Seismic, Well Log and Core Data Integration

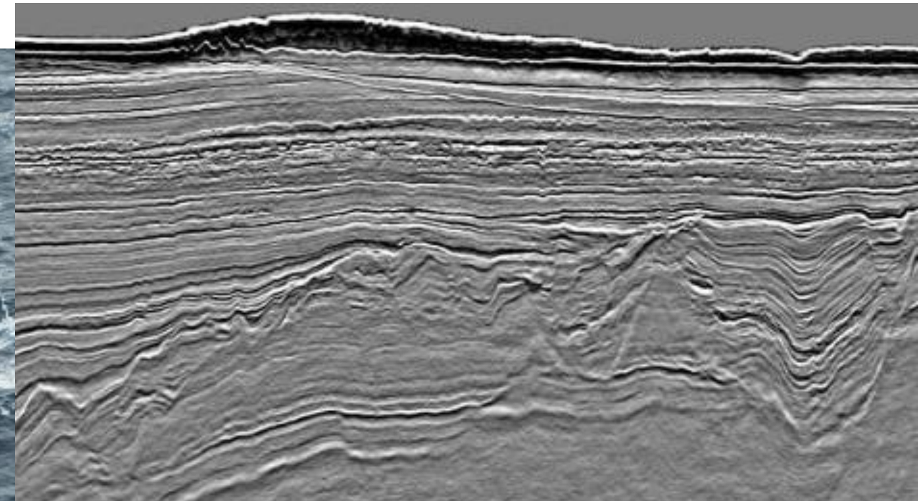
https://www.wgcg.co.uk/wgcg-feb-2025-workshop/

WGCG Geo-Data Workshop

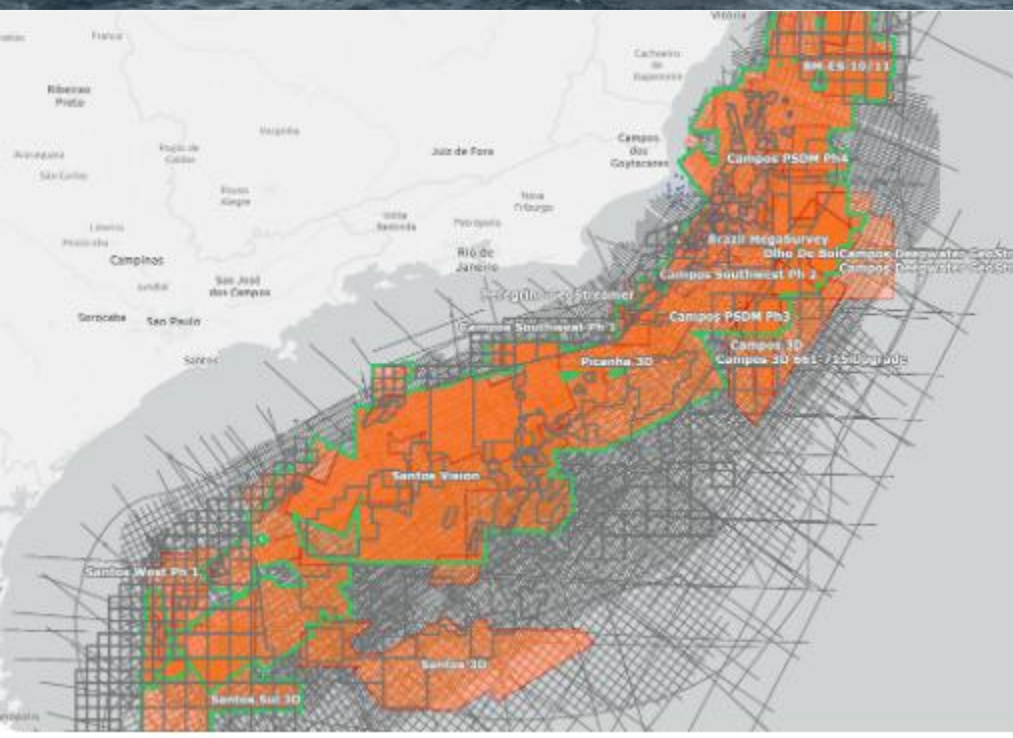
15/2/25 KSCC

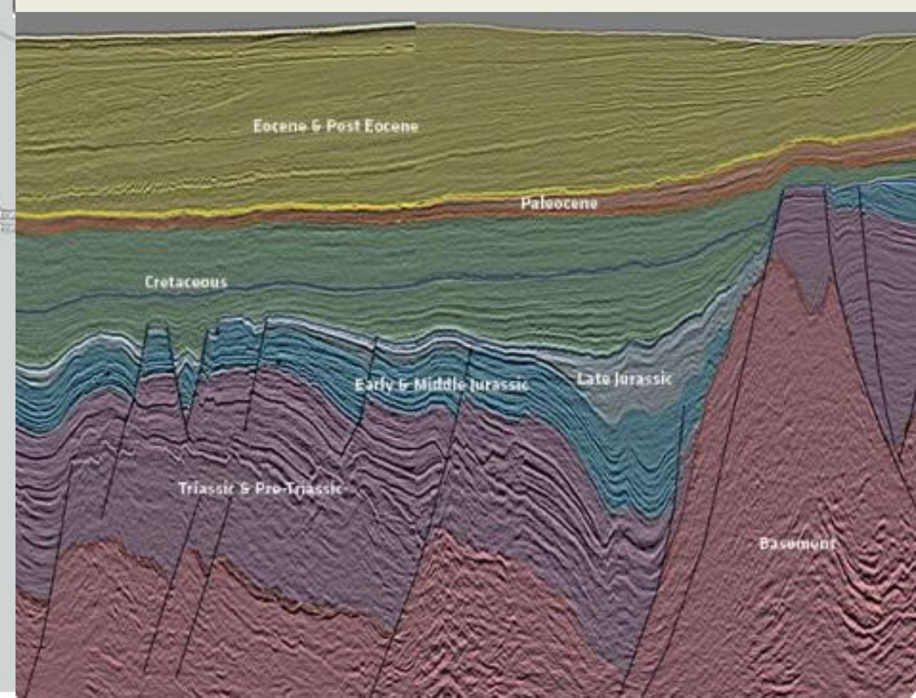
Ray Pratt

SEISMIC

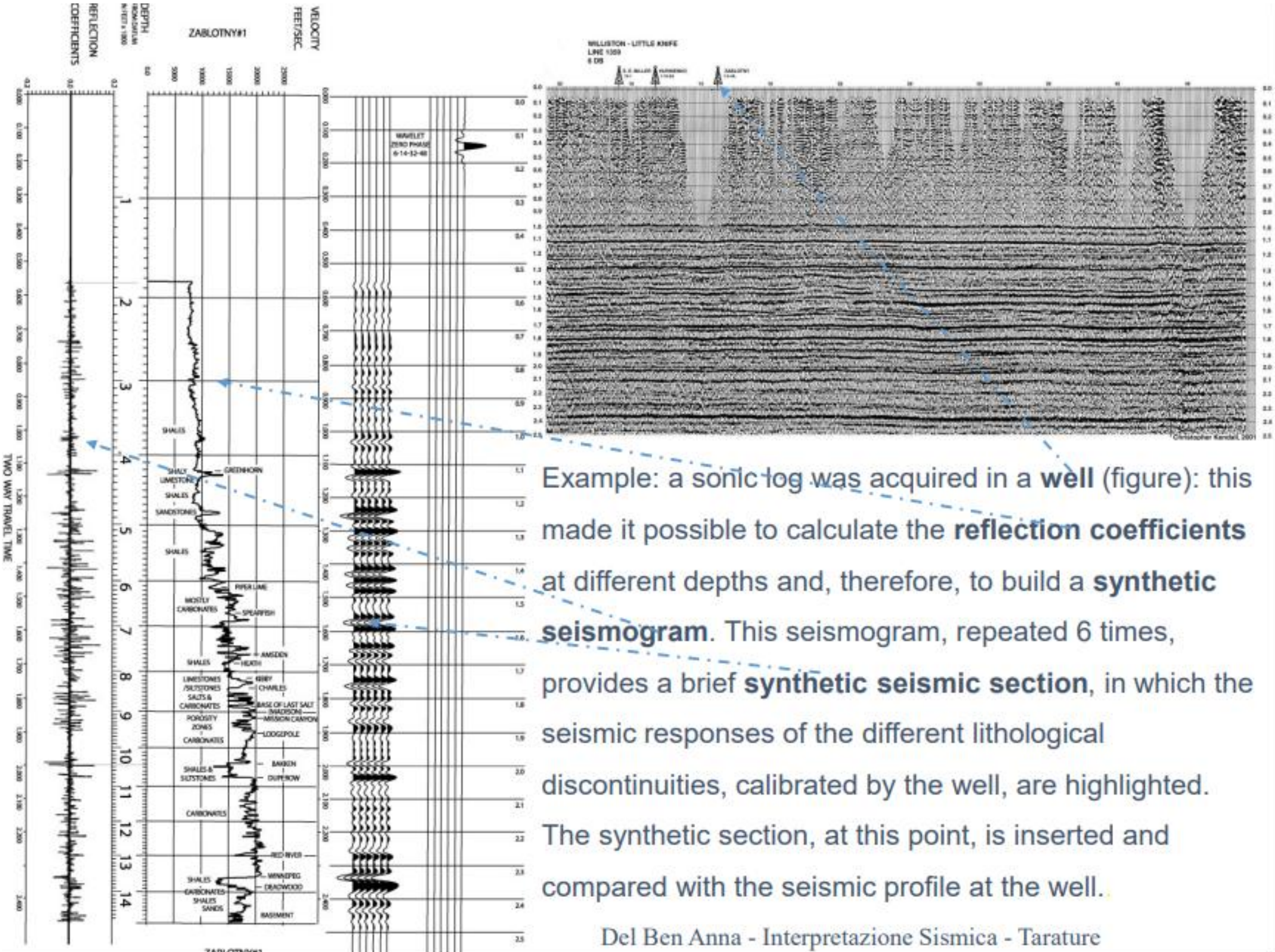


To convert time reflections to a depth surface we need to know the velocity. depth = velocity x time. The velocity of a rock is a fundamental physical property related to its hardness.





Integrating seismic with well logs



Example: a sonic log was acquired in a **well** (figure): this made it possible to calculate the **reflection coefficients** at different depths and, therefore, to build a **synthetic seismogram**. This seismogram, repeated 6 times, provides a brief **synthetic seismic section**, in which the seismic responses of the different lithological discontinuities, calibrated by the well, are highlighted. The synthetic section, at this point, is inserted and compared with the seismic profile at the well.

Well Geological Data Records

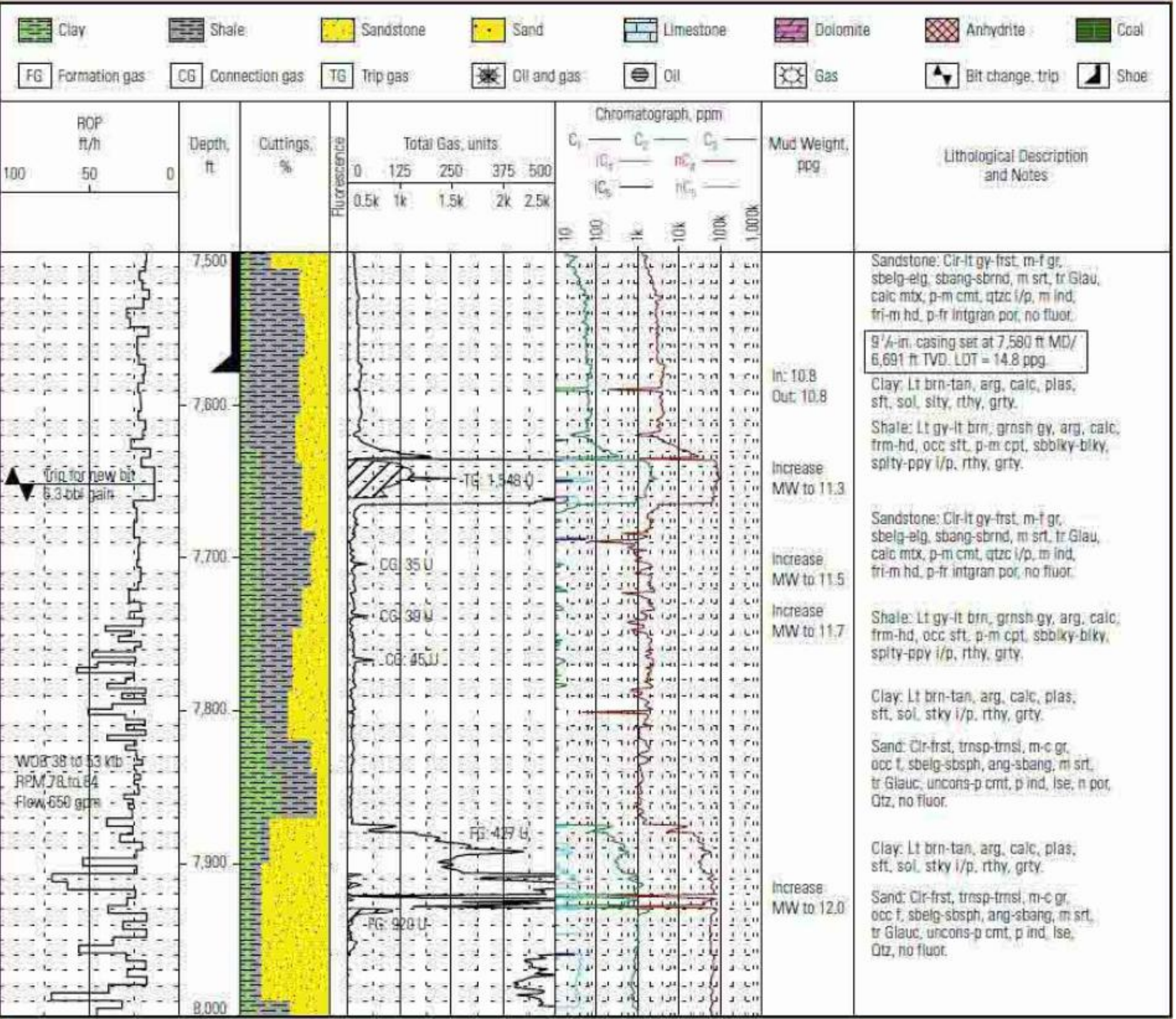
- Mudlog
- Completion / Composite Log
- Computer Processed Interpretation (CPI)
- Core Data
- *Biostratigraphy*
- *Other – Fluids, Pressure, Samples, Reports etc*

Mud Log

- A mud log typically displays ROP, depth, cuttings lithology, gas measurements and cuttings descriptions along with notes on mud rheology or drilling parameters.
- How to read a mudlog (YouTube)
  - https://www.youtube.com/watch?v=P6yly2mHU1s&t=4s


EXPLORATION
LOGGING
NO SMOKIN
DILARANG
MEROKOK


OLL-RAND



Download of abbreviations is available https://geotechnology-sciences.blogspot.com/2011/05/abbreviations-of-mudlogging.html

COMPLETION LOG

- This is a graphical log containing all the primary measurements in a wellbore.
- As a minimum it will contain
  - Well header data
  - Primary well logs.
- The Composite Log should integrate the geological columnar section with selected petrophysical logs i.e.
  - a lithology indicating log,
  - a porosity log and
  - a resistivity log.
  - Geological zones
  - Lithology core intervals
  - Testing intervals
  - Casing / liner seats

Completion Log

COMPOSITE WELL LOG 1: 500

WELL: 1/3-8
API NO. : 97 557 03636 00

OPERATOR	:	AMOCO NORWAY
COUNTRY	:	NORWAY
AREA	:	South Central Graben
LICENSE	:	PL011
BLOCK	:	1/3
NPD PERMIT NO	:	L855
GROUP INTEREST:		Amoco 30% Shell 50% Conoco 20%

GEOGRAPHICAL COORDINATES
LAT : 56 52' 07.14" N UTM : 493238.8 X
LONG : 02 53' 20.75" E 6302911.1 Y

TARGET COORDINATES
LAT : 56 52' 07.14" N UTM : 493238.8 X
LONG : 02 53' 20.75" E 6302911.1 Y

BOTTOM HOLE COORDINATES
LAT : 56 52' 07.14" N UTM : 493238.8 X
LONG : 02 53 20.75" E 6302911.1 Y

K.B. ELEV.	:	41 m	TOTAL DEPTH	:	5201 m
WATER DEPTH	:	68.6 m	BOTTOM HOLE FM	:	Triassic

PRE-SPUD CLASSIFICATION	:	WILDCAT
DATE ON LOCATION	:	09-Dec-96
SPUD DATE	:	12-Dec-96
DATE T.D. REACHED	:	08-May-97
COMPLETION DATE	:	none
RIG RELEASE DATE	:	28-May-97
WELL STATUS	:	P & A
WELL CLASSIFICATION	:	Dry Hole

RIG	:	TRANSOCEAN NORDIC
DRILLING CONTRACTOR	:	Transocean
W/L - LOGGING CONTRACTOR	:	Atlas Wireline
MWD - LOGGING CONTRACTOR	:	Atlas Wireline
MUD-LOGGING CONTRACTOR	:	BHI

WELLSITE GEOLOGISTS :
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Stuart Robinson
Steve Crittenden
Alan Williams
Ian Clement

COMPILED BY :
John Hopkins
Martin Kendall
Astrid Midtun

CASING RECORD

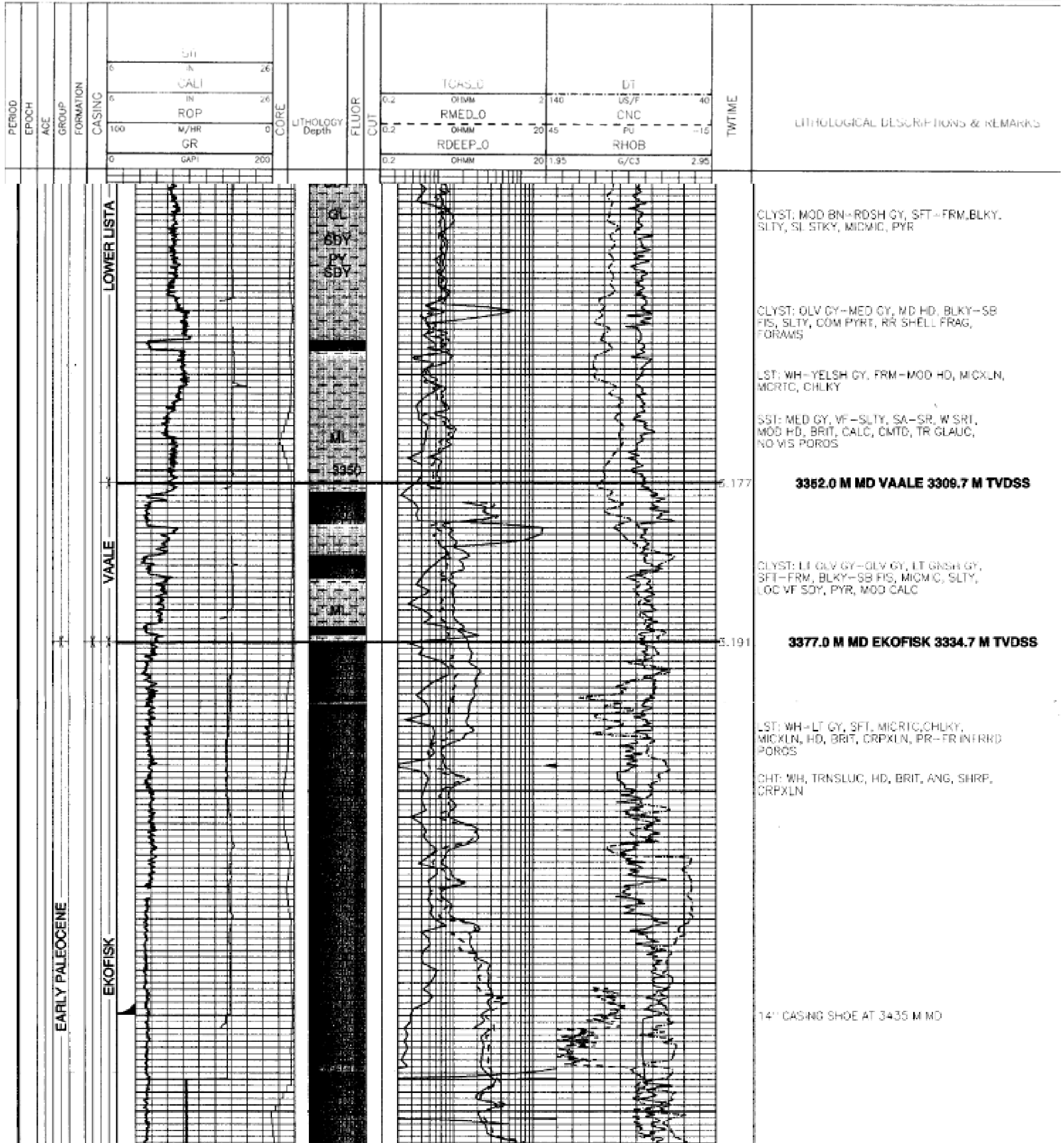
CASING	SHOE m RKB	HOLE SIZE	INTERVAL m RKB	REMARK
30"	303	36"	109.6 - 310	
		9 7/8"	310 - 1105	Pilot hole
20"	1096	26"	310 - 1105	
14"	3435	17 1/2"	1105 - 3445	
9 5/8"	4515	12 1/4"	3445 - 4529	Well kicked 4529m
7 5/8"	4904	8 1/2"	4529 - 4905	
		6 1/4"	4905 - 5201	T.D.

MUD DATA

FLUID TYPE	HOLE size	MW ppg	VISCO sec	PH	FLUID loss
Bentonite	36"	8.7	72	-	-
Low solids non dispersed	9 7/8"	9.[illegible] - 9.3	60 - 77	[illegible] - 9.5	4 - 10
	26"	9.5 - 9.7	65 - 66	[illegible]	7 - 10
KCl/Polymer/Glycol	17 1/2"	15.5 - 15.9	[illegible] - 100	7 - 8	3 - 4
Ancovert OBM	12 1/4"	13.8 - 14.8	90 - 100		
Ancovert OBM	8 1/2"	16.7 - 17.[illegible]	70 - [illegible]		
Ancovert OBM	6 1/4"	17.9 - 18.9	74 - [illegible]		

WELL PROFILE

WELL LOCATION MAP



PERIOD
EPOCH
AGE
GROUP
FORMATION
CASING
SH
6 IN 26
CALI
6 IN 26
ROP
100 M/HR 0
GR
0 GAPI 200
CORE
LITHOLOGY Depth
FLUOR
CUT
TCAS_C
0.2 OHMM 2
RMED_O
0.2 OHMM 20
RDEEP_O
0.2 OHMM 20
DT
140 US/F 40
CNC
45 PU -15
RHOB
1.95 G/C3 2.95
TWTIME
LITHOLOGICAL DESCRIPTIONS & REMARKS
EARLY PALEOCENE
LOWER LISTA
VAALE
EKOFISK
GL
SDY
PY
SDY
ML
3350
ML
3.177
3.191
CLYST: MOD BN-RDSH GY, SFT-FRM,BLKY, SLTY, SL STKY, MICMIC, PYR
CLYST: OLV GY-MED GY, MD HD, BLKY-SB FIS, SLTY, COM PYRT, RR SHELL FRAG, FORAMS
LST: WH-YELSH GY, FRM-MOD HD, MICXLN, MCRTC, CHLKY
SST: MED GY, VF-SLTY, SA-SR, W SRT, MOD HD, BRIT, CALC, CMTD, TR GLAUC, NO VIS POROS
3352.0 M MD VAALE 3309.7 M TVDSS
CLYST: LT OLV GY-OLV GY, LT GNSH GY, SFT-FRM, BLKY-SB FIS, MICMIC, SLTY, LOC VF SDY, PYR, MOD CALC
3377.0 M MD EKOFISK 3334.7 M TVDSS
LST: WH-LT GY, SFT, MICRTC,CHLKY, MICXLN, HD, BRIT, CRPXLN, PR-FR INFRRD POROS
CHT: WH, TRNSLUC, HD, BRIT, ANG, SHRP, CRPXLN
14" CASING SHOE AT 3435 M MD

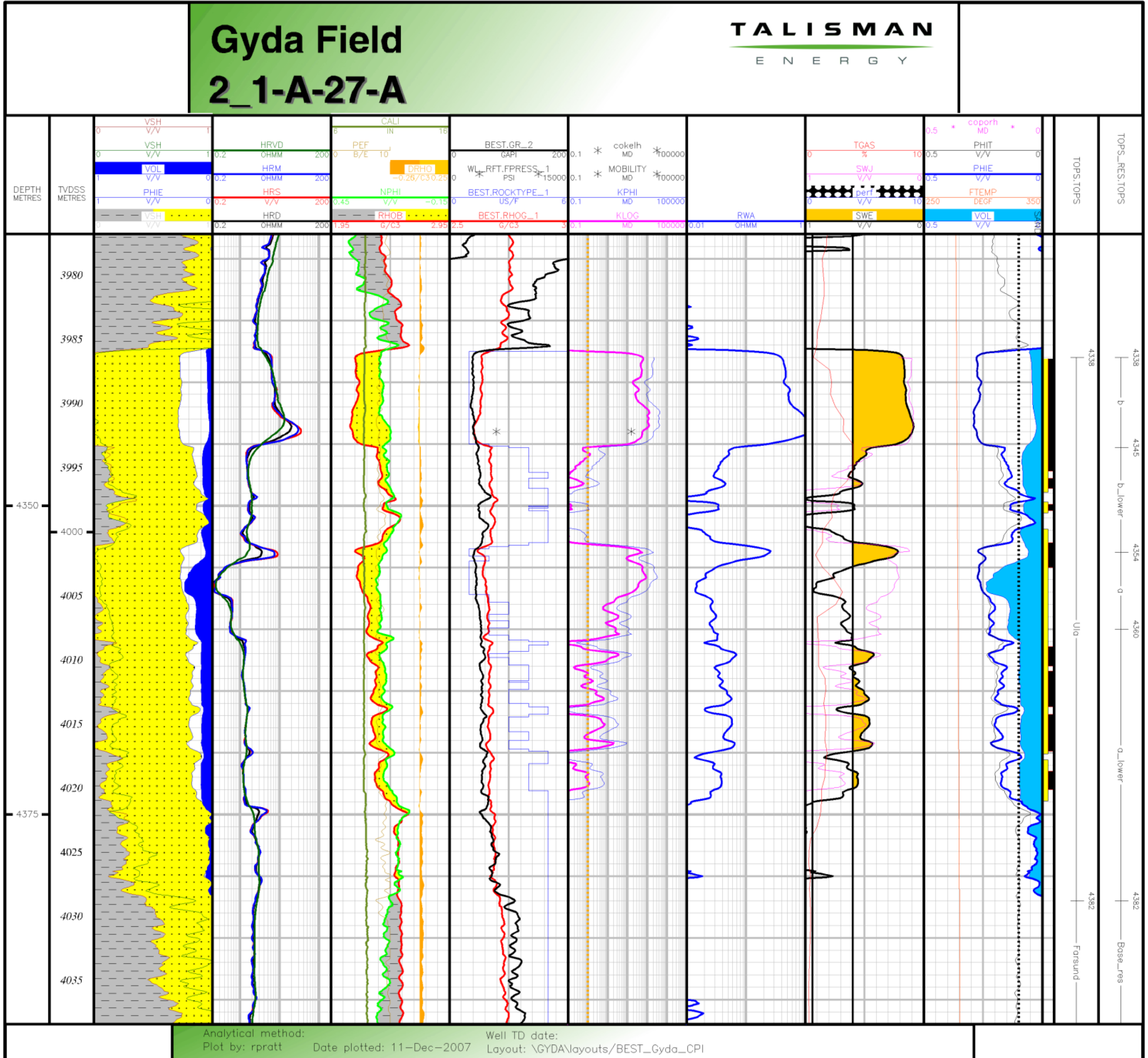
CPI

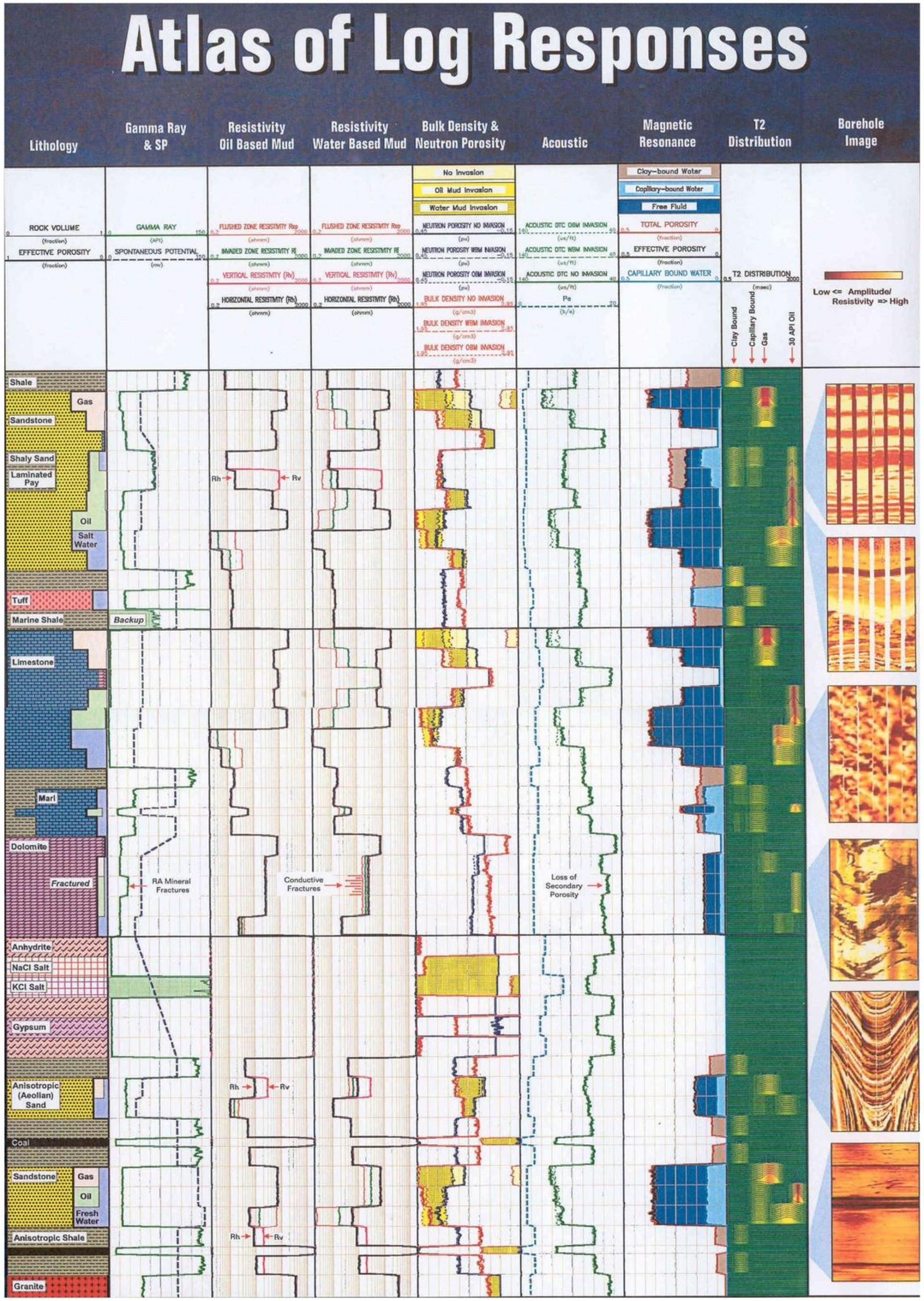
- Well **logs** data are the most widely used data to evaluate subsurface rocks, their petrophysical properties include porosity, permeability and fluid saturation.

- Well logs present a concise, detailed plot of formation parameters versus depth. From these plots, interpreters can identify lithologies, differentiate between porous and nonporous rock and quickly recognize pay zones in subsurface formations. The ability to interpret a log lies in recognizing the significance of each measurement.

https://www.slb.com/resource-library/oilfield-review/defining-series/defining-log-interpretation

CPI


Gyda Field
2_1-A-27-A
TALISMAN ENERGY
DEPTH METRES
TVDSS METRES
VSH
PHIE
VOL
HRVD
HRM
HRS
HRD
CALI
PEF
DRHO
NPHI
RHOB
BEST.GR_2
WL_RFT.FPRESS_1
BEST.ROCKTYPE_1
BEST.RHOG_1
cokelh
MOBILITY
KPHI
KLOG
RWA
TGAS
SWJ
perf
SWE
coporh
PHIT
FTEMP
TOPS.TOPS
TOPS_RES.TOPS
Analytical method:
Plot by: rpratt
Date plotted: 11-Dec-2007
Well TD date:
Layout: \GYDA\layouts/BEST_Gyda_CPI



https://www.scribd.com/doc/191399572/Log-Responses

The document discusses formation evaluation and provides a general log matrix showing expected responses for different logging tools in various rock types. It includes lithology, resistivity, density, neutron, and other logs for materials like shale, sandstone, salt, gas and oil.

Integration of Core with Log Evaluation

- Important Parameters derived from core
  - Porosity
  - Permeability
  - Grain density
  - Rw
  - SW
- *SCAL data – not discussed*

Core received at the lab.

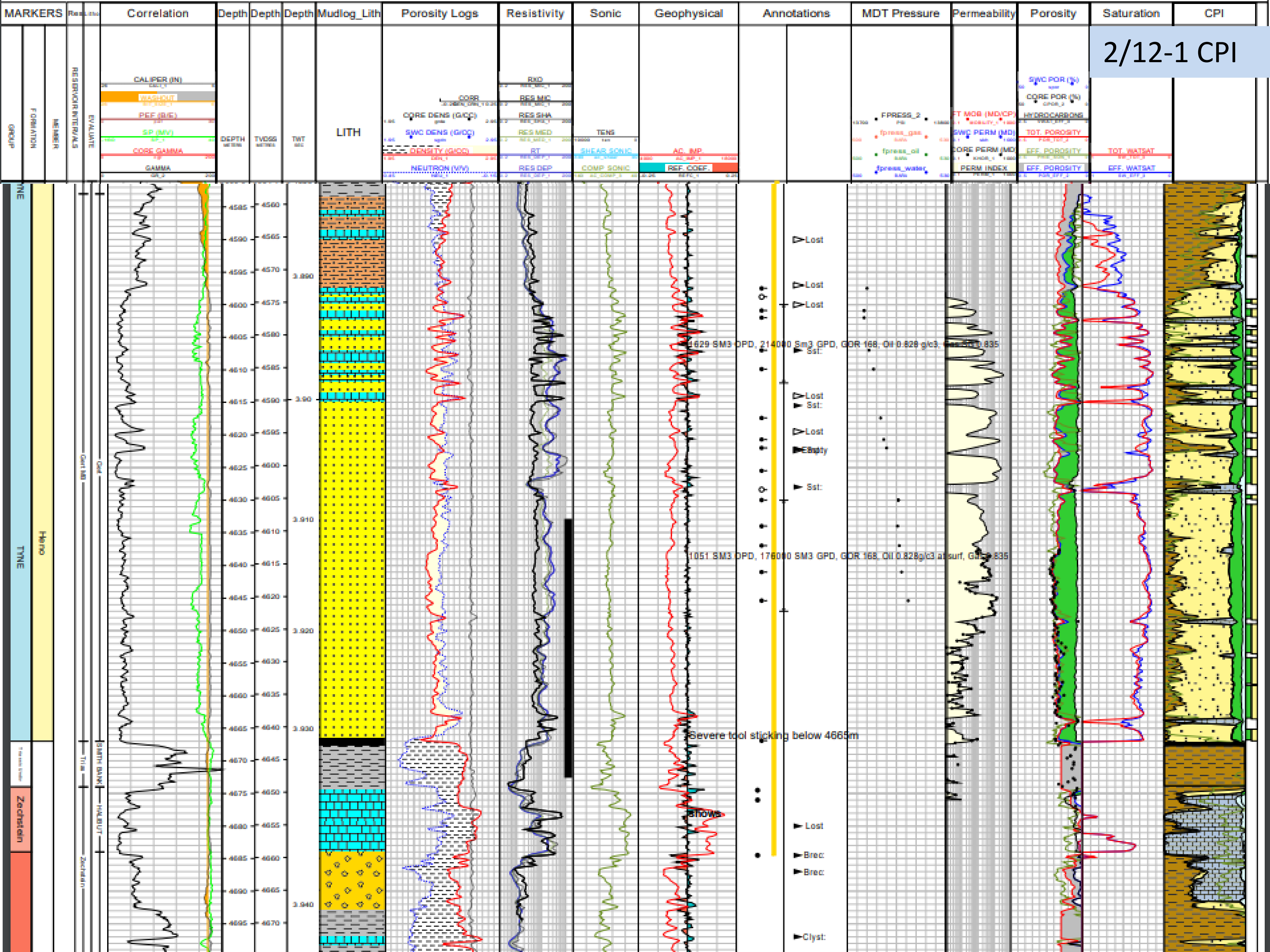
CORE PHOTOS


CORE 3
BOX 8
BOX 9
BOX 10
BOX 11
BOX 12
CORE ANALYSIS LABORATORY
15. MARTS 1995


CORE 3
BOX 8
BOX 9
BOX 10
BOX 11
BOX 12
CORE ANALYSIS LABORATORY
15. MARTS 1995

Damage due to gas expansion on rapid POOH with “low” permeability core. Core shattered and wedged into inner barrel. Required to slab with liner in place. 15/12-12 (Varg field) Oxfordian sandstone.

2/12-1 CPI


MARKERS
Correlation
Depth
Depth
Depth
Mudlog_Lith
Porosity Logs
Resistivity
Sonic
Geophysical
Annotations
MDT Pressure
Permeability
Porosity
Saturation
CPI
CALIPER (IN)
WASHOUT
PEF (B/E)
SP (MV)
CORE GAMMA
GAMMA
DEPTH
TVDSS
TWT
LITH
CORE DENS (G/CC)
SWC DENS (G/CC)
DENSITY (G/CC)
NEUTRON (V/V)
RXO
RES MIC
RES SHA
RES MED
RT
RES DEP
TENS
SHEAR SONIC
COMP SONIC
AC. IMP
REF. COEF.
FPRESS_2
fpress_gas
fpress_oil
fpress_water
FT MOB (MD/CP)
SWC PERM (MD)
CORE PERM (MD)
PERM INDEX
SWC POR (%)
CORE POR (%)
HYDROCARBONS
TOT. POROSITY
EFF. POROSITY
TOT. WATSAT
EFF. WATSAT
TYNE
Heno
Zechstein
1629 SM3 OPD, 214000 Sm3 GPD, GOR 168, Oil 0.828 g/c3, Gas 0.835
1051 SM3 OPD, 176000 SM3 GPD, GOR 168, Oil 0.828g/c3 at surf, Gas 0.835
Severe tool sticking below 4665m
Shows
Lost
Sst:
Empty
Brec:
Clyst:

Metrics vary

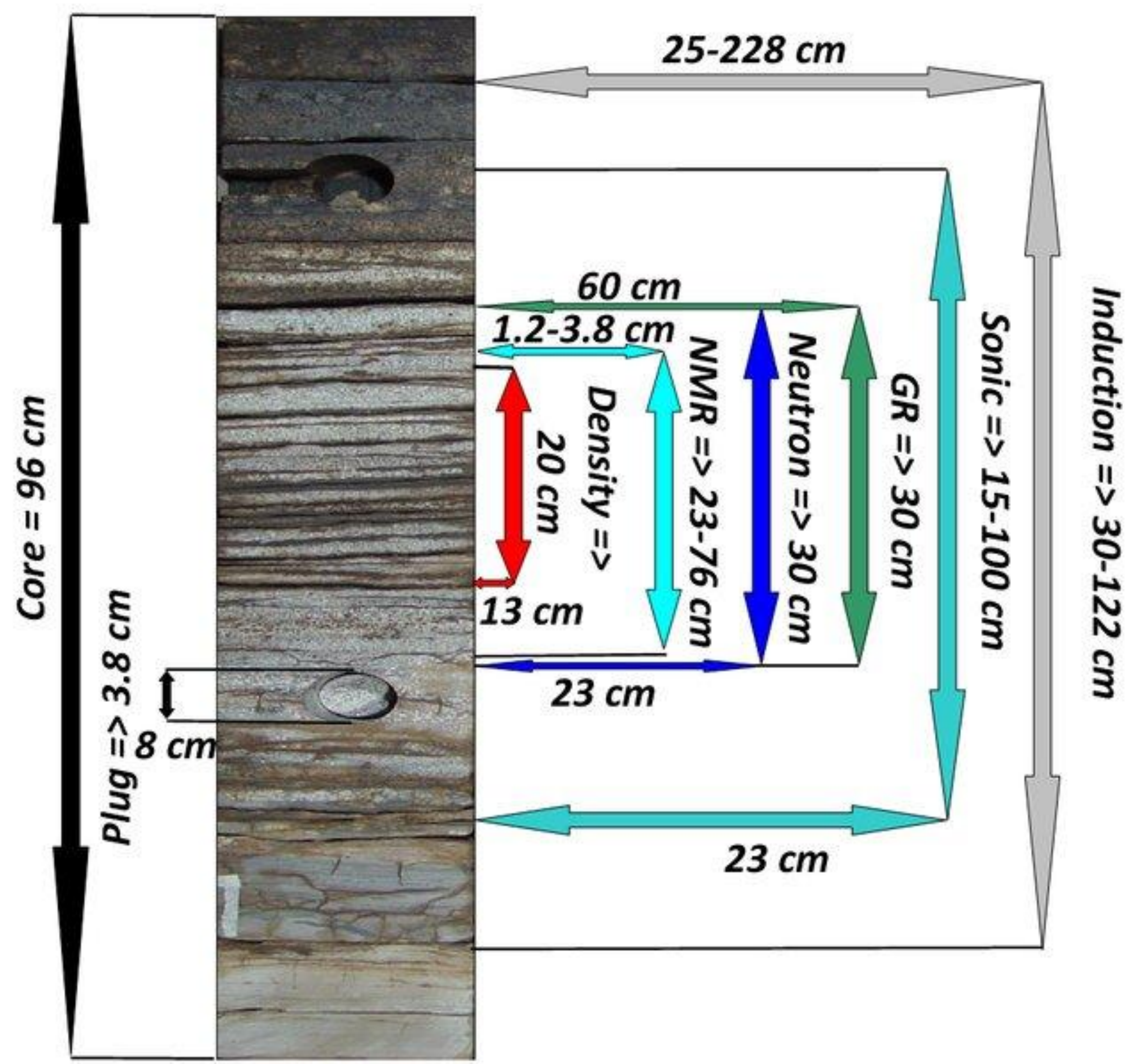
- Apparent disparities between core data and CPI data may be down to
  - Depth discrepancies
  - Bed thickness (averaging)
  - Environmental influences
  - Measure core at effective stress


INDUCTION
NEUTRON
LATEROLOG
SONIC
CORE
MDT
GAMMA
vertical resolution in feet
DENSITY/
NMR
MICRO-RESISTIVITY
IMAGE
1
2
3
4
5
6
depth of investigation in feet
TRACS
TRAINING

Vertical Resolution & Depth of Investigation - Comparisons

Routine core analysis plugs are 1” c. 2.5 cm dia

SCAL plugs are 1.5” c 3.8cm dia

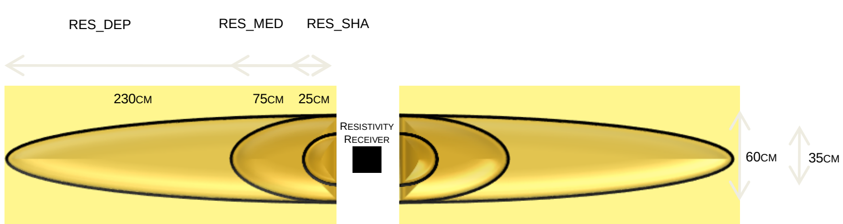


Collecting data from the subsurface

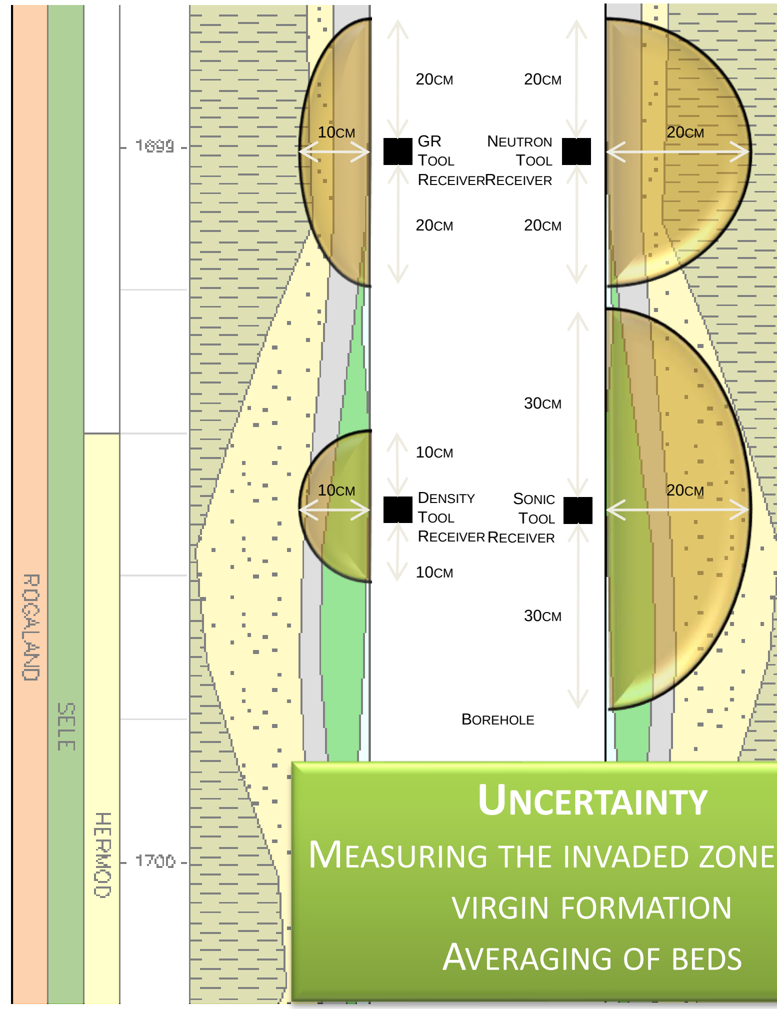
Depth of investigation

Tool	Resolution	
	vertical	depth
Gamma Ray	40cm	10cm
Density	20cm	10cm
Neutron	40cm	20cm
Resistivity	35/60/60cm	25/75/230cm
Sonic	60cm	20cm

Average tools at average logging speeds in average holes

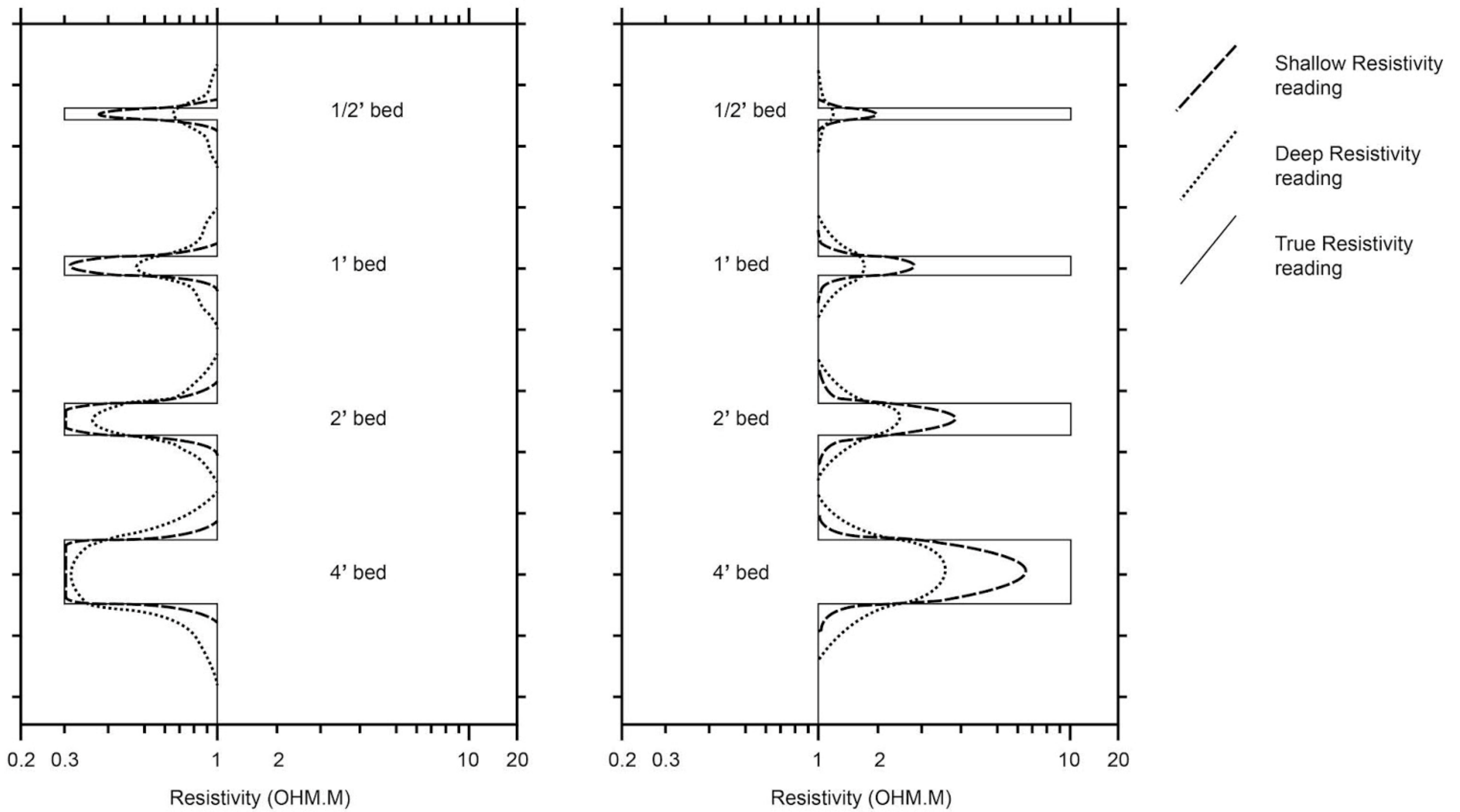


Average invasion depth:
WBM: 60cm
OBM: 5cm

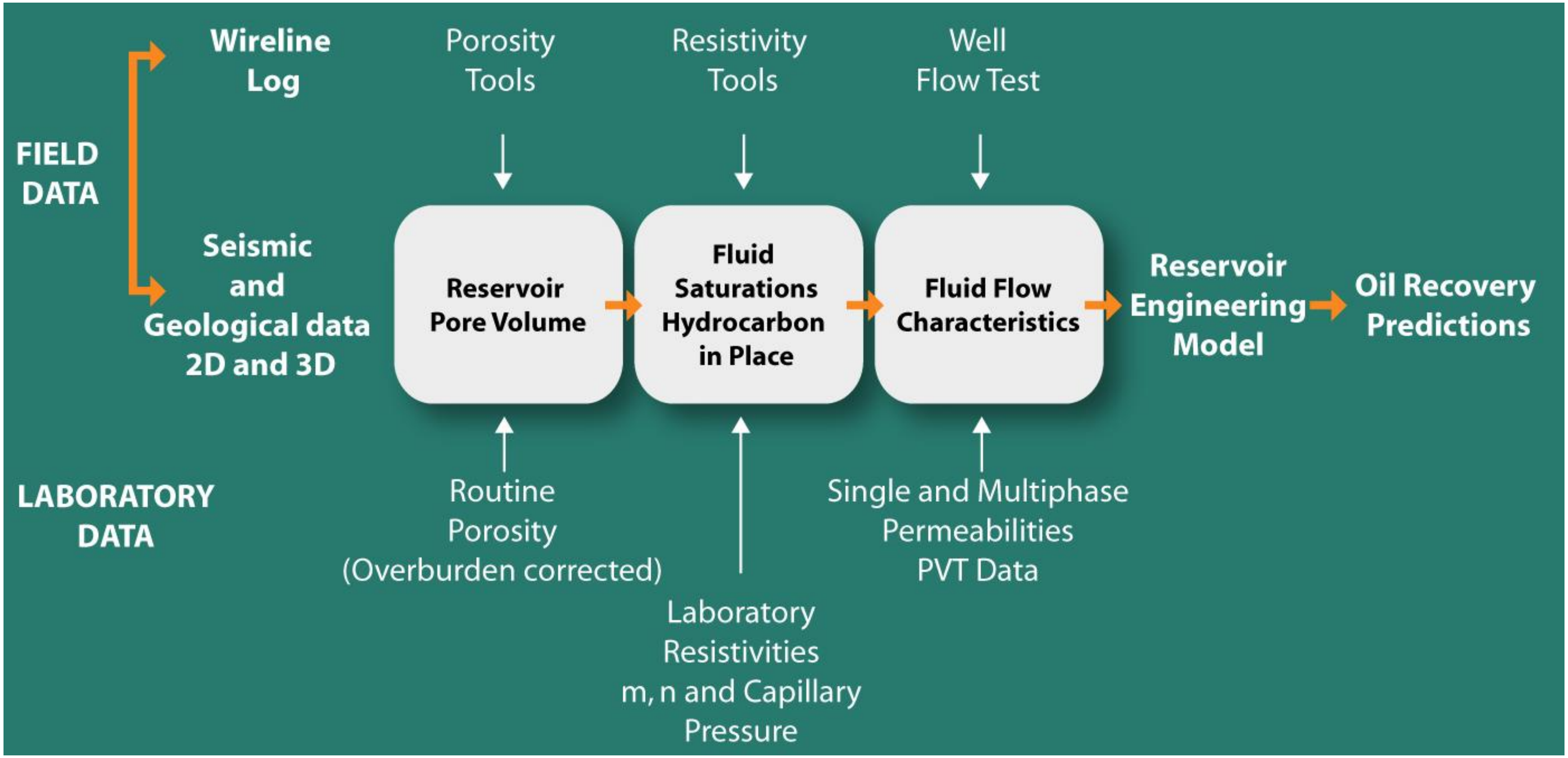


Uncertainty
Measuring the invaded zone – not virgin formation
Averaging of beds

Resistivity Tool Vertical Resolution
Conductive beds v resistive beds



Integrating Core and CPI data into the Reservoir Model
Reservoir Engineering Data Sources



Summary

•This talk has focussed on how different types of data sets can be calibrated and integrated to create a reservoir model
•Exploration and the drilling of boreholes results in large volumes of geological information
•Huge databases of information are available in the form of plots and reports, commonly free of charge
•UK, Eire, Norway, Netherlands and Denmark (including Greenland) all have national repositories that are accessible by the general public

North Sea Transition Authority https://www.nstauthority.co.uk/data-and-insights/data/

UK National Data Repository https://ndr.nstauthority.co.uk/

GSNI Geological Survey of Northern Ireland www.bgs.ac.uk/gsni
https://www2.bgs.ac.uk/gsni/
https://www2.bgs.ac.uk/gsni/tellus/data_licensing/index.html

UK Onshore Geophysical Library https://ukogl.org.uk/archives/

SOKKELDIREKTORATET Norway https://www.sodir.no/en/diskos/wells/

Norge Diskos Well Data https://www.sodir.no/en/

NLOG
Dutch Oil and Gas portal https://www.nlog.nl/en/oil-and-gas

GEUS Geological Survey of Denmark and Greenland
https://eng.geus.dk/products-services-facilities/archives/well-data-archive
https://eng.geus.dk/products-services-facilities/data-and-maps/national-well-database-jupiter

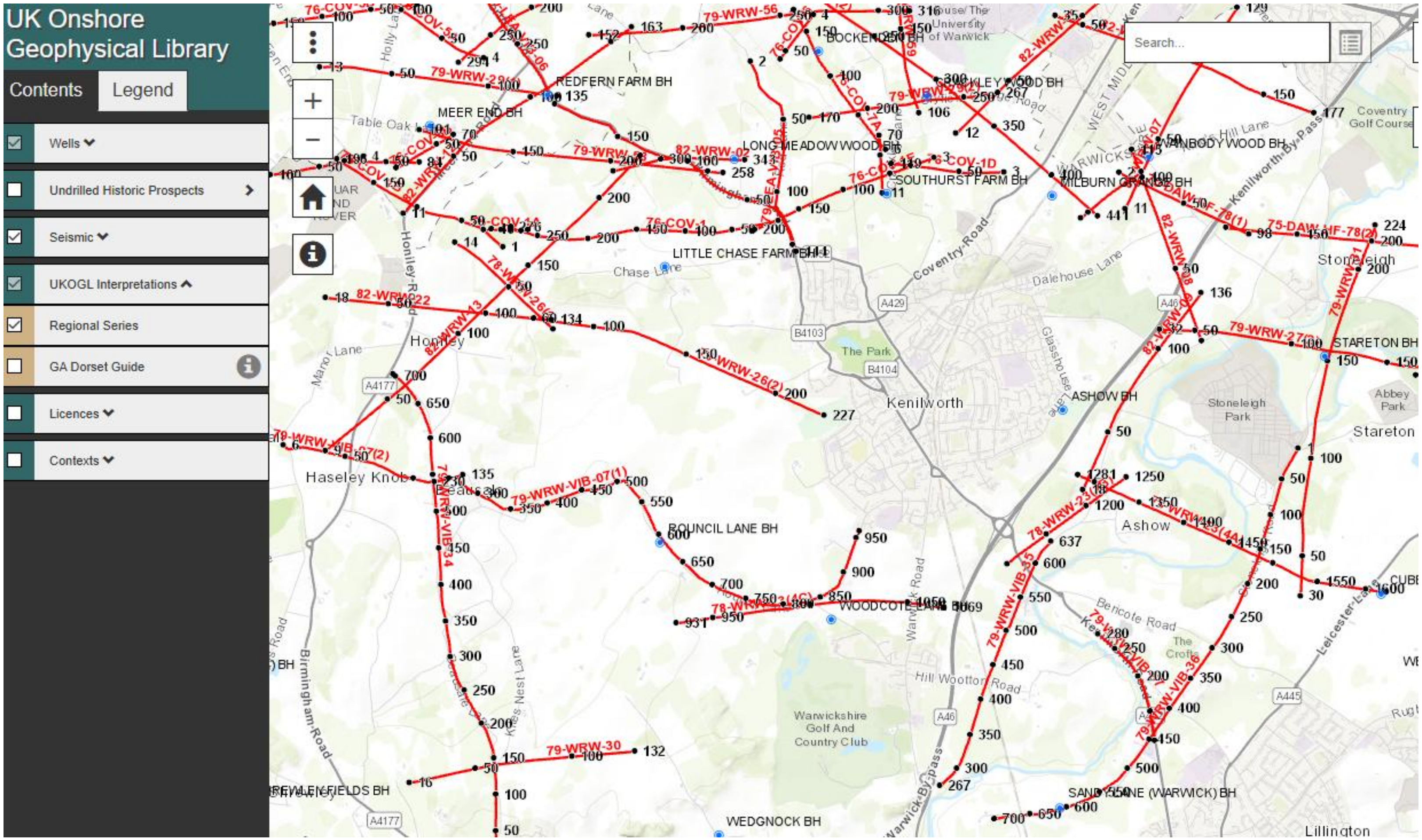
https://pub.geus.dk/en/publications/?pageSize=50&ordering=publicationYearThenTitle&descending=true&showAdvanced=false&andConceptIds=2c027024-e5f5-4383-98c1-51c842f6df13&allConcepts=true&inferConcepts=true&searchBy=RelatedConcepts

IPAS
Integrated Petroleum Affairs System
Department of Communications, Energy and Natural Resources http://gis.dcenr.gov.ie/internetIPAS/servlet/internet/IPAS2IHome

Spanish Geological maps https://www.geamap.com/en

UK Onshore Geophysical Library

https://ukogl.org.uk/archives/



Graphic Logging - Reference

Journal of Sedimentary Research

Journal of Sedimentary Research, 2013, v. 83, 723–745
Research Article
DOI: 10.2110/jsr.2013.52

SEPM Society for Sedimentary Geology

GRAPHIC LOGGING FOR INTERPRETING PROCESS-GENERATED STRATIGRAPHIC SEQUENCES AND AQUIFER/RESERVOIR POTENTIAL: WITH ANALOG SHELF TO SHOREFACE EXAMPLES FROM THE ATLANTIC COASTAL PLAIN PROVINCE, U.S.A.

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