ENERSON
GEOPHYSICAL EXPLORATIONS COMPANY

WIRELINE SERVICES
ENERSON

ENERSON WIRELINE SERVICES

Presentation

GEOPHYSICAL WIRE-LINE LOGGING SERVICES

Enerson Wireline Services utilizes state of the well logging technology & methods for exploration and assessment of various minerals, coal assessment works Coal Bed Methane, Radioactive minerals, Hydrological studies, Water well installation, Litho-logical Studies & other services.

Enerson has the Geophysical Loggers with latest digital data acquisition system & undertake the logging with different tools like Cement Bond, Density-Caliper, Neutron, Gamma-ray, Resistivity, Full Wave Sonic, Spectral Gamma Ray, Deviation, Flow-meter, Acoustic Tele-viewer, Optic Tele-viewer & Magnetic Susceptibility tools in open hole & cased hole by industrially well experienced logging engineers.

We firmly believe that Geophysical Logging services play a major role in assessment & planning of mineral resources and hence ensure the clients' benefits with services rendered. Our précised open hole logging services also include advanced interpretation and magnificent presentation of the acquired data from the field.

In fleet of Enerson, there are 5 numbers of Logging Unit. All of them are equipped with electrically driven winch. Our systems are exclusively designed to meet expectation of clients from minerals and coal industry.

Enerson has two types of Digital Data Acquisition Systems with multiple combinations which are from MountSopris Instruments, USA and Century Geophysical Corp., USA. Data acquired from both types of the system are interpreted with the extremely versatile software WellCAD and are presented in the desirable industrial format by the clients.

Our calibrated and borehole compensated measurements are designed by physicists and engineers for application in all mineral fields from coal through base and precious metals to unconventional hydrocarbons such as CBM and tight shale gas. The physics and equipment characterization underlying each measurement is generally regarded as the best available to mineral explorers.

In addition to our low rates, our clients appreciate our straight forward all inclusive billing with no hidden charges or additional costs for additional hours moving between holes etc. Our clients are able to set their well logging budget in stone and know exactly what their expenses will be.

Enerson Offers Following Borehole Logging Suit

Enerson Wireline Services offer a comprehensive range of borehole logging technology to the mineral exploration practitioner. Services include, but are not limited to:

Borehole Parameters

- Dummy Sonde (borehole depth, safety and fluid level)
- Single, Dual or Three Armed Caliper (calibrated diameter)
- Four Arm Caliper (orientated borehole geometry)
- Sonic 360 Degree Orientated Caliper (from televiewer)
- Magnetic Borehole Verticality
- Continuous Gyroscopic Borehole Navigation
- Cement Bond Log and Casing Collar Locator / Gamma Ray

Fluid Parameters

- Fluid Temperature and Differential Temperature
- Fluid Conductivity and Differential Conductivity
- Impeller Flowmeter (spinner)

Seismic Parameters

- Three Channel Full Waveform Sonic (P, S and Stoneley waves)
- Dual Compensated Density (for acoustic impedance)

Lithological Parameters

- Total Natural Gamma Ray (calibrated in UPPM, API or KCl)
- Spectral Gamma Ray (K, U and Th)
- Dual Ultra-Slim Density / Natural Gamma Ray (calibrated)
- Dual Compensated Sidewall Density / Gamma Ray / Caliper
- Dual Compensated Neutron Porosity / Gamma Ray
- Multi-Channel Compensated Sonic Porosity
- Dual Focussed Resistivity / SP / Gamma Ray
- Dual Inductive Conductivity (wet and dry hole or thru-PVC)
- Induced Polarisation (normal and electrode decay time)
- Magnetic Susceptibility (calibrated and borehole compensated)

Structural and Geotechnical Parameters

- Ultra High Resolution Optical Televiewer / Navigation
- High Resolution Acoustic Televiewer / Gamma Ray / Navigation
- Multi-Channel Compensated P-Wave Sonic
- Three Channel Full Waveform Sonic (P, S and Stoneley waves)
- Dual Compensated Density (for acoustic impedance)
- Uniaxial Compressive Intact Rock Strength
- Dynamic Moduli of Elasticity
- Fracture Frequency, RQD
- Fluid Ingress Depths (aligned with ATV Image)
- Rock Mass Rating (based on Laubscher)

BOREHOLE LOGGING ANALYSIS

Unfortunately, borehole logging is not an exact science. Measurements from different contractors (and different loggers on different days) vary in quality. If we recognize that the logging sonde is a machine and (given the benefits of modern engineering) that sondes of a particular design should behave in a similar manner, our first goal is **precision.**

Once precision is achieved, by proper calibration and verification procedures, we can nudge the measurements, where necessary, to achieve an acceptable level of **accuracy**.
In a typical coal logging operation, where density is usually the key measurement, it is prudent to enforce a rigorous calibration and verification procedure from the outset. This involves base calibration, site verification and the monthly logging of a test well, which represents the ultimate assurance of **log quality**.

Experience and knowledge are needed to ensure that borehole data are both accurate and repeatable. It is critical to ensure that logging speeds and system setups are appropriate for any given borehole tool. Lack of experience or care can lead to misleading interpretations, skewed resource calculations or worse. Enerson has the experience and expertise needed to ensure that boreholes are logged to an extremely high standard of care.

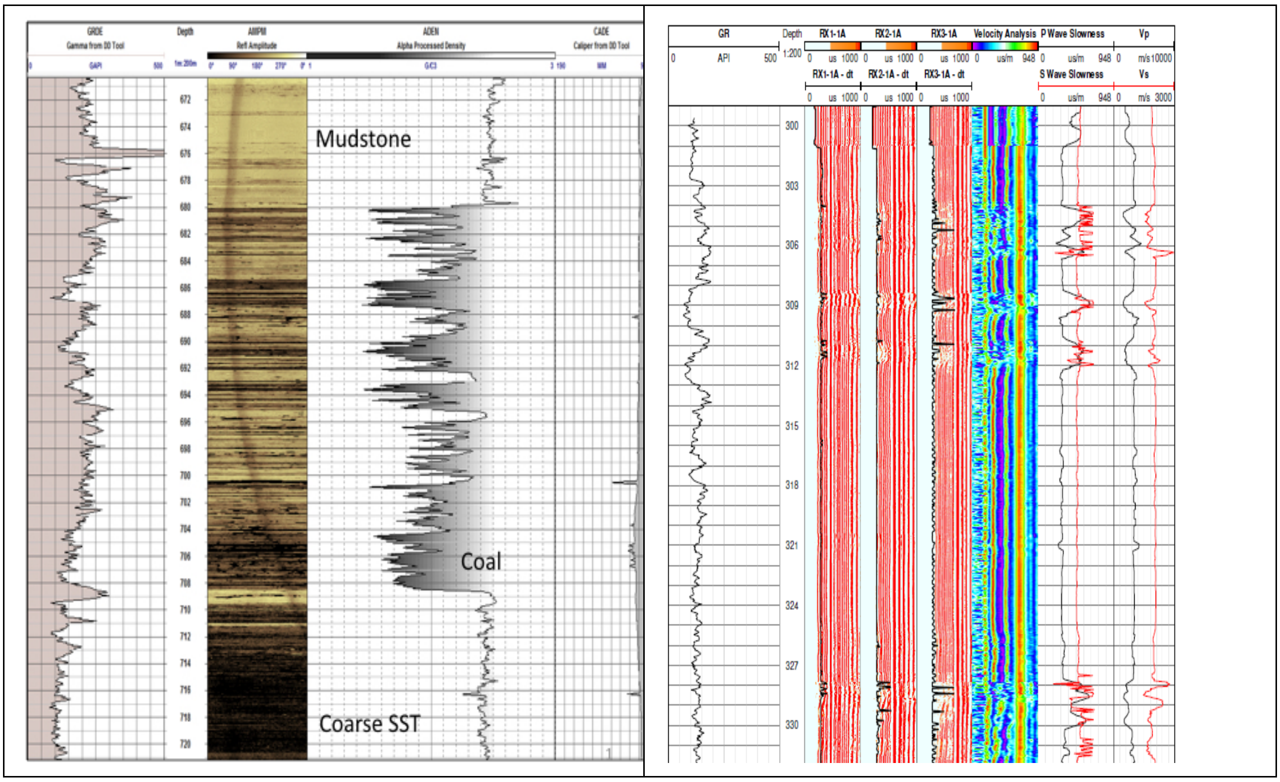


Fig-1: Borehole Full Wave Sonic & Density Logging

BOREHOLE LOGGING IN METALLIFEROUS MINES FOR ORE BODY DELINEATION AND ROCK MASS CHARACTERIZATION

The principal applications of borehole logging in minerals mines are:

1. geological interpretation (hole-to-hole correlation);
2. ore boundary definition;
3. grade estimation;
4. geotechnical characterization of the rock mass.

Magnetic susceptibility is a well-known measure of iron grade in magnetite ore bodies and natural gamma activity is an effective indicator of uranium grade. Conductivity correlates closely with grade for some base metal sulphide deposits, Spectral gamma-gamma and neutron activation are also of potential value for grade estimation.

Fullwave Sonic and density logging are by no means the only geophysical options for rock mass characterization.

Good structural logging is an invaluable tool in the prediction and definition of ore bodies. Generally, acoustic and optical imaging is crucial for structural logging. Because, structural data collection from drill core relies on the ability of the core to be accurately oriented. A number of methods are available for core orientation, but broken zones and core loss present difficulties in obtaining orientation data, which can result in a paucity of structural data for significant intervals of a drill hole.

ORE BOUNDARY DEFINITION AND GRADE ESTIMATION USING BOREHOLE LOGS

For geological interpretation and ore boundary definition, qualitative interpretation of logs is often adequate. If, however, borehole logs are to be used as a basis for quantitative modelling, be it for ore reserve determination or geomechanical analysis, petrophysical calibration of probe responses is a prerequisite.

Defining the limits of mineralisation to high accuracy is the most common application of borehole logging in mines. Ore boundaries can be defined within centimetres down-hole with geophysical logging, but the achievable 3-D positional accuracy, hence the geometrical validity of any model, will be governed by the exactitude of the logging depths and the quality of the borehole trajectory data.

For some ore types there is a close correlation between petrophysical properties and grade. For example; magnetic susceptibility is a well-known measure of iron grade in magnetite ore bodies and natural gamma activity is an effective indicator of uranium grade. Conductivity correlates closely with grade for some base metal sulphide deposits, e.g. Enonkoski nickel deposit in Finland. Spectral gamma-gamma and neutron activation are also of potential value for grade estimation.

For virtually all gold deposits and many base metal deposits, the abundance of the target commodity and/or the petrophysical contrast of its host mineral is insufficient to permit grade estimation by direct detection. However, in some cases a strong mineralogical association exists between ore and a mineral which is readily detectable. In some Witwatersrand Basin mines, for example, a correlation between uranium content and gold grade permits prediction of gold grades using natural gamma in logging or face scanning modes. In other cases grade estimates are based on multiple parameters, e.g. copper grade at an oxide deposit in Arizona is estimated from a linear combination of density (gamma-gamma), natural gamma, and neutron activation log values.

In order to define the correlation between petrophysics and grade, a control study must be undertaken. Since petrophysical data is normally recorded at intervals of a few centimeters, it is necessary to derive a petrophysical value representative of the coarser (1–2 m) geochemical sampling interval, a process termed upscaling in the petroleum. Simple averaging will not always be appropriate, e.g. if the petrophysical parameter is related non-linearly to grade.

if the petrophysical parameter is related non-linearly to grade. If rules relating petrophyiscal responses to grade can be codified, automatic grade estimation is achievable using a variety of techniques, including multivariate statistics and neural networks. The assumption underlying automated interpretation is that the relationships between petrophysics and grade established in control holes are valid for other holes some distance away. Often it will be necessary to invoke different control data sets in different sections of a mine.

ROCK MASS CHARACTERISATION

The strength and integrity of the rock mass is fundamentally important in mine design and blasting optimization. Geophysics is poised to enhance mine economics and safety by providing the input data for more detailed and complete geomechanical models on which to base crucial mine design decisions.

Sonic logging is the premier geophysical tool for rock mass characterization, since seismic velocity and attenuation are sensitive to rock stress, strength, degree of fracturing, porosity, and the nature of the material occupying the voids. Sonic velocity can be related to mechanical parameters such as hardness and uniaxial compressive strength (UCS). Seismic attenuation is more pronounced in fractured rock, especially at high frequencies, as witnessed by the variations in full waveform sonic spectra with changing fracture frequency.

Sonic logging has distinct advantages over testing individual core samples insofar as it provides a continuous record of rock character in situ. At the very least, sonic logs can be used to optimize core sample selection for testing and hence calibration. Ideally, the sample suite should fully and evenly span the strength range for each rock type. Properly calibrated, sonic velocity data can provide rock strength information in weak zones, which are not amenable to core testing due to core fragmentation and loss. Thus sonic logging offers a means for overcoming sample selection bias which is difficult to avoid in conventional core testing.

Full waveform sonic logs allow determination of the shear wave velocity,Vs , in addition to the usual compressional velocity, Vp. Alternatively, the shear wave velocity can sometimes be estimated from the compressional velocity and the density of the rock. The dynamic elastic moduli and Poisson's ratio can be calculated from Vp, Vs, and density.

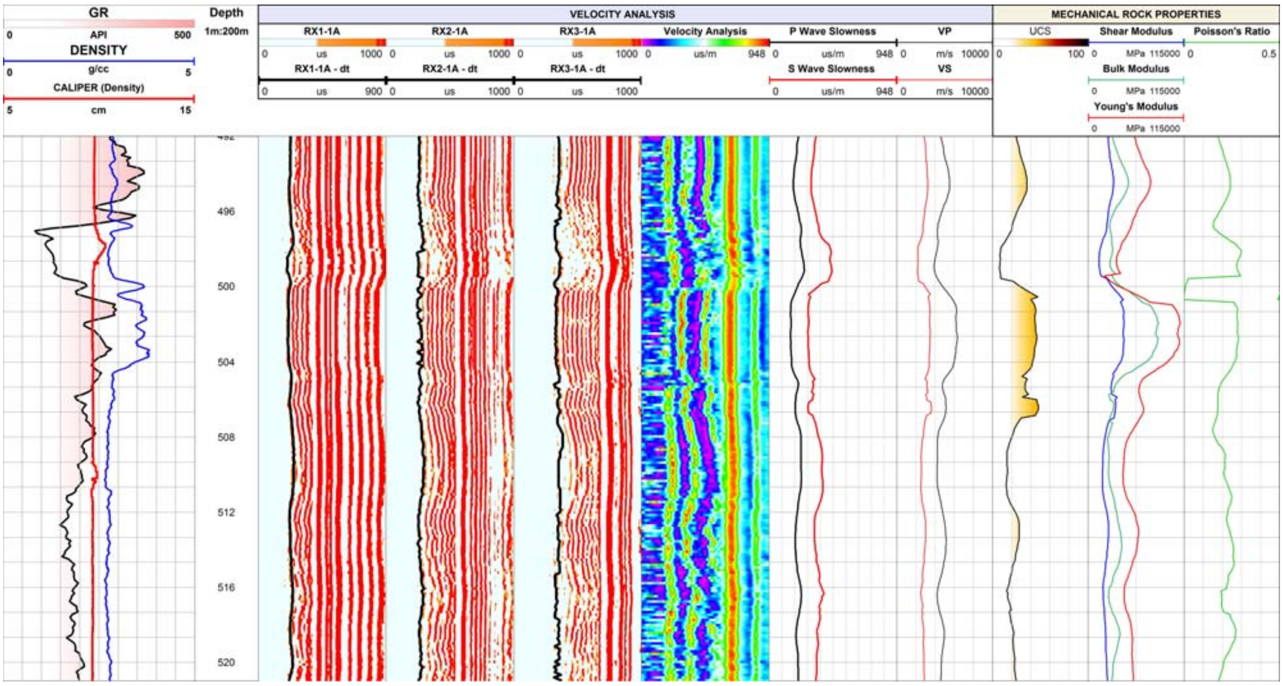


Fig-2: Full Wave Sonic & Density Log Sample (Pakistan -Iron ore Exploration and Resource Estimation Project)

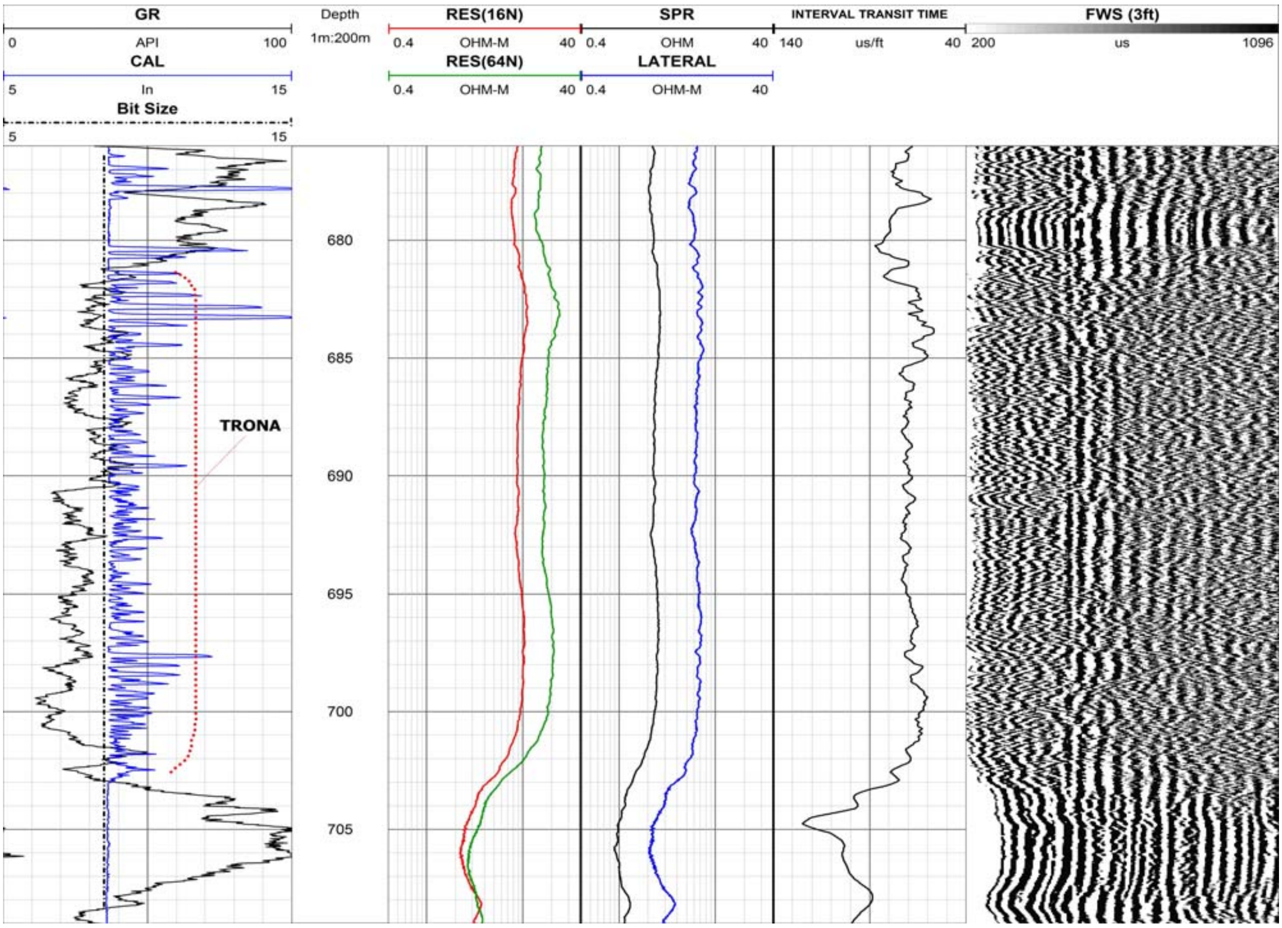


Fig-3: Dual Lateral log & Full Wave Sonic Log Sample (Turkiye-Kazan Soda Elektrik Üretim)

BOREHOLE IMAGING TECHNOLOGY

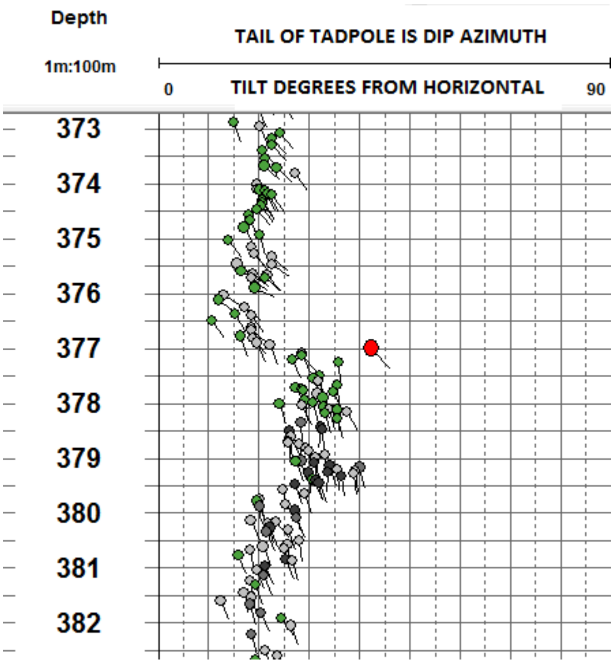
In recent years, the advent of borehole imagery and the ability of computers to manage and process the much larger data sets involved, have revolutionized the mineral wireline logging industry.

A continuous, orientated, high resolution representation of the borehole wall offers many advantages to the geologist. The data provide knowledge about geology, structure, fractures and stress orientation. Most of this knowledge might be gained by analysis of orientated drill-core but that option has proved to be time consuming, imprecise and costly.

In this age of information technology, objective and precise data, captured in-situ, is transferred directly from borehole to computer where it can be stored, processed, analyzed and disseminated, literally at the touch of a button. This is good for density, gamma ray and resistivity measurements. It is fantastic for borehole imagery, which uses all the functionality and capacity of a modern computer. It brings the formation to the geologist's desk.

Most logging technology, in both mineral and oilfield exploration, targets sedimentary formations and there has always been a need to measure dip and direction of strata.

Twenty years ago, the resistivity Dipmeter was the answer...the correlation of three or four high resolution resistance logs whose depth and position on the borehole wall was known. The result was a tadpole plot, a braille-like representation of bedding dip orientation. In mineral logging, the advent of borehole televiewers has made dipmeter logging a rare and specialized event but the tadpole plot, as a means of displaying derived structures, has endured.

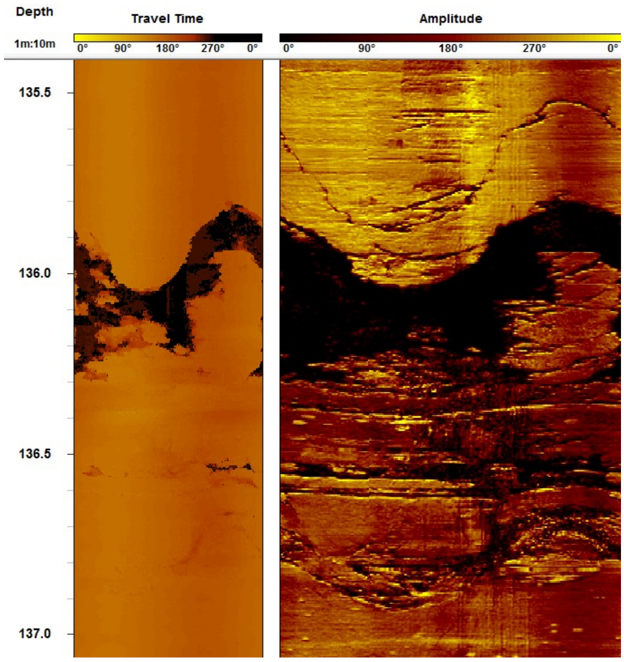


A Tadpole Plot

The Acoustic Televiewer logs the borehole wall in terms of hardness, measuring the amplitude of a high frequency reflected sonic pulse at very high resolution. It describes the borehole skin rather than the formation beyond. Hard rocks reflect high amplitude signals and soft rocks and fractures reflect low ones. The individual measurements of reflected amplitude are made continuously (send-receive cycles last a few hundred microseconds) by a rotating transducer or, more often in slim tools, a rotating sonic mirror aligned with a stationary transducer. The result is a map of the borehole wall with an individual resolution of about 2 millimetres in ideal conditions.

The images on the right show what the log looks like. The borehole wall is unwrapped with the left edge of the resulting image aligned with magnetic north. Fractures and bedding planes appear as sinusoidal lines where the deepest point on the line is the direction of dip.

Reflection travel times (left image) for each cycle are measured and mapped in the same way as the reflected amplitudes (right image), resulting in a complete description of borehole cross-section. Tool centralization is important to ensure similar travel time and signal strength in all directions. Resolution is reduced in large boreholes and/or drilling mud where signal dispersal is a problem.



An acoustic televiewer log

The images on the right show what the log looks like. The borehole wall is unwrapped with the left edge of the resulting image aligned with magnetic north. Fractures and bedding planes appear as sinusoidal lines where the deepest point on the line is the direction of dip.

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Because the acoustic televiewer is sensitive to rock hardness and can measure fracture orientations and apertures (lost in drill-core), it has become an important geotechnical tool in both sedimentary and hard-rock environments.

A limitation of acoustic tools is that they only function in fluid-filled holes. If data required from dry boreholes, the Optical Televiewer should be employed. It measures the color and shade of reflected light. The borehole wall is lit by a ring of light emitting diodes (LEDs) on the tool and reflections are directed to a light- sensitive sensor via a conical mirror. Resolution is very high, with pixel sizes down to well below 1 millimeter at HQ borehole diameter.

The optical televiewer provides an orientated photograph of the borehole wall at high resolution and without perspective...like virtual drill-core. It is an excellent geological tool. The system does not offer a travel time image and log quality is dependent on clean borehole fluid if it is run below the water table. In slim holes, optical televiewer images can be of such high quality and value that it is usually worth cleaning the borehole wall and replacing dirty fluid before logging.

It is sometimes difficult to decide whether to run an acoustic or an optical image. They offer slightly different information where the acoustic tool is an excellent descriptor of rock condition whereas the optical version provides more geological detail. It is not unusual to run both tools in order to maximize knowledge gained.

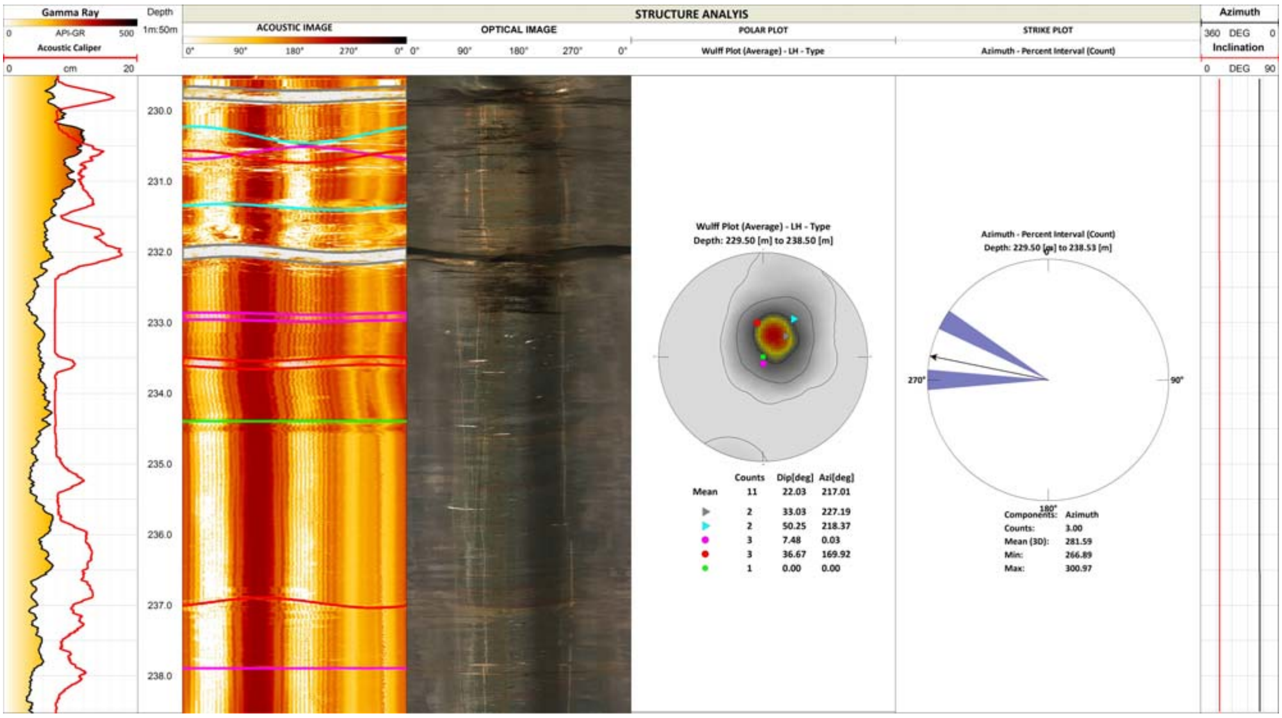


Fig-4: Optical & Acoustic Televiewer Log Sample (Pakistan-Iron Ore Exploration and Resource Estimation Project)

THE OPTICAL TELEVIEWER

It is common in exploration projects for the geologist to photograph the drill core. Sometimes this is an informal picture of a core box where depth markers are clearly visible. It is a prudent record of the rocks intersected by the borehole. Quite often the photography is more thorough, including ultra high resolution images of rotated and orientated core. The resolution is excellent, the orientation is usually uncertain and the cost is relatively high.

The ultra high resolution camera has the advantage that individual mineral grains may be identified on the image. Drill core photography allows control of image quality because core sticks can always be cleaned and wetted. Modern computers can cope with huge file sizes. Orientation and cost remain problematic.

For image orientation, the acoustic televiewer provides some certainty (assuming its log is quality assured). It is an excellent geotechnical tool. A similar device, called the optical televiewer offers the geologist accurate orientation as well as a moderately high resolution image (about 1mm pixel size). Resolution of the optical image is certainly higher than that of the acoustic one and instead of the wiggly lines it shows an orientated optical image of the rock mass. It is an impressive record of formations intersected by a borehole. Unfortunately, unlike the acoustic version, optical image quality depends very much on borehole conditions.

Dirty water and mud-covered borehole walls seriously impact on optical televiewer image quality. Typically, the OTV senses reflected light in red, green and blue (RGB) color scales via a conical mirror housed at the bottom of the sonde. The source of light, which illuminates the borehole wall, is a ring of light-emitting diodes positioned next to the sensor.

There are limitations to the diameter of borehole that can be effectively illuminated. In water, 200mm is usually about the limit. In dry holes, achieved excellent results can be achieved to well over 300mm by attaching battery powered lamps to the tool's centralisers. The latest optical tools have more effective lighting due to advances in LED technology and some will work to 500mm borehole diameter.

Image resolution is better than that achieved by the acoustic televiewer or the micro-scanner. An effective pixel size of better than 0.20mm of borehole wall may be achieved at HQ diameter (depending on system design). A range of image enhancement tools is available. There are advantages and disadvantages when comparing the OTV with the ATV sonde.

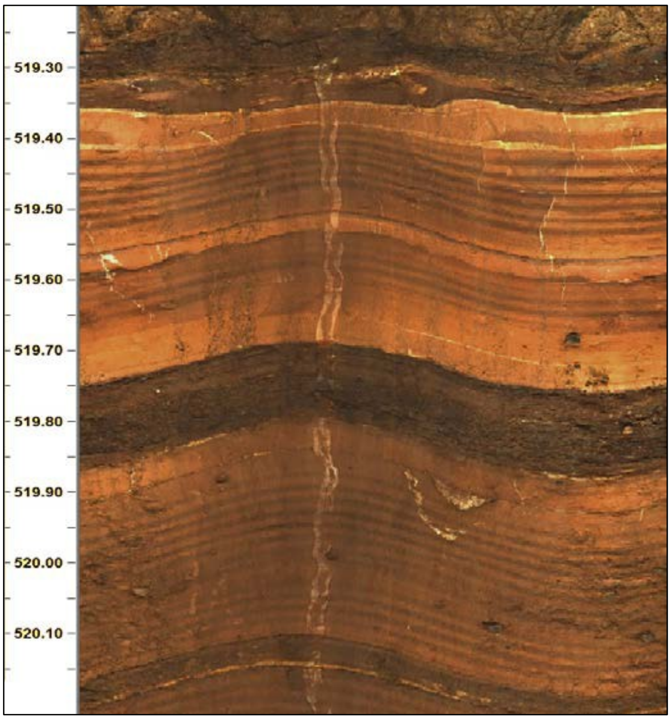
- OTV offers higher resolution than ATV, as discussed above.
- OTV works in dry hole, ATV does not.
- OTV images describe geology more clearly than ATV images.
- Picking and classifying fractures is usually more difficult and time-consuming using the OTV image
- ATV offers a borehole cross section (360 degree caliper) with caving and breakout, OTV does not.
- OTV is adversely affected by opaque fluids and mud cake, ATV is mostly unaffected.

If the OTV image is poor due to fluid conditions in the borehole, it is probably worth trying a water replacement exercise using clean water.

Lighting intensity can usually be adjusted from the surface. This is important as intense light in small diameter bores is not always optimum and some tools overheat if run on maximum power in dry hole conditions.

As with the ATV sonde, a borehole magnetometer- based navigation log is generated from the OTV system. Effective centralization improves log quality.

From the logger's perspective, the optical televiewer log is not proper geophysics; it is a photograph of a rock. It is a geological tool rather than a geophysical one. Nevertheless, the logger is, of course, pleased to capture something of value to the geologist and the processing of the optical image results in wireline data that can be juxtaposed with other logs - resulting in a powerful link between geology and geophysics.



Meta-sediments produce excellent OTV images. In this example the density sonde was run first...see the vertical scoring from its caliper arm.

Exactly as with core stick examination, the OTV image in dry hole is improved by wetting, if that is practical. Optical televiewer log resolution continues to improve and, while not yet equal to the core scanner in that respect, it offers a continuous log with reliable orientation. Clean borehole conditions and effective tool centralization are essential to the capture of high quality data.

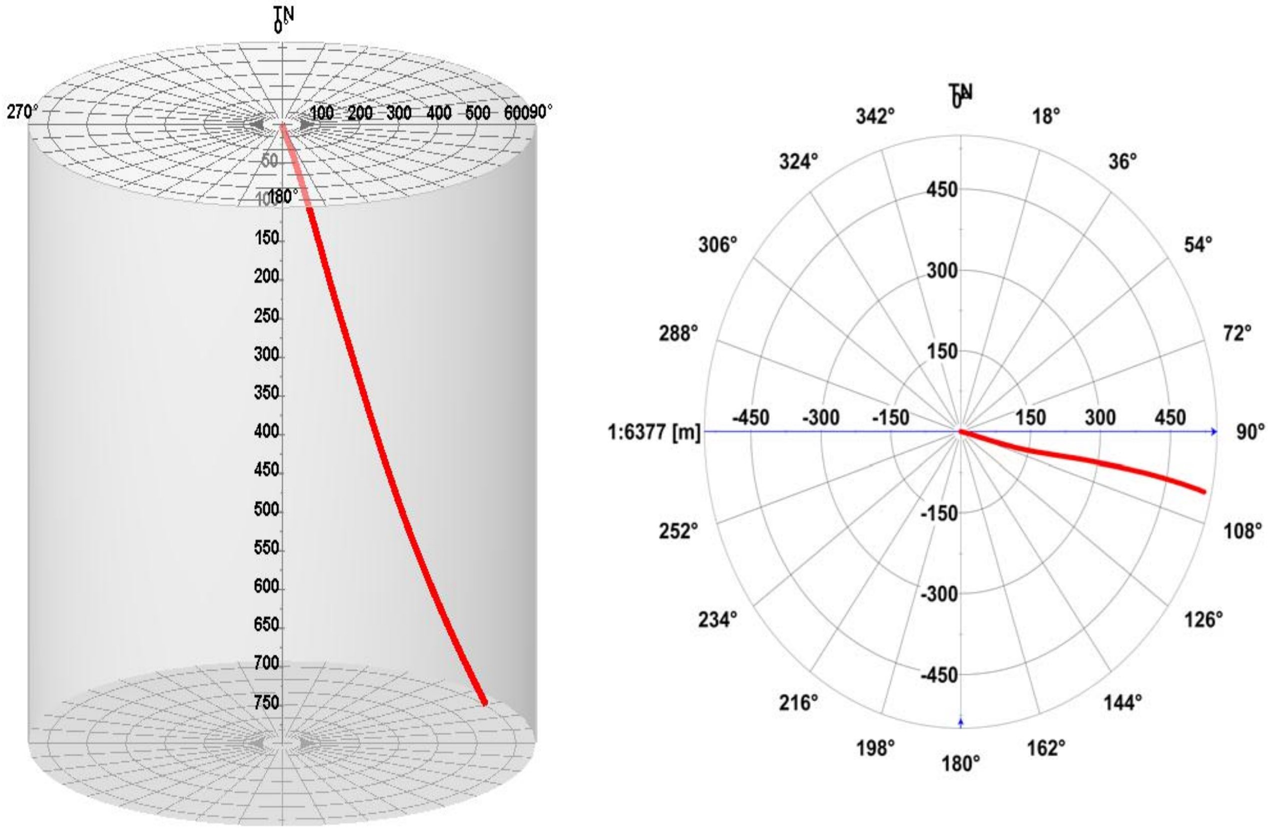


Fig-5: GYRO Deviation Log Sample (Iron ore Exploration and Resource Estimation Project /PAKİSTAN)

ENERSON WIRELINE SERVICES PERFORMING STRUCTURAL LOGGING BY MEANS OF ACOUSTIC AND OPTICAL IMAGING TOGETHER WITH HIGH ACCURACY GYROSCOPIC NAVIGATION SURVEYS FOR MINERAL EXPLORATION INDUSTRY. TELEVIEWER SURVEYS, BOTH OPTICAL AND ACOUSTIC, PROVIDE A RELIABLE AND ACCURATE METHOD OF RECORDING STRUCTURAL DATA, BY CAPTURING A DOWNHOLE IMAGE OF THE INTERNAL DRILL HOLE WALLS, AS WELL AS ORIENTATION DATA.

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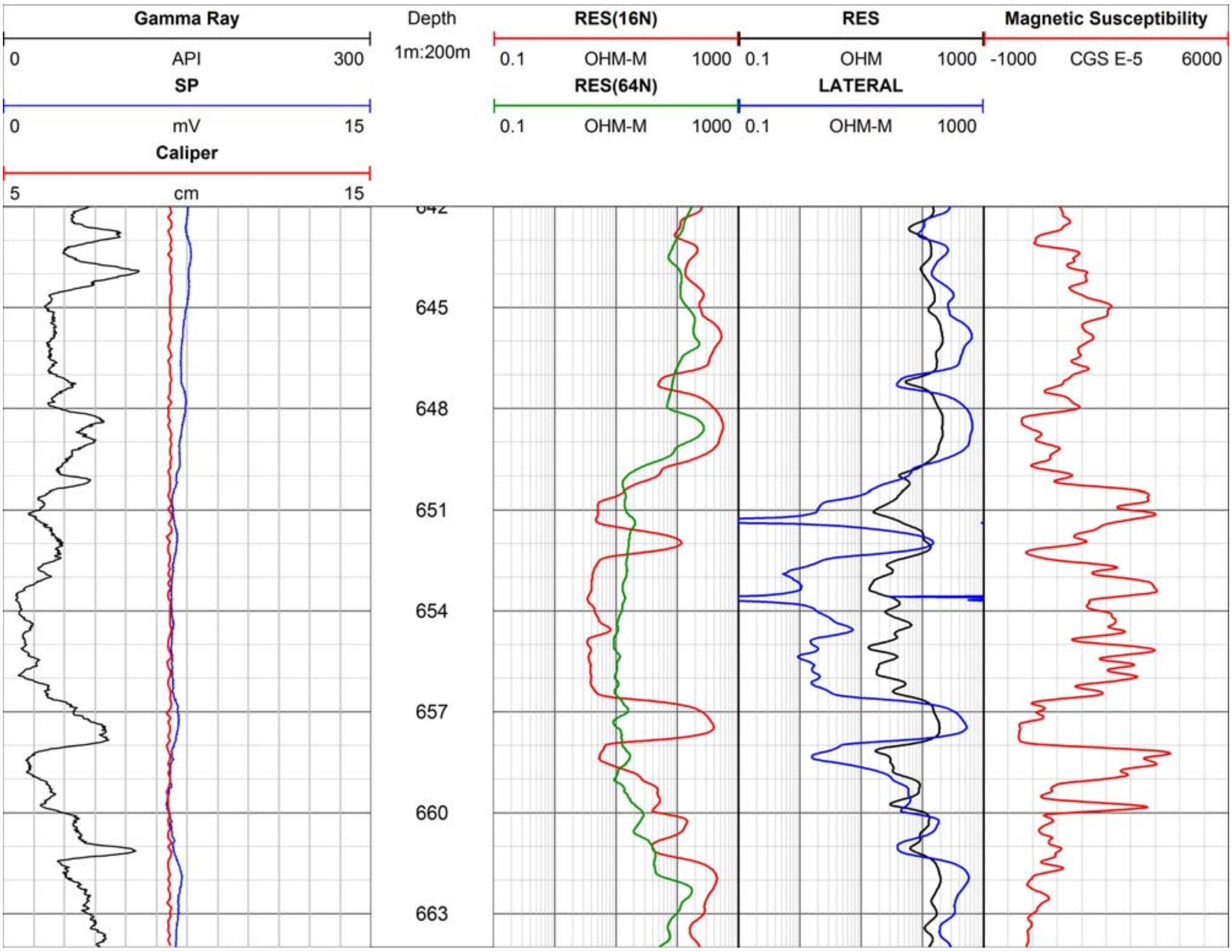

Fig-6: Gamma Ray-SP-DLL-Magnetic Susceptibility Log Sample (Pakistan Iron ore Exploration and Resource Estimation Project)

Common Logging Tools and Summary of Their Uses

TOOL	ITS USE
Natural Gamma	• Can help to define lithology
	• Stratigraphic correlation
	• Assessment of relative sand/silt/clay content
	• Well completion studies
	• Uranium/coal/shale exploration
Magnetic Susceptibility	• Detects magnetic minerals, which can help to define lithology
	• Formation-water salinity mapping
	• Delineation of altered sequences
Conductivity	• Can help to define lithology in sections of wells not cased with metal
	• Stratigraphic correlation
	• Can be used to assess relative sand/silt/clay content
Neutron	• Can help to define lithology
	• Can aid in defining zones of saturated porosity
Gamma-Gamma	• Can help to define lithology
	• Provides estimates of bulk density, moisture content
Caliper	• Provides a record of borehole diameter
	• Helps to delineate fracture zones
	• Delineates areas of borehole collapse
	• Provides correction factors for other borehole tools
Full Waveform Sonic	• Calculation of P and S wave velocities
	• Delineation of zones of saturated porosity
	• Can help to define lithology
	• Estimates of rock strength and elasticity
	• Borehole completing studies: to identify zones of incomplete or inconsistent casing grout
Optical Televiewer	• Provides an oriented digital image of the borehole wall
	• Fracture delineation, measurement and characterization (strike, dip, aperture size, frequency)
	• Structural and geological information
	• Allows for the identification of layering, fabric, foliation
Acoustic Televiewer	• Fracture identification and characterization (strike, dip, aperture size, frequency)
	• Rock Integrity / Hardness
	• Identification of layering/fabric/foliation
Resistivity	• Identification of zones of conductive mineralization
	• Delineation of fracture zones
	• Permeability Profiling
Induced Polarization	• Permeability estimates
	• Results can show the presence of disseminated sulphides
Temperature / Fluid Resistivity	• Identification of zones of variable water quality
	• Identification of zones of variable salinity
	• Fracture delineation
	• Assessment of temperature gradient
	• Temperature log provides valuable correction data for other logs
Impeller Flow Meter	• Delineation of water flow zones

Pictures From Wireline Logging Work on KAZAN SODA Trona Mining Site - TURKEY

Pictures From Wireline Logging Works at KAZAN SODA Trona Mining Site - TURKEY

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Pictures From Wireline Logging Works at PMC Iron Ore Exploration Site -PAKISTAN

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Pictures From Wireline Logging Works at MTA Coal Exploration Site -TURKEY

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Some of Our References

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