



# HOW, WHEN & WHY to Geophysically Log in S.I.?

by  
Kim Beesley

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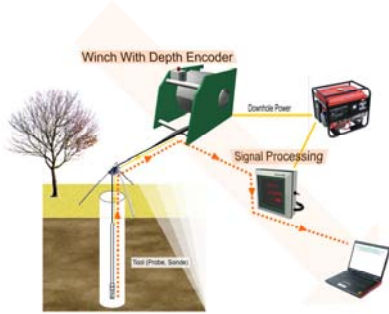
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## HOW



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## HOW

vehicle mounted units  
portable units also available



Access to borehole  
Depth of borehole – sump / rat -hole?

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## HOW ?

- subject to borehole conditions

LOG	fluid filled	unlined	air filled	cased	screen
Caliper	*	*	*	*	*
Natural Gamma	*	*	*	*	*
Resistivity	*	*			
Induction	*	*	*	plastic	plastic
Sonic	*	*			
Density <small>(uses radio-active source)</small>	*	*	qualitative	qualitative	qualitative
Acoustic Imager	*	*			
Optical Imager	*	*	*		
Temp /EC/Flow	*	*			*

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## WHY LOG?

- **Characterise rock in situ** - continuous data unlike sampling
- Identification of lithology, minerals and aquifers
- Determine some engineering properties
- Check borehole integrity for other testing (packers) and installations (piezometers) and aid design
- Obtain sub-surface data that may be unobtainable from surface methods or samples
- Aid to optimising coring or sampling points
- Supplements geologist / drillers' logs & geophysical surveys - providing control data
- Aid to correlation between boreholes

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## When to log

- Before setting permanent casing
- At total depth
- During drilling – *if problems arise*
- Upon final completion  
*- to check construction & integrity*

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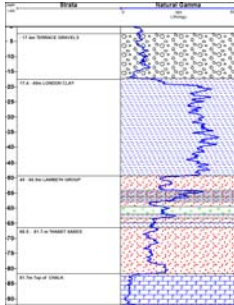
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## Natural Gamma log

clays gravels sands above chalk



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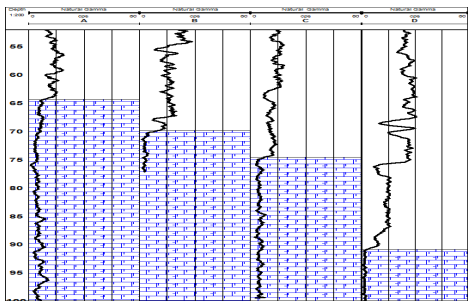
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## Natural Gamma logs

correlation between boreholes  
showing top of the chalk



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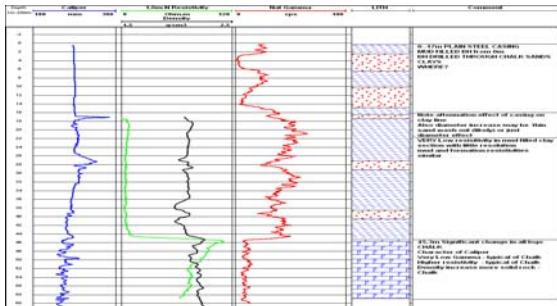
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## FORMATION LOGS



Resistivity function of mineralogy/porosity/pore-water salinity

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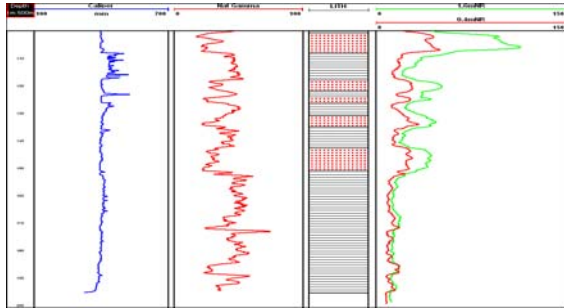
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## Formation Logs mudstones and sandstones



Above logs were used to aid to packer positioning and screen location

**NOTE:** Resistivity function of mineralogy/porosity/pore-water salinity

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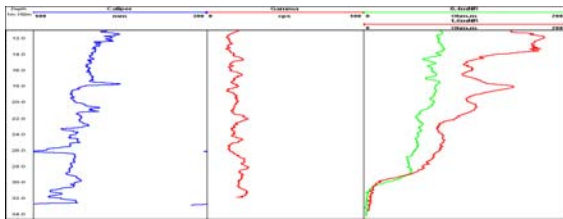
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## SALINE INTRUSION



Resistivity function of mineralogy/porosity/pore-water salinity

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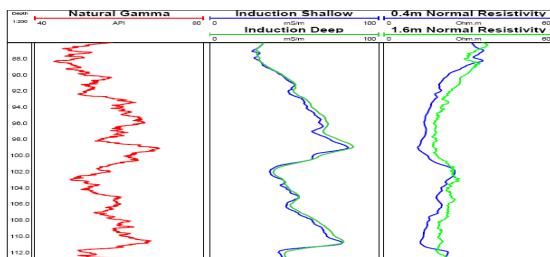
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## INDUCTION

(formation conductivity – 1/resistivity)  
 an application info for earthing mats – corrosion potential



Induction - works thro' plastic

comparisons with Nat.Gamma & Resistivity

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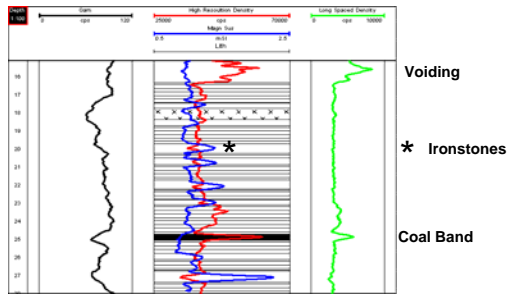
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## Magnetic Susceptibility



Detection of iron stone bands

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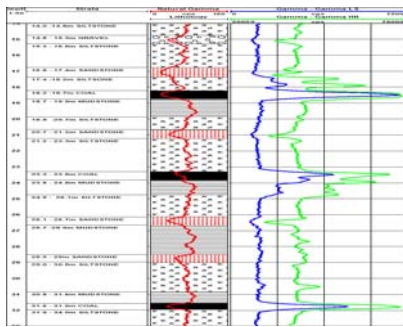
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## Nat Gamma & Gamma - Gamma logs

Coal Measures - logged through steel casing



Note: LSD / HRD in cps

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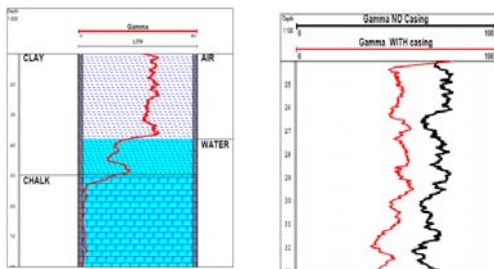
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## Nuclear logs - borehole effects



Difference between air and water (natural gamma)

Attenuating effect of 150mm steel casing on gamma log  
Note statistical variations

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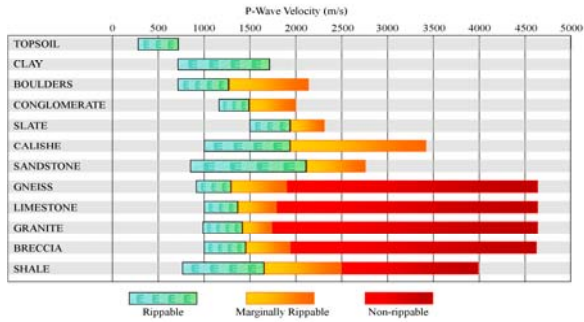
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## Sonic Velocities

Seismic Rippability Chart




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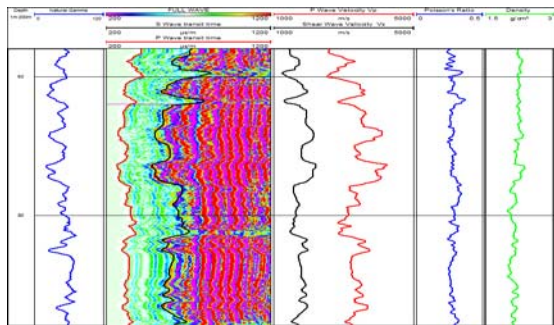
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## P & S Wave from Full Wave Sonic (FWS)



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## Logs to support Cross Hole Surveys

- Verticality
- Density -preferably in uncased BH for Db
- Full wave sonic – control for X shooting
- Full wave sonic – check on coupling through grouted plastic casing to formation

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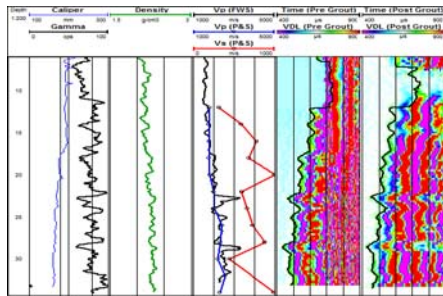
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## Full Wave-Sonic Logging



P(-o-o-) & S(-o-o-) waves in open hole using micro seismic suspended tool

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## BH Conditions for imagers

- Good quality bore – diamond drilled
- Clear / homogeneous BH fluid
- Casing to open hole diameters (+/- 20mm)
- Undisturbed fluid – **do not even dip just before** (allow 0.5-2 days?)
- Minimum sediments in suspension
- Good centralisation – critical for best results

*Note the optical imager not as sensitive to diameters as acoustic*

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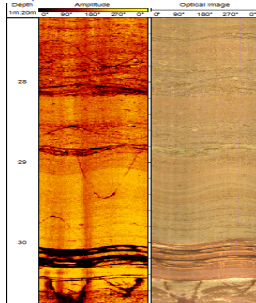
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## ACOUSTIC & OPTICAL IMAGERS

(televiewers / borehole scanners)



Comparison of Acoustic and Optical images  
Some features are seen on the acoustic and not on the optical

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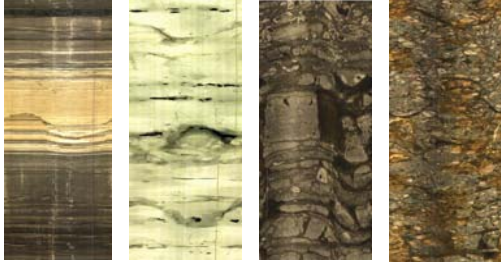
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## OPTICAL IMAGES



Mudstones  
&  
Sandstones

Chalk

Faulted Rock

Conglomerate

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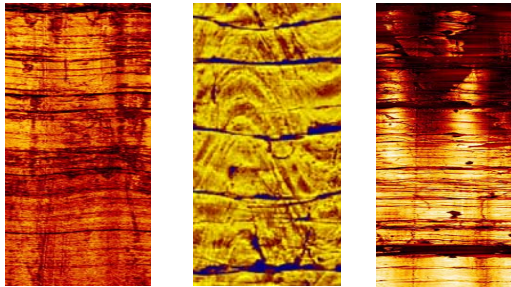
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## ACOUSTIC IMAGES



soft  
Sandstone

hard  
Limestone

through plastic lining  
Sandstone  
subject to formation velocity / hardness

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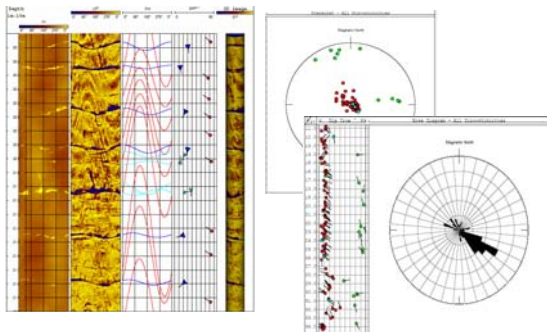
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Interpretation of Imager Data  
including virtual core - aid to core orientation

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## Environmental Investigations



Contaminant ingress



Clean formation

Using an optical imager - same sandstone borehole

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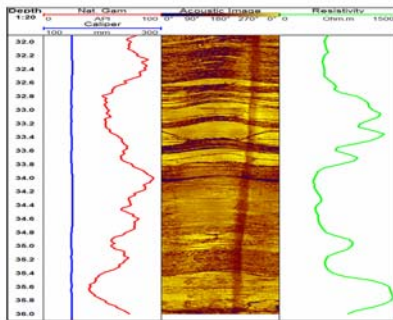
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## DETAILED LOG MUDSTONE / LIMESTONE



What Resolution do you want ?

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## Consequences of not cleaning out the borehole



Optical image of sandstone where lower section has not been sufficiently cleaned out - resulting in a smeared borehole wall

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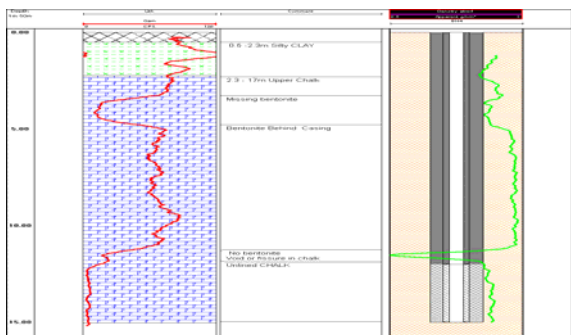
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## Well Construction Check bentonite seal / grout




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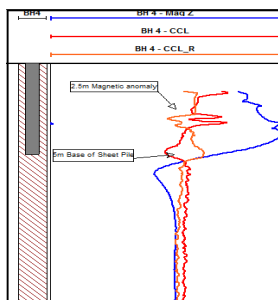
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## SHEET PILE DETECTION



Using magnetics and electro-magnetics

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## Density logging during gravel pack insertion



density increases >>>>>>

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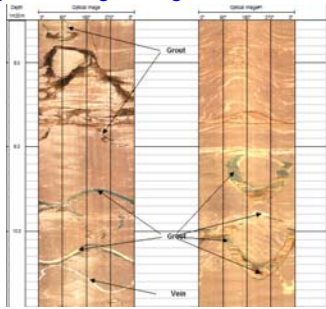
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**cement pressure grouting of fractured formation**



This borehole was drilled 3m away from one used to grout fractures in broken sandstone. The grout is seen as white (1st phase) and grey (2nd phase) fracture filling.

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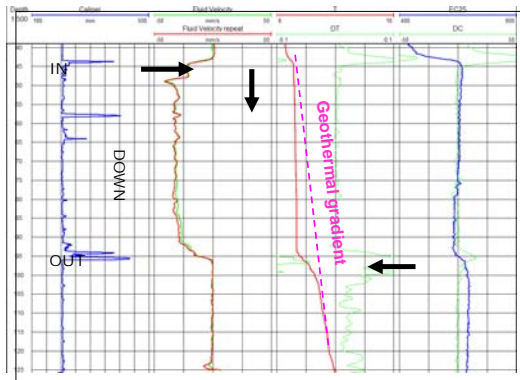
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**Example Fluid Logs showing down-flowing cooler, better quality water**



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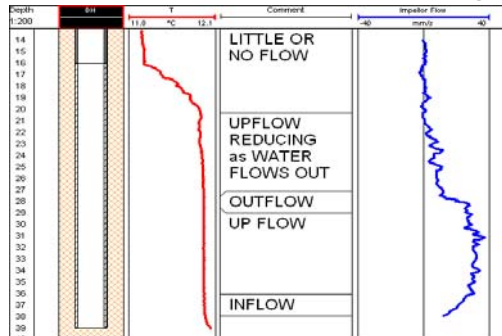
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**Artesian Flow – Mine workings**



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## WHEN: order of Logging

- **Imagers** (before disturbing visibility don't even dip the BH !)
  - **Fluid Logs\*** do not log immediately after air lifting !
  - \* Allow BH fluid to settle, needs to be in equilibrium with groundwater system unless under pumped or recharge conditions
  - **Caliper** for BH diameters ( for packer placement)
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EEEEEEEEEEEEEEEE

VALUE of DATA

V

ALL COSTS

allow for rig /plant standing

consequences of poor data capture?

**Impatience**

not cleaning out the borehole sufficiently  
not waiting for borehole water to clear (imaging)  
and  
and allowing to reach equilibrium with groundwater system  
( certain fluid measurements)

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