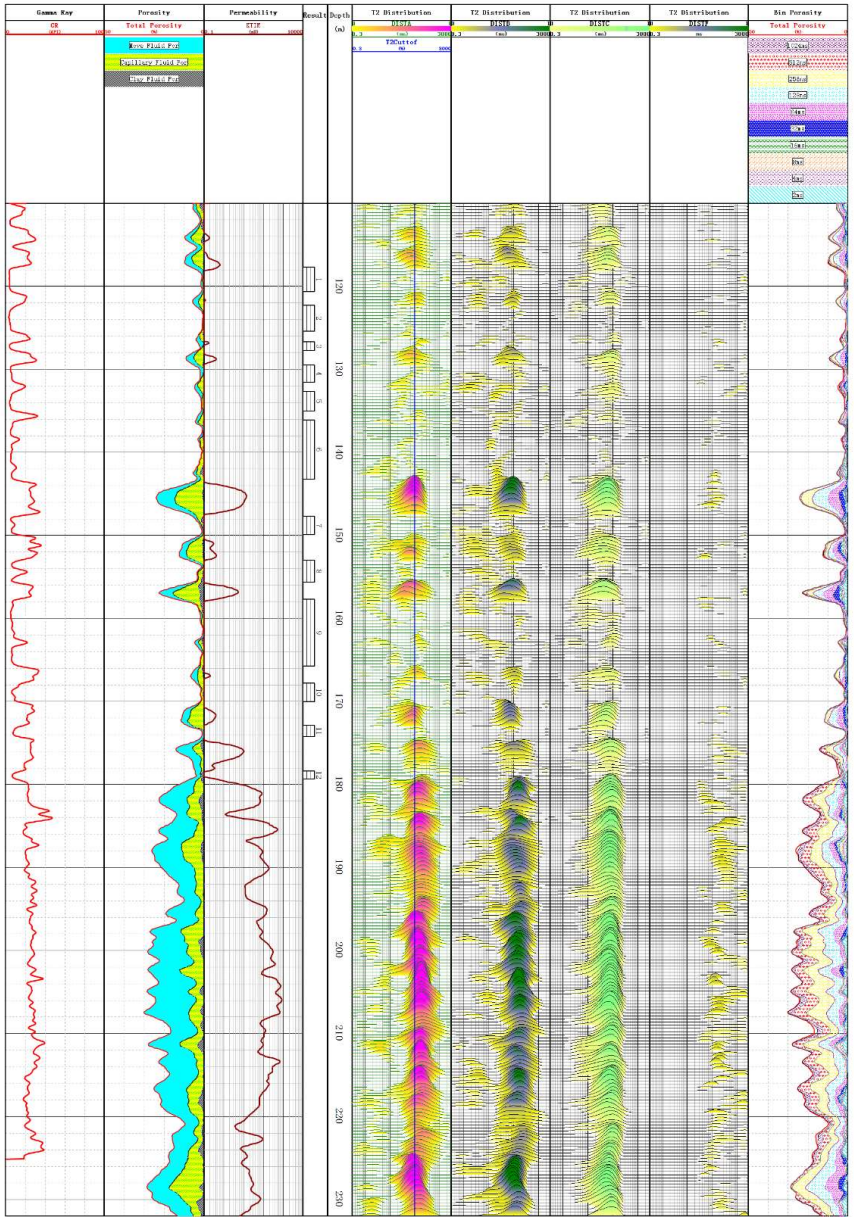
NMR-M Logging Data





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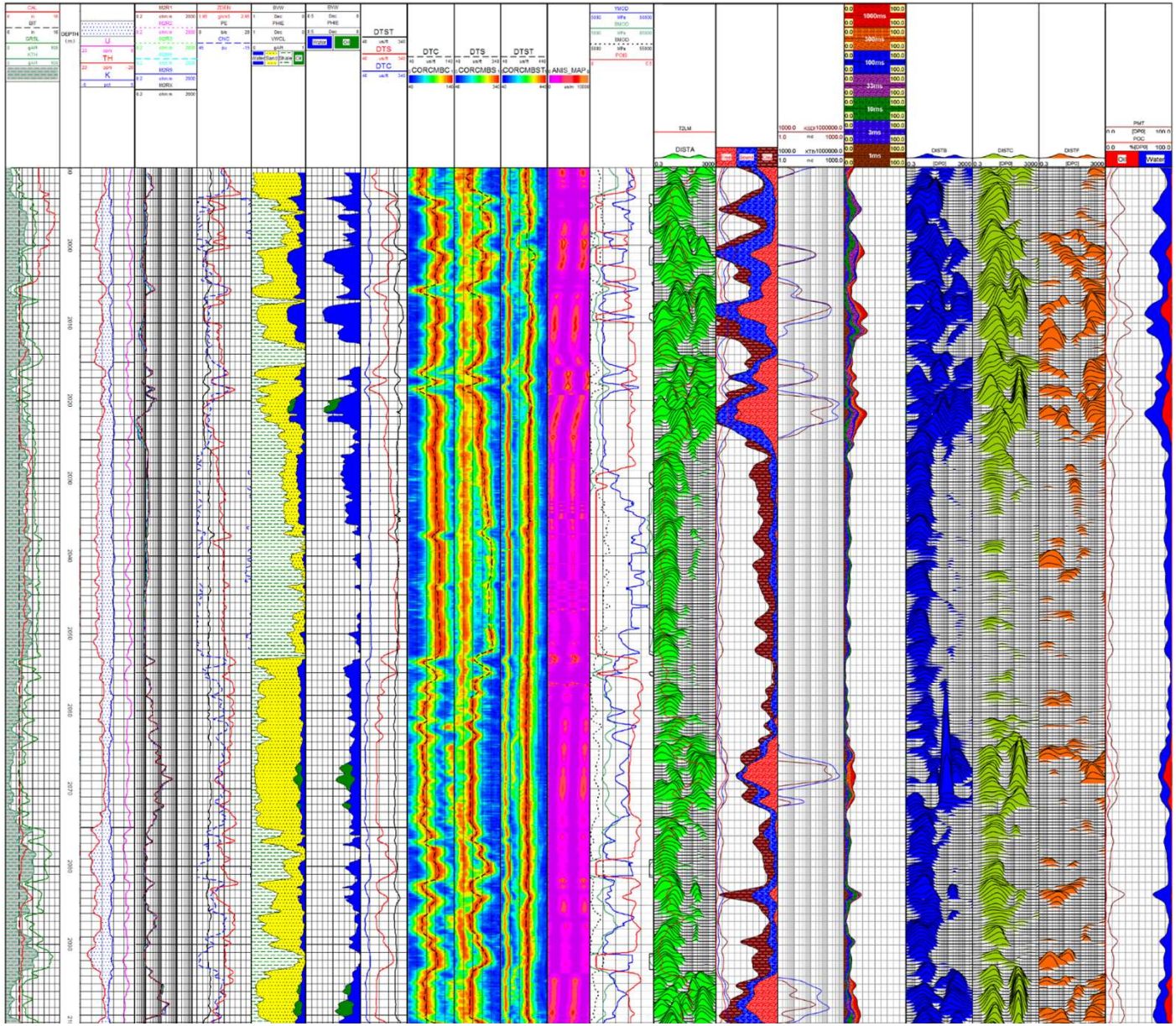
NMR-M/MAA/FULLSET(AIT)
Logging Data



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ALT Introduction

Introduction

The Array Laterolog Tool (ALT) provides five independent, actively focused, depth- and resolution- matched measurements that can resolve the true formation resistivity in thinly bedded and deeply invaded formations.
Unprecedented combinability results from the through-wired tool design. The absence of a current return at surface as well as no required use of a bridle greatly improves wellsite efficiency.

Application:

- Resistivity determination in conductive mud systems
- Thin-bed evaluation
- Invasion characterization for permeability indication
- Water saturation Determination
- Identification of fluid contacts

Features & Benefits:

- Five resistivity measurements, each with increasing depth of investigation, give a clear indication of invasion
- Data measured from common central electrode using multiple frequencies give simultaneous measurements that are naturally resolution matched and depth-aligned.

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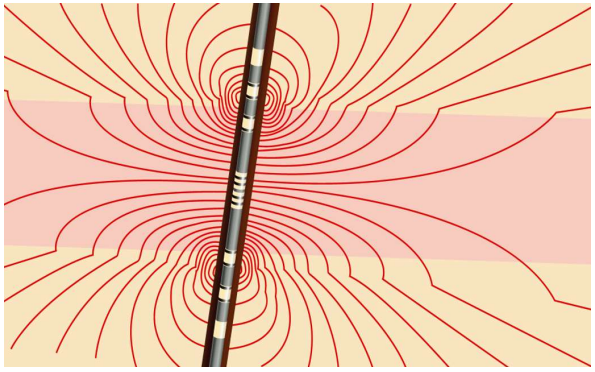
ALT Specifications

Maximum temperature	300° F (150° C)
Maximum pressure	15,000 psi (103.4 MPa)
Tool Diameter	3.625 in. (92 mm)
Make-up Length	24 ft.-1.2 in. (7.34 m)
Weight	394 lbs. (179 kg)
Minimum Hole Diameter	≥5 in.
Maximum Hole Diameter	16.0 in (406.4 mm)
Hole deviation	Vertical to horizontal
Maximum Logging Speed	60 ft./min (18 m/min)
Resistivity Range (Rm=1)	0.2 to 100,000 ohm-m
Resistivity Range (Rm=0.02)	0.2 to 20,000 ohm-m
Accuracy	±0.1 ohm-m@0.2~1 ohm-m ±5%@1~10,000 ohm-m ±20%@10,000~40,000 ohm-m
Vertical Resolution	12 in. (30.48 cm)
Depth of Investigation	RLA1: 12.60 in. (32 cm) RLA2: 15.35 in. (39 cm) RLA3: 18.90 in. (48 cm) RLA4: 25.20 in. (64 cm) RLA5: 55.12 in. (140 cm)
Maximum Tensile Force	30,000 lbf
Maximum Compressive Force	with fin standoff: 3600 lbf with rigid centralizers: 7800 lbf



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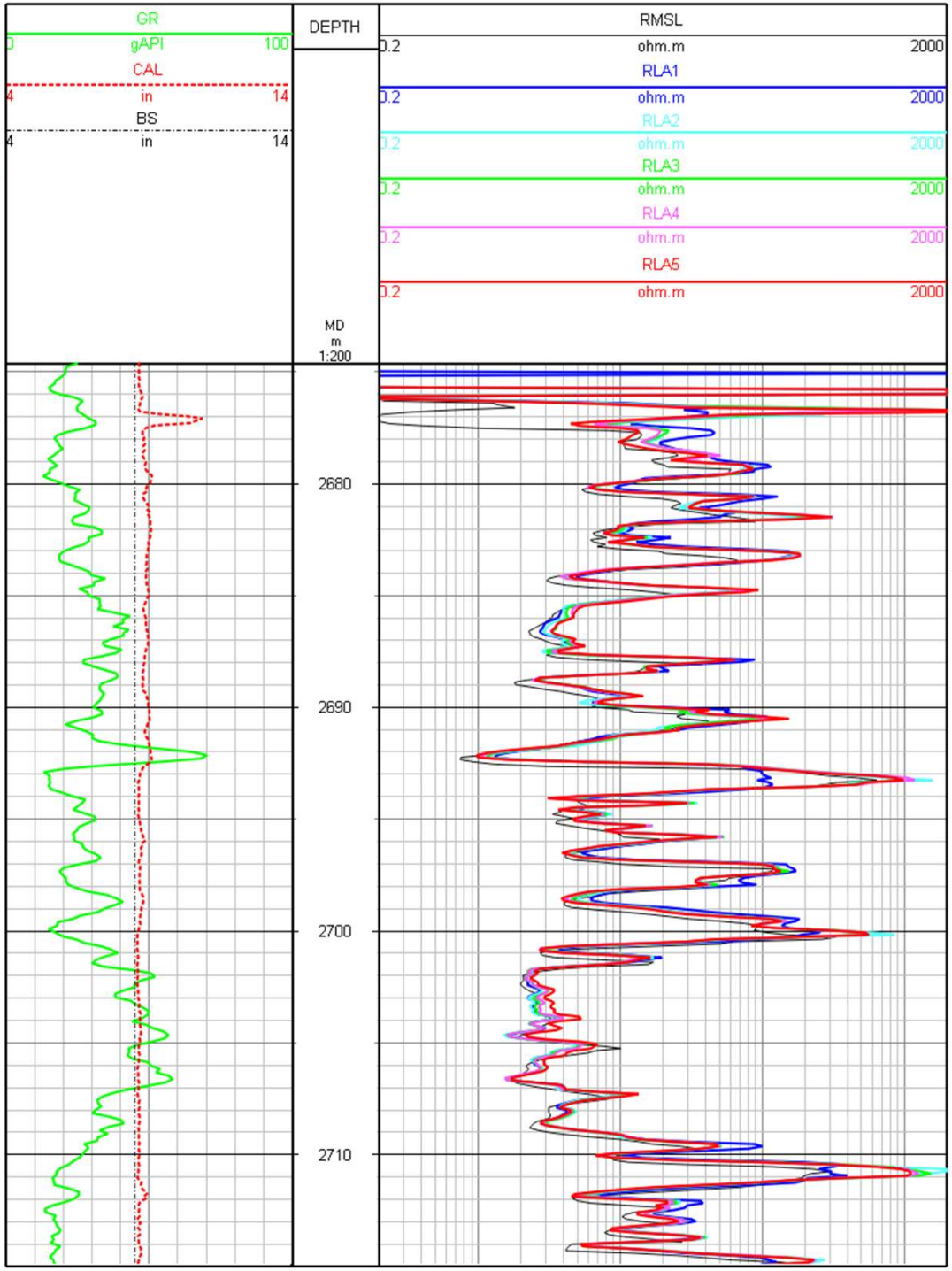
Logging Data

Five resistivity measurements, each with increasing depth of investigation, give a clear indication of invasion Additionally, MSF can be combined in the tool string to get a RMSL curve.

Arrays are actively focused using both software and hardware, reducing shoulder-bed sensitivity and enhancing thin-bed definition.



Telemetry/Spectrolog Tool-Hostile Longtime (TST-HL)

Introduction

TST-HL is thermostatic regulation tool, it is fully competent of work continuously and stably for 36 hours under the harsh environment of 400°F(204°C), in high temperature environment, TST-HL needs continuous supply power to achieve the effect of cooling. TST-HL acquires data and communicates between downhole tools and surface system. It transmits downhole temperature/tension/ mud resistivity data to surface system at the same time. It also measures natural gamma-ray and digital spectralog.

Specifications

Max Temperature	400°F(204°C) ＞36 hours
Max Pressure	25,000 psi (172.4 MPa)
Tool Diameter	3.75 in. (95.2 mm)
Minimum Hole Diameter	4.50 in. (114.5 mm)
Make-up Length	10 ft.-4.96 in. (3.174 m)
Shipping Length	11 ft.-9.44 in. (3.592 m)
Weight	132.3 lbs. (60 kg)
Maximum Logging Speed	30 ft./mim (9 m/min)
Maximum Tensile Force	78,000 lbs (35,381 kg)
Maximum Compressive Force	78,000 lbs (35,381 kg)
Gamma Ray Accuracy	±3% of measured value
Gamma Ray Energy Range	0.06 to 3.5 MeV
Spectralog Measuring Range	0.04 to 3.5 MeV

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PI Data Acquisition System (PIDAS)

PI Data Acquisition System (PIDAS) is designed for data acquisition and processing in combination with Open-hole and Cased Hole tool. This PIDAS is based on portable notebook as a host and remote transmission system with high-speed data communication.

Software is based on WindowsOS with multi-task & multi-user, and using a large number of modern image processing technology.

By equipment array, imaging and large information, real-time logging data acquisition, control and processing achieve multi-parameter acquisition and multi-task time-sharing processing.