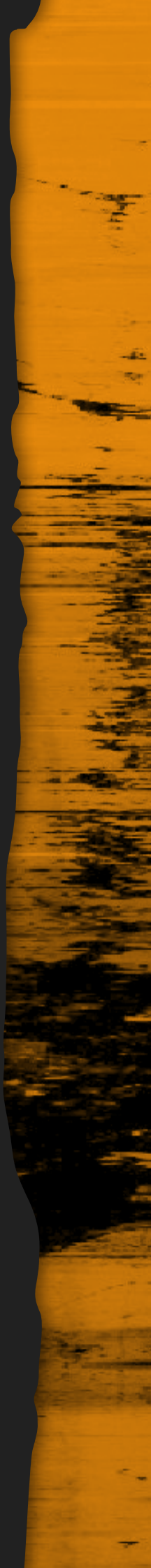
Borehole imaging

Solutions



Advanced Logic Technology

Our Company

Since the company's foundation in 1993, Advanced Logic Technology has grown to become a globally recognised leader in developing borehole logging **instruments, data acquisition & processing software.**

With more than 20 years of experience, ALT has built a solid reputation for the design and production of state of the art imaging tools.

Our data processing software WellCAD provides a framework for the daily work of thousands of people dealing with borehole data. WellCAD handles the entire data loading, log editing, analysis and presentation workflow.

Our instruments and software are used for

- **Mining & Mineral exploration**
- **Oil & Gas**
- **Geotechnical projects**
- **Groundwater applications**
- **Geothermal energy**

Our Technology

The Acoustic Borehole Imager records a 360° unwrapped 3D image of the borehole wall. The tool emits an ultrasonic beam towards the formation and records the amplitude and the travel time of the reflected signal. The amplitude record is representative of the impedance contrast between the rocks and the fluid. The travel time is used to determine accurate borehole diameter data which makes the tool ideal for borehole deformation description, stress field analysis and casing inspection. Sophisticated algorithms and real time processes are also implemented to extend the possible tool applications to casing thickness measurement, corrosion evaluation and measurement behind a PVC casing.

The Optical Borehole Imager produces a continuous, sharp, true color, 360° unwrapped digital image of the borehole wall in dry and water filled boreholes.

Both technologies use a built in high precision orientation package incorporating a 3-axis fluxgate magnetometer and 3 accelerometers for the orientation of the images to a global reference and determination of the borehole's azimuth and inclination.
All tools are fully digital and can operate on standard wirelines.
They can be combined with other logging tools in the QL product line to build tool strings or operated as standalone tools.

Acoustic Borehole Imager (ABI™)

*QL40 ABI / **ABI40 GR

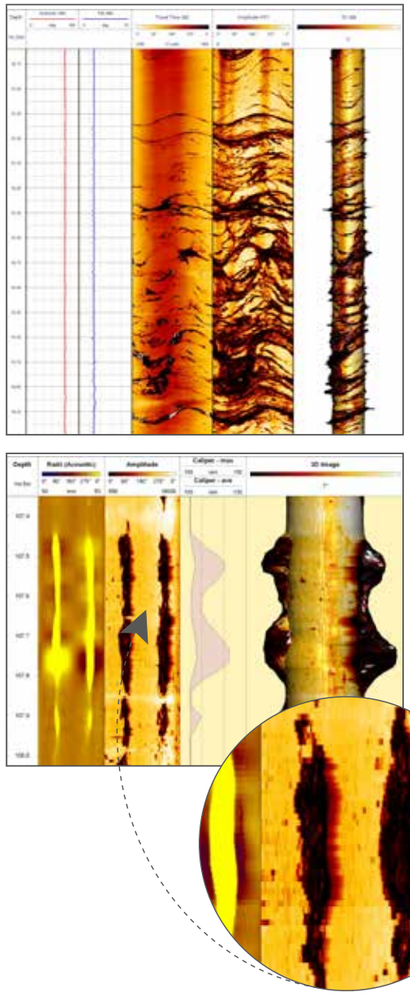
Technical specifications

Diameter	40 mm (1.6”)
Length (min/max)	1.61*/2.12 m** (63/83”)
Weight (min/max)	6.7*/8.7 kgs** (14.7/19.2 lbs)
Max temp	70°C (158°F)
Max pressure	200 bar (2900 PSI)
Acoustic sensor	Fixed transducer and rotating focusing mirror
Focusing	Collimated acoustic beam
Frequency	1.2 MHz
Rotation speed	Up to 35 revolutions per second - automatic
Caliper resolution	0.08mm (0.003”)
Deviation sensor	APS544-3 axis magnetometer - 3 axis accelerometer
Natural gamma sensor	Integrated (ABI40.GR) or in line sub (QL40.GR - QL40.GR CCL)
Sensor	0.875” x 3” NaI (Ti) scintillation crystal

Operating conditions

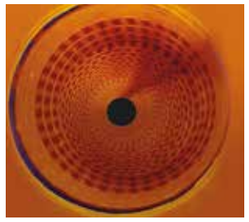
Cable type	Mono, multi-conductor, coax
Compatibility	ALTIogger / Bbox / Matrix
Digital data transmission	
Telemetry	Variable baudrate telemetry according to cable length/type
Logging speed	Variable - function of image resolution, borehole diameter, wireline and acquisition system model. e.g. 8m/min in 7” diameter borehole with 144 azimuthal resolution - 4mm vertical sampling rate @ 250kbps baud rate.
Centralisation	Required
Borehole fluid	Water, water based mud, brine, oil (oil based mud not applicable)
Measurement range	Open hole: up to 24” - depending on mud conditions Cased hole: 5” to 23” - minimum thickness 5 mm

*QL40 ABI / **ABI40 GR



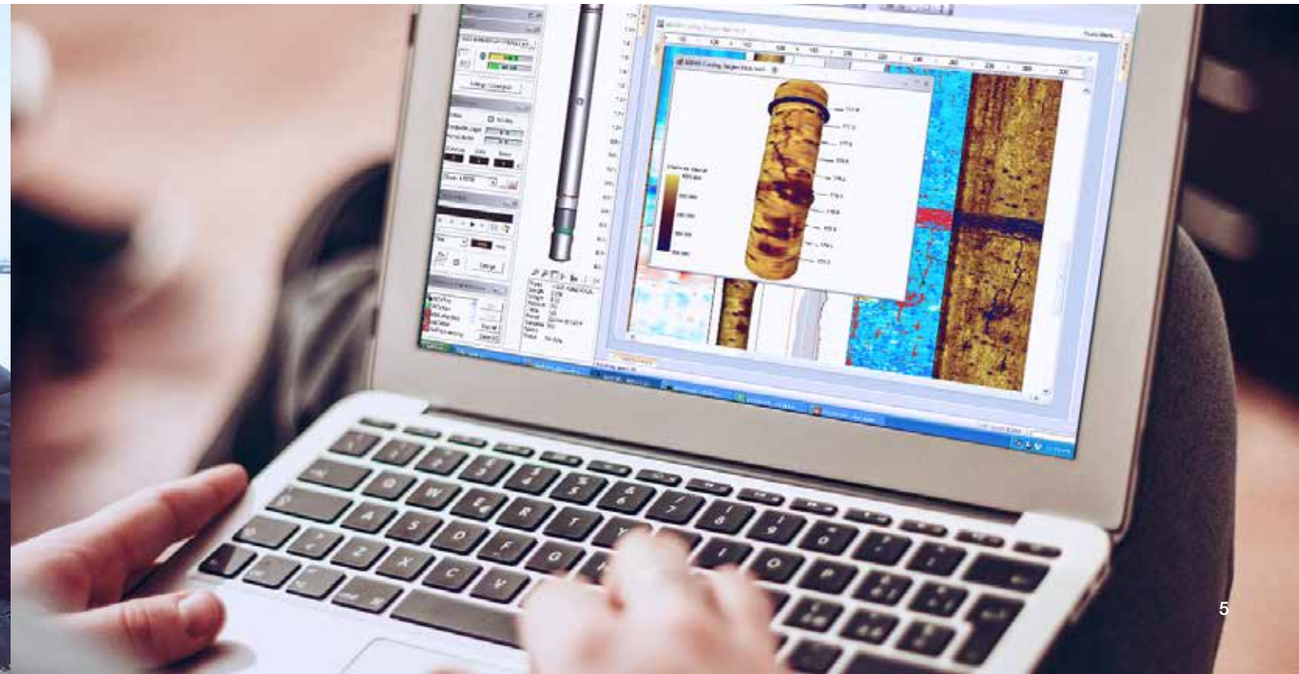
Open hole

- Detailed and oriented caliper and structural information
- Borehole deformation (stress field analysis)
- Fracture detection and evaluation
- Breakout analysis
- Detection of thin beds
- Determination of bedding dip
- Lithology characterization (detection of thin beds, determination of bedding dip)
- Rock strength



Cased hole

- Casing inspection
- Inside & outside diameter
- Casing thickness & corrosion rate
- Scale & hole detection
- Casing wear & deformation
- Metal loss indicators



Optical Borehole Imager (OBI™)

*QL40 OBI / **OBI40 GR

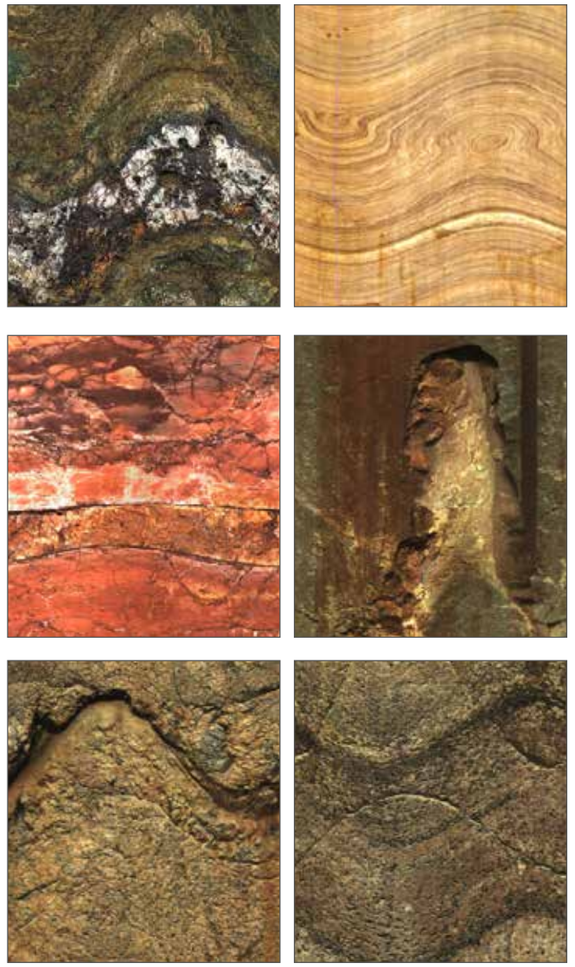
Technical specifications

Diameter	40 mm (1.6”)
Length (min/max)	1.5*/1.7 m** (57,9/67”)
Weight (min/max)	5.5*/6.5 kgs** (11,7/14,3 lbs)
Max temp	70°C (158°F) NEW
Max pressure	200 bar (2900 PSI)
Optical sensor	1/3” high sensitivity CMOS digital image sensor
Color resolution	24 bits RGB true colors
Responsivity	5.48V/lux-sec
Light source	High efficiency LEDs
Azimuthal resolutions	120, 180, 360, 600, 900, 1800 points
Vertical resolution	User defined. Function of depth encoder vertical resolution
Deviation sensor	APS544-3 axis magnetometer - 3 axis accelerometer
Natural gamma sensor	Integrated (OBI40.GR) or in line sub (QL40.GR - QL40.GR CCL)
Sensor	0.875” x 3” NaI (Ti) scintillation crystal

Operating conditions

Cable type	Mono, multi-conductor, coax
Compatibility	ALTIogger / Bbox / Matrix
Digital data transmission	
Telemetry	Variable baudrate telemetry according to cable length/type
Logging speed	Function of image resolution and wireline electrical properties e.g: 6 m/min with 900 pixels azimuthal resolution, 2 mm vertical sampling rate @ 100 Kbps
Centralisation	Required
Borehole fluid	Dry, clear water filled
Measurement range	Up to 21”

*QL40 OBI / **OBI40 GR

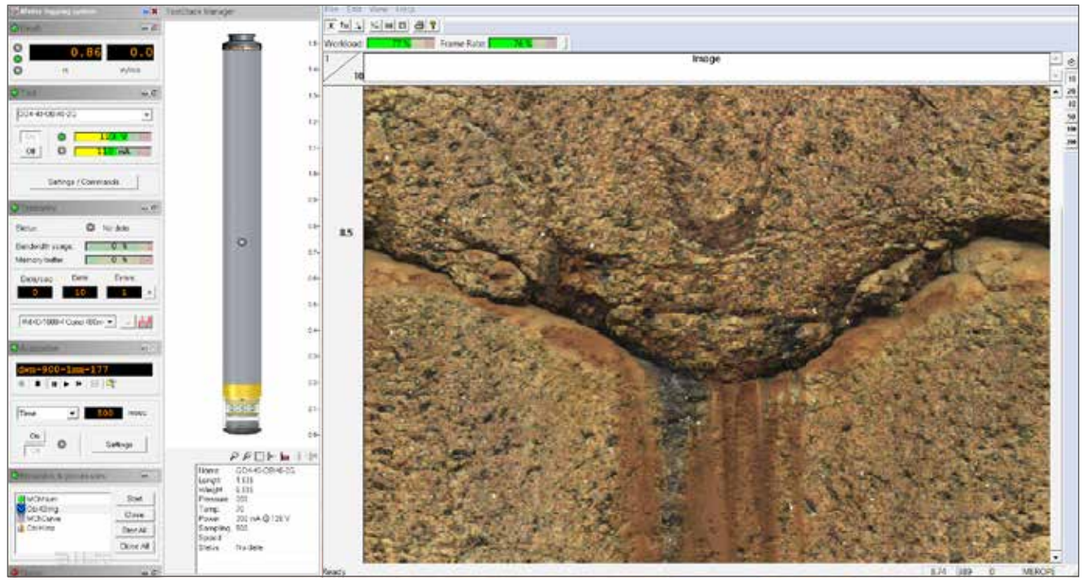


Open hole

- Detailed and oriented structural information
- Reference for core orientation
- Fracture detection and evaluation
- Breakout analysis
- Detection of thin beds
- Determination of bedding dip
- Lithology and mineralogy characterization
- Rock strength

Cased hole

- Casing inspection



Slimhole, High Temperature Acoustic Borehole Imager

QL43 ABI

Technical specifications

Diameter	43mm ($1^{11}/_{16}$")
Length	1.77 m (70")
Weight	10kgs
Max temp	Open hole 125°C (257°F) Cased hole 170°C (338°F) **(in development)**
Max pressure	700 bar (10160 PSI)

Field exchangeable acoustic head*

Acoustic sensor	Fixed transducer and rotating focusing mirror
Focusing	Collimated acoustic beam
Frequency	1.2 MHz - 0.5 MHz
Caliper resolution	0.08mm (0.003")
Deviation sensor	3 axis accelerometer (170°C) APS544-3 axis magnetometer - 3 axis accelerometer (125°C)

Operating conditions

Cable type	Mono, multi-conductor, coax
Compatibility	ALTIogger / Bbox
Digital data transmission	
Telemetry	Variable baudrate telemetry according to cable length/type e.g : 7500 m (24600 ft) – 5/16" mono - 62 Kbps 1800 m (5900ft) – 1/8" mono – 222 Kbps
Logging speed	Variable function of resolution, wireline and surface system
Centralisation	Required
Borehole fluid	Water, water based mud, brine, oil (oil based mud not applicable)
Measurement range	Open hole: up to 21" - depending on mud conditions Cased hole: $2^{7}/_{8}$" to 15" (see below)

Field exchangeable acoustic head

OPEN HOLE & CORROSION
QL43 ABI HEAD OHCO-L

5½" x 15"
depending on borehole conditions with a minimum of 5 mm thickness

CORROSION SMALL PIPE DIAMETER
QL43 ABI HEAD CO-S

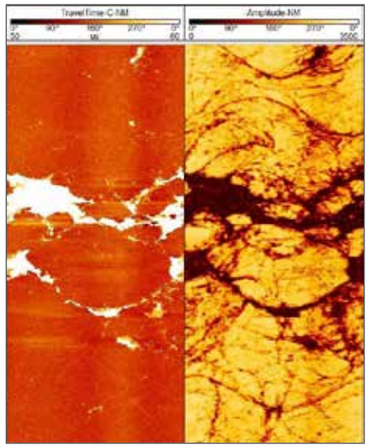
$2^{7}/_{8}$" x 5½"
depending on borehole conditions with a minimum of 3 mm thickness

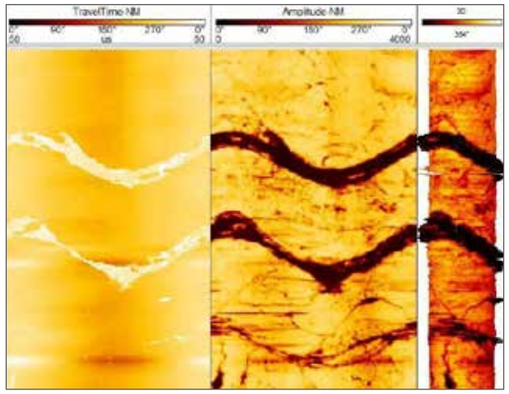
CEMENT (in development)
QL43 ABI HEAD CE-L

5½" x 15"

CEMENT SMALL PIPE DIAMETER (in development)
QL43 ABI HEAD CE-S

$2^{7}/_{8}$" x 5½"





Open hole

- Detailed and oriented caliper and structural information
- Borehole deformation (stress field analysis)
- Fracture detection and evaluation
- Breakout analysis
- Detection of thin beds
- Determination of bedding dip
- Lithology characterization (detection of thin beds, determination of bedding dip)
- Rock strength

Perforation position & aperture

Internal/external casing surface imager

Internal casing diameter

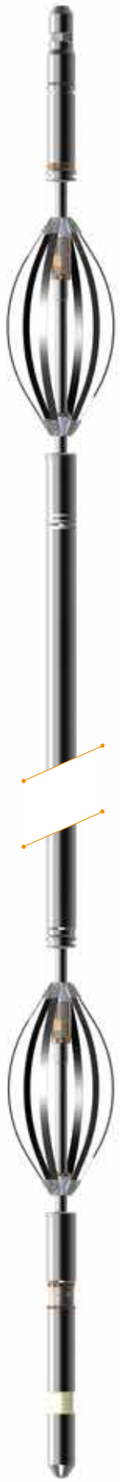
External casing diameter

Casing inspection

- Inside & outside diameter
- Casing thickness & corrosion rate
- Scale & hole detection
- Casing defects
- Casing wear & deformation
- Metal loss indicators

Cement evaluation (in development)

- Cement location
- Cement channeling



High Temperature Acoustic Borehole Imager

QL85 ABI

Technical specifications

Diameter	85 mm (3⅜”)
Length	
with “inline” centralisers	5.2 m (205”)
without “inline” centralisers	3.7 m (145”)
Weight	150 kgs
Operational temp & pressure	See figure 1
Acoustic sensor	Fixed transducer and rotating focusing mirror
Focusing	Collimated acoustic beam
Frequency	1.2 MHz
Caliper resolution	0.08mm (0.003”)
Deviation sensor	APS544-3 axis magnetometer - 3 axis accelerometer

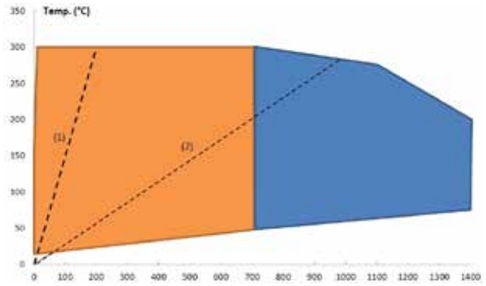
Operating conditions

Cable type	Multi conductor
Compatibility	ALTIogger / Bbox
Digital data transmission	
Telemetry	Variable baudrate telemetry according to cable length/type
Centralisation	Required
Borehole fluid	Water, water based mud, brine, oil (oil based mud not applicable)

Options

Centralisers	In-line 85 mm & 92 mm (OD versions)
Pressure housing	92 mm (OD version)
Fluid excluder (figure 2)	7.5” (OD version)

figure 2



(1) Geothermal gradient - hot spot

(2) Geothermal gradient - common

Pressure (bar)

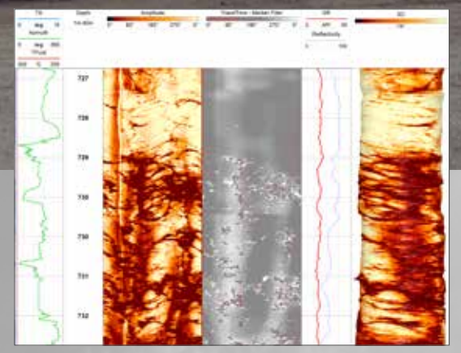
Applicable for QL85-ABI with 85mm and 92mm pressure housing

Applicable for QL85-ABI with 92mm pressure housing only

figure 1

Open hole

- Detailed and oriented caliper and structural information
- Borehole deformation (stress field analysis)
- Fracture detection and evaluation
- Breakout analysis
- Detection of thin beds
- Determination of bedding dip
- Lithology characterization (detection of thin beds, determination of bedding dip)
- Rock strength



Since the delivery of the first 2 systems to Sandia National Laboratories in 2005, the ABI85 has been deployed successfully in several geothermal fields including Iceland, New Zealand, Australia & Japan.

Publications

C.Massiot, D.D. McNamara,B.Lewis (2014) Processing and analysis of high temperature geothermal acoustic borehole image logs in the Taupo Volcanic Zone, New Zealand (Geothermics 53, 2015)

Wallis, McNamara, Rowland & Massiot (2012) « The Nature of Fracture Permeablity in the Basement Greywacke at Kawerau Geothermal Field, New Zealand, Proceedings 37th Workshop on Geothermal Reservoir Engineering, Stanford University, January 30- February 1, 2012

Davatzes, N.C. and Hickman, S.H. (2010), “The Feedback Between Stress, Faulting, and Fluid Flow: Lessons from the Coso Geothermal Field, CA, USA”,Proceedings World Geothermal Congress 2010, Bali, Indonesia.

WellCAD™

Advanced software toolbox for borehole image analysis

Data import

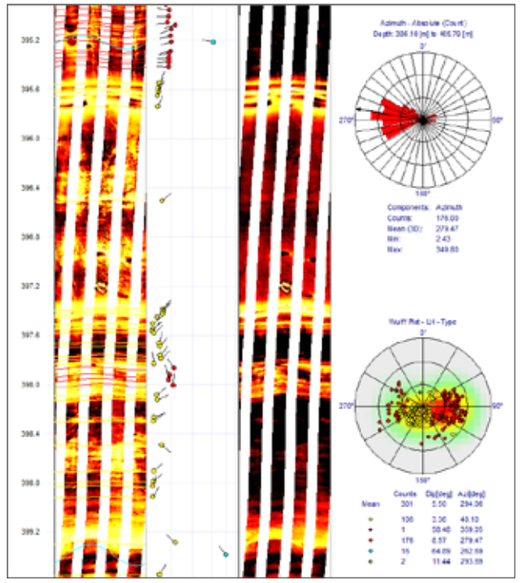
Borehole image data from a variety of tools including acoustic televiewer, optical televiewer, corescanned images, FMI, FMS, CAST, CBIL, UBI, STAR and Sondex MIT are supported.

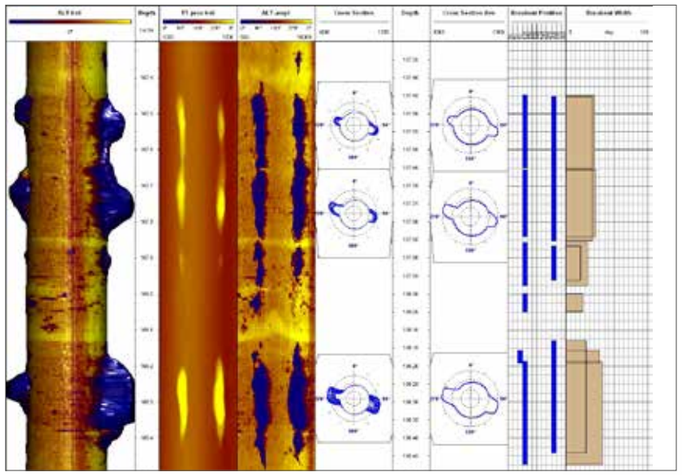
Data processing

Before any form of analysis is performed, the data needs to be processed. This involves the creation of a reliable high quality image from raw tool measurements.
A number of processing options are available for enhancing the quality of the data.

These include :

- Bad trace interpolation
- Image normalization
- Despiking filters
- Centralize image
- Adjust brightness and contrast (for RGB logs)

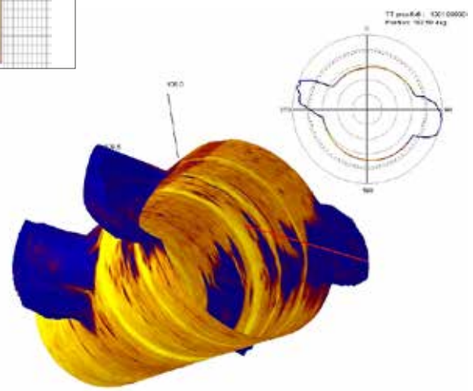




Acoustic televiewer breakout measurement

Data presentation

Data can be displayed as an image (user definable image color palette), as curves (shifted or stacked curves) or as 3D cylinder display (virtual core).
Data can be visualized as 3D images using 3D borehole view (ideal to visualize breakouts, well deformation, pipe corrosion).
Data can be oriented to North or Highside, or rotated by a user defined input (magnetic North to true North correction).



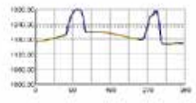
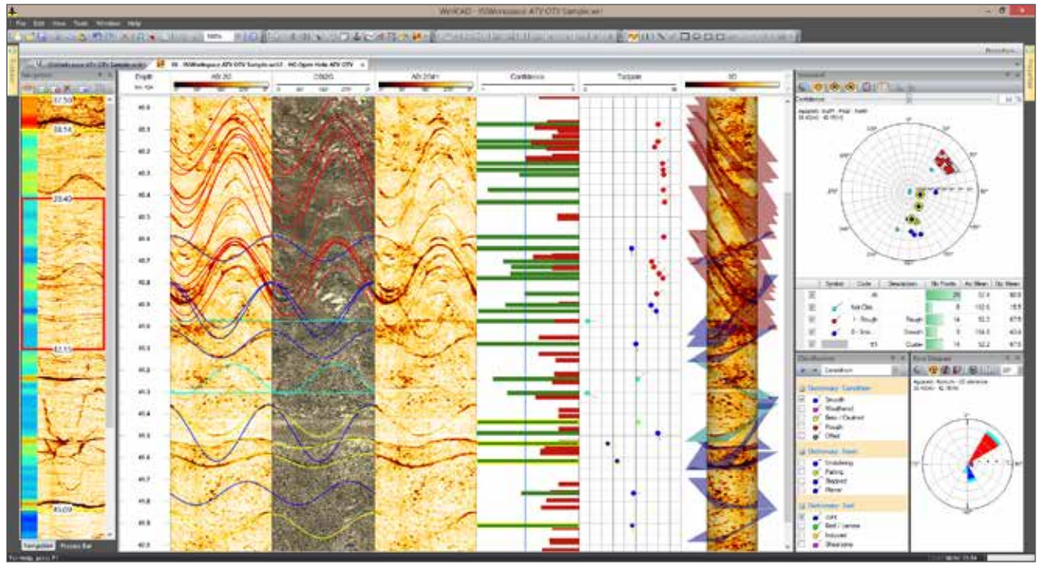
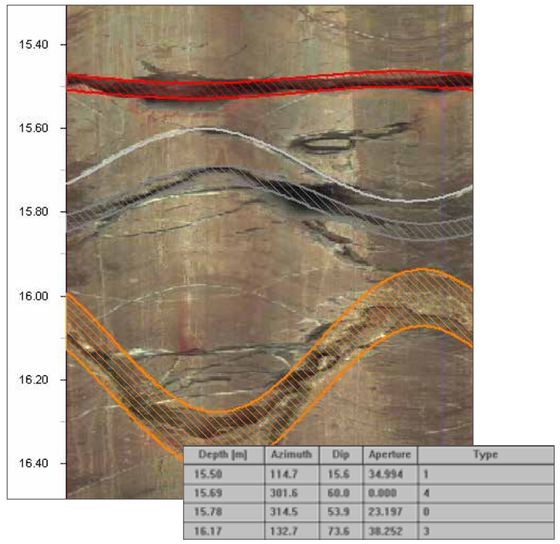


Image & Structure Interpretation (ISI) workspace NEW

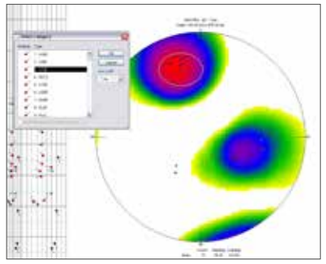


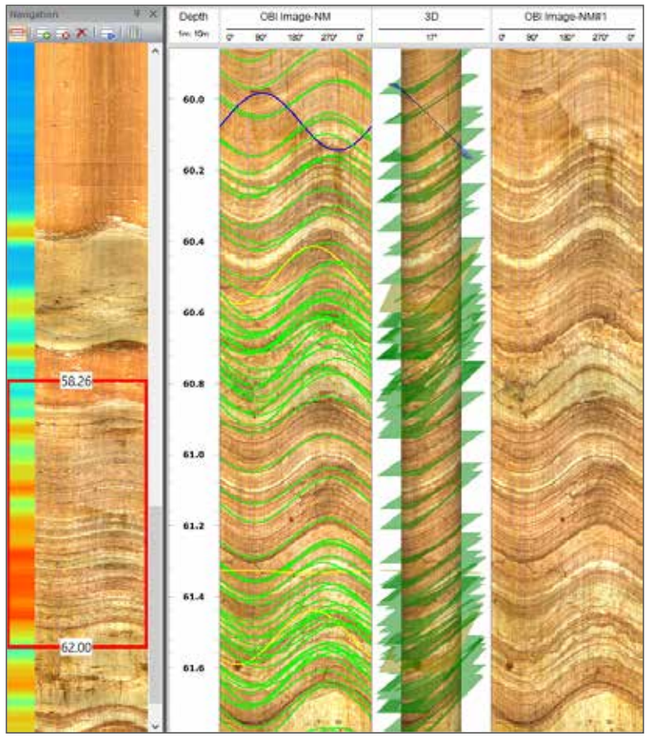
Data interpretation



Any number of planar features can be interactively picked recording azimuth, dip values and aperture. Each pick can be qualified into user definable categories (ToadCAD). Picks can be displayed as sinusoid, tadpole or stick plot.
Picking of linear features (e.g. breakouts, tensile fractures) is also possible.

Fully interactive structure interpretation including dips workspace with polar, rose and vector plots. The module includes specific processes such as, caliper calculation from traveltime images, extraction of curves indicating rock strength and reflectivity from images.



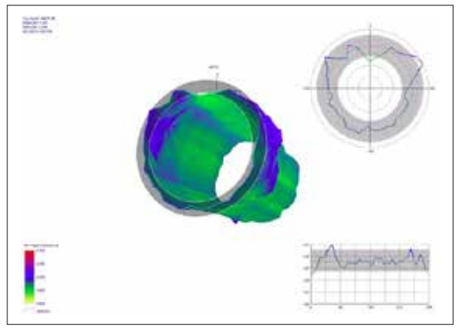


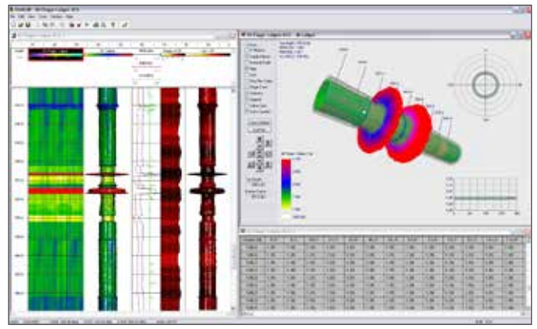
The new Image & Structure Interpretation (ISI) workspace combines manual and automated structure picking tools, sophisticated data visualization and a logical workflow into a powerful, built for purpose processing and interpretation platform.

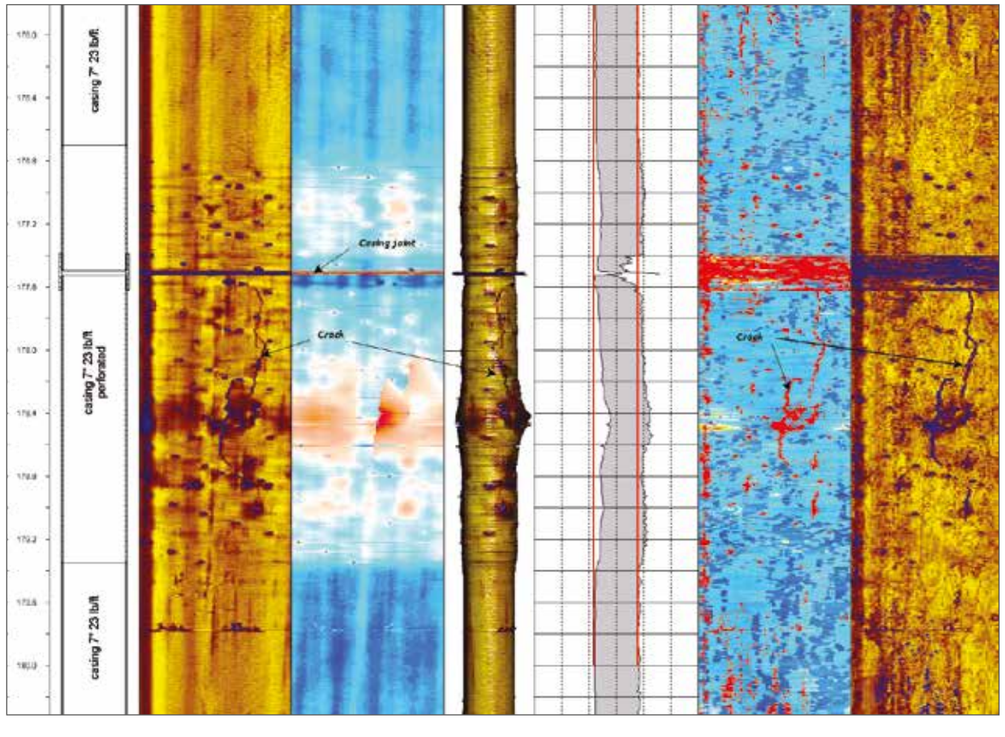
- A navigation bar allows structuring the workload by zonation based on a structure complexity map and image data overview.
- Simultaneous picking of planar, linear and free hand features on multiple images is supported.
- The geologist controls the manual, semi-automatic and auto picks.
- Picking results are tagged with a confidence value and structural planes are displayed superimposed on to a virtual 3D core improving the data quality control.
- Real time conversion from apparent to true picks.
- Interactive stereonet algorithms to find similar or most representative picks enhance the interpreters control of the data and optimise the picking results.

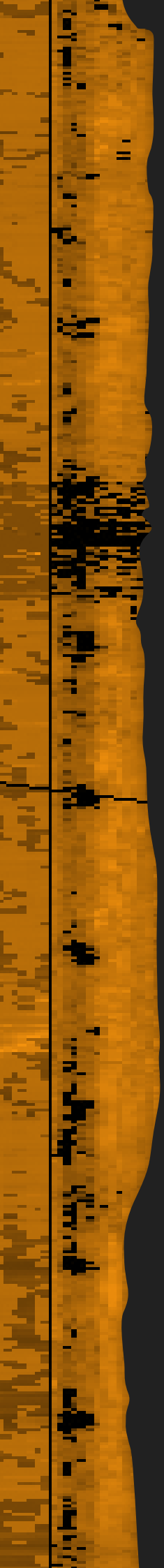
Corrosion evaluation

Mapping distribution, configuration, orientation and severity of corrosion through the entire borehole. WellCAD 3D data virtual borehole reality can help to identify internal deposits, localized pipe deformity or pipe buckling.
The software includes specific processes such as metal loss calculation for multi-arm calliper.









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