Monitoring While Drilling

Presented by: Paul Emerson

Director

MSc, DIC, CGeol, FGS

EMD

Introduction

- What is MWD?
- Where did it come from?
- How does it work
- What are its applications?
- Limitations
- Case Studies
- Future uses

Lead driller and engineer discussing parameters

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MWD is not….

- Accelerometers
- Magnetometers
- Inclinometers
- Other down-hole parameters
- Geophysics

Pictures courtesy of Halliburton

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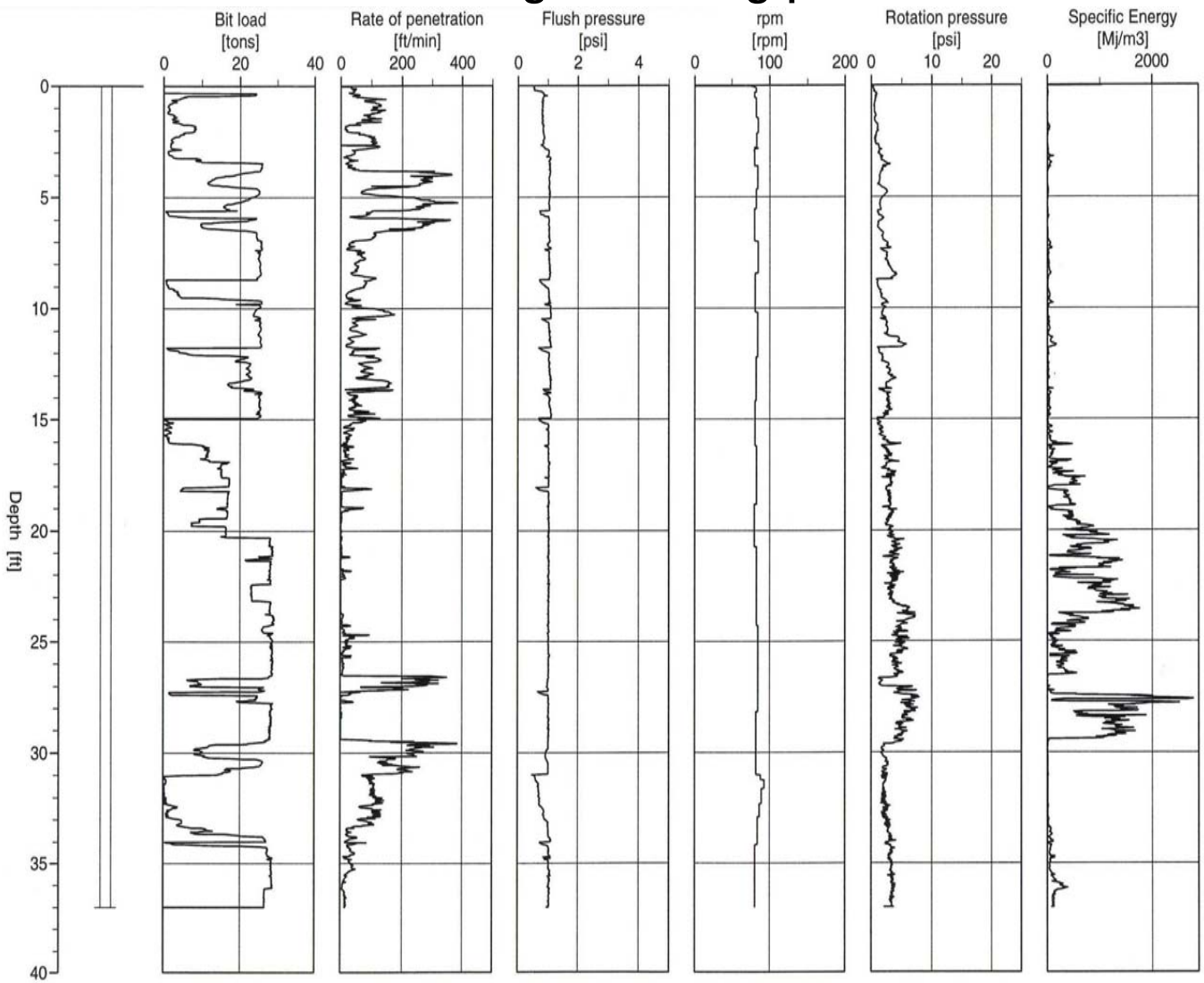
What is MWD?

Measurement and recording of drilling parameters in real time:



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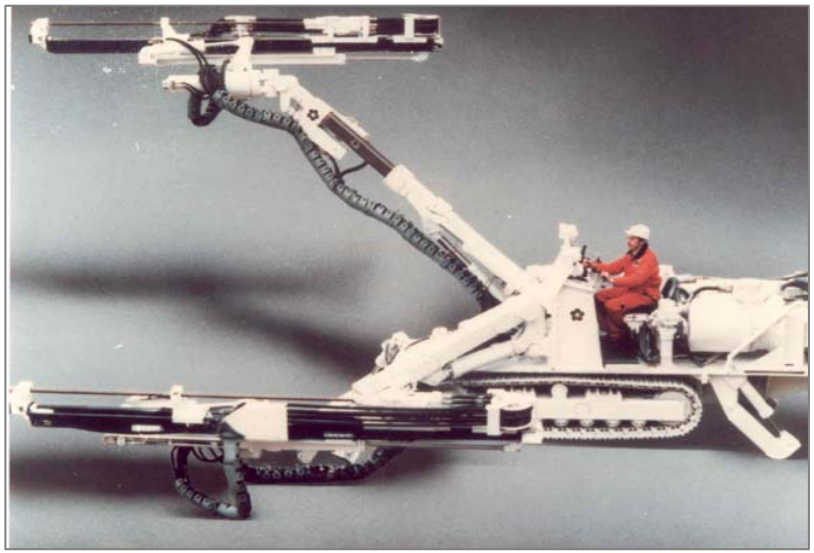
History



Photograph courtesy pf Boart Longyear

Photograph showing EMD rig undertaking Geotechnical investigations for voids. Caribbean 2006

- Originated from mining sector
- First systems were developed in 1980's, including:
  - Detection of weak water bearing zones.
  - Determine bedrock depth for piling (probing).
  - Fracture location and lithology definition.
- EMD have been operating the Envi system since 2005
- Other manufacturers include Jean Lutz (France) and Geotech (Sweden)

What is MWD?

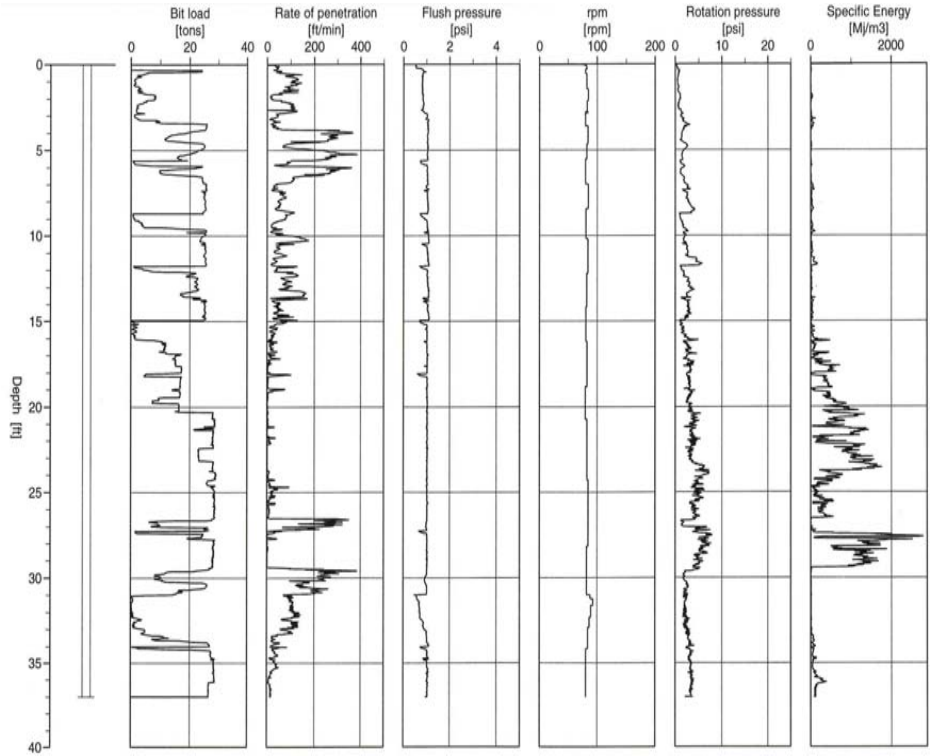
Aims:

•Obtain data during drilling to increase the information available rock material and rock mass characteristics including, material type, fracture location / zones;

•Efficiency of operations;

• Improve reliability and accuracy of data;

It can be used with both rotary coring and open-hole drilling techniques.



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How does it work?

Rotary coring supplemented by MWD for geotechnical investigations for potential nuclear waste depository sites, Sweden. Photograph courtesy of Environmental Mechanics, SE

- This Driller is not holding a stopwatch and has no chalk in his hand.

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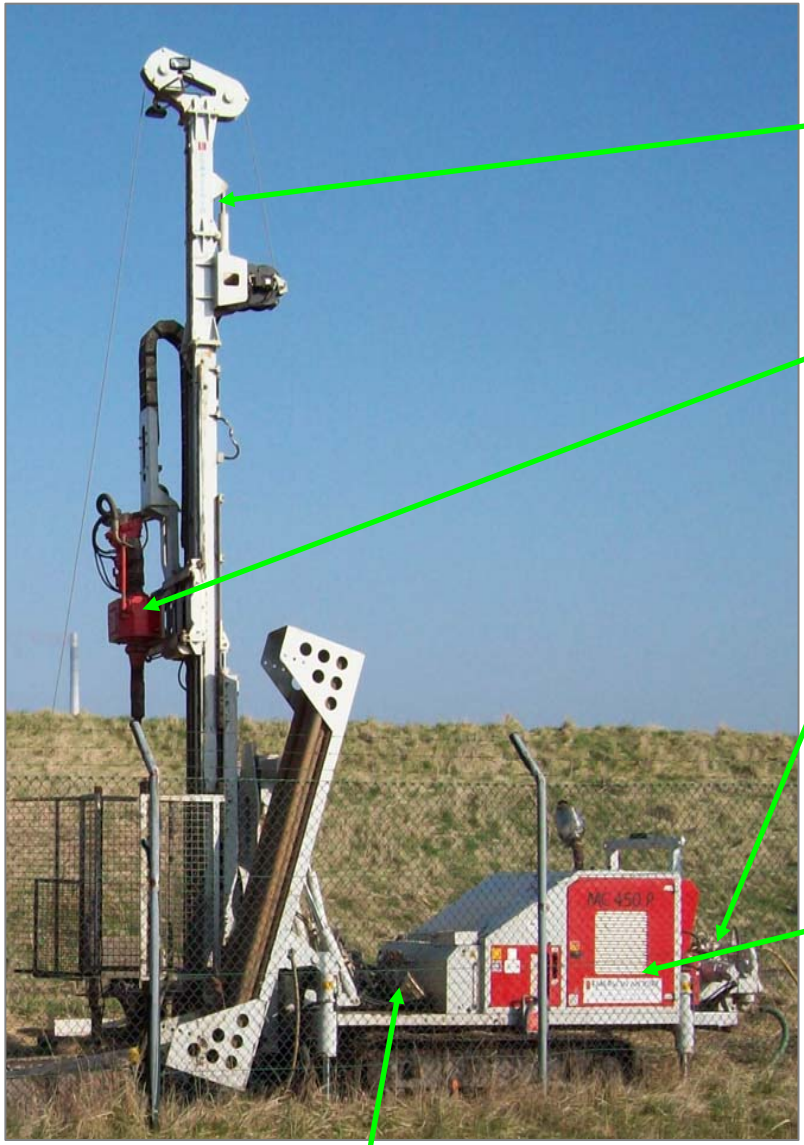

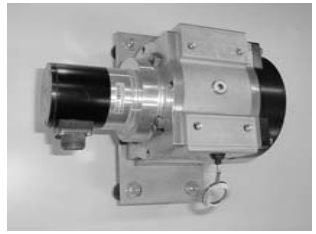

Depth Registration Unit: Wire goes from the unit to the top of drill head, the wire follows the drill head up and down.

Revolution Gauge: Records the revolutions of drill head.

Flow and Pressure Unit: Measures flow when drilling with mud/water / air.

Control Box: Consists of electronic transducers connected to rig hydraulics.

Feed force – bit load: Is measured directly from the rigs hydraulic system and is calibrated using a load cell

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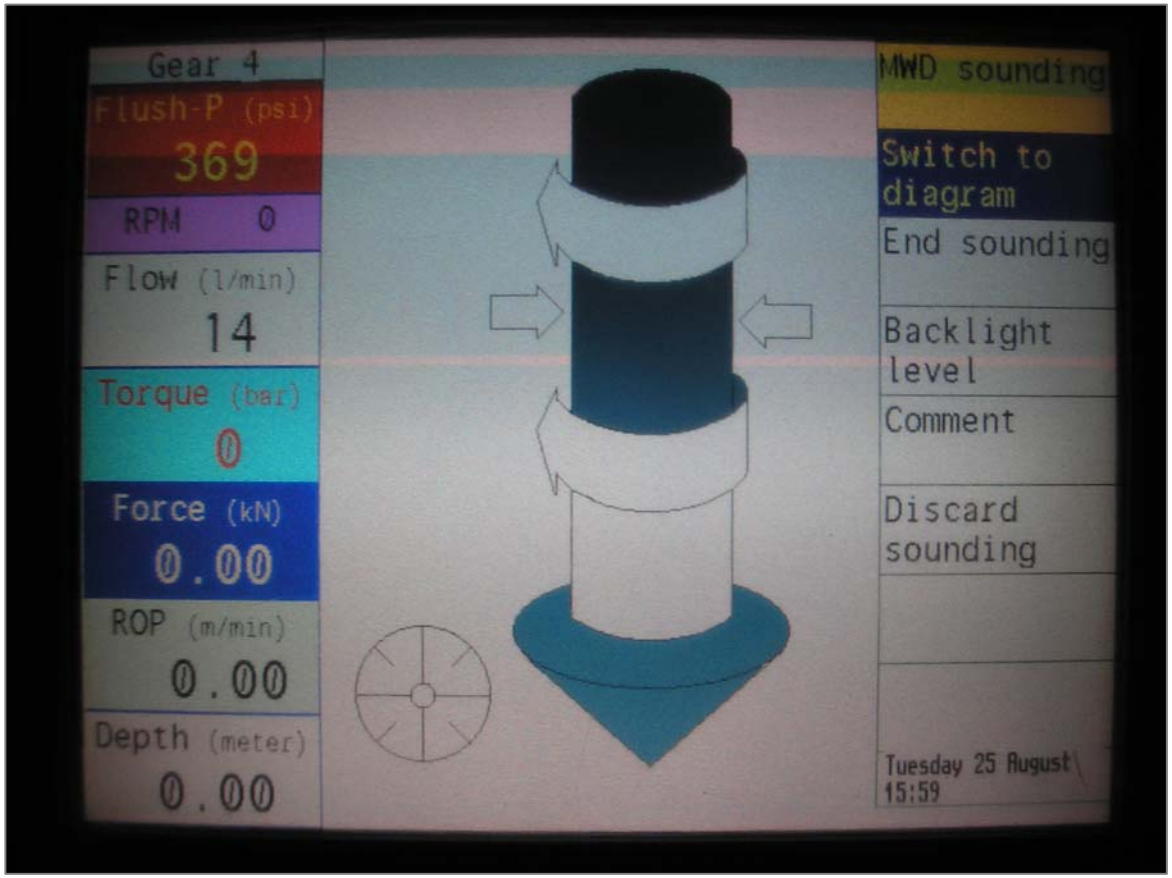
What is Displayed



- **Depth;**
- **Rate Of Penetration** - Very important this is influenced by several factors, including,
  - Strength, type and frequency of mass and materials
  - Type of rig and bit used
  - Flushing media and pressures
  - Drill personnel.
- ROP is function of depth, correlate logs at same scale from different holes
- Width of penetration rate peaks/ troughs are important

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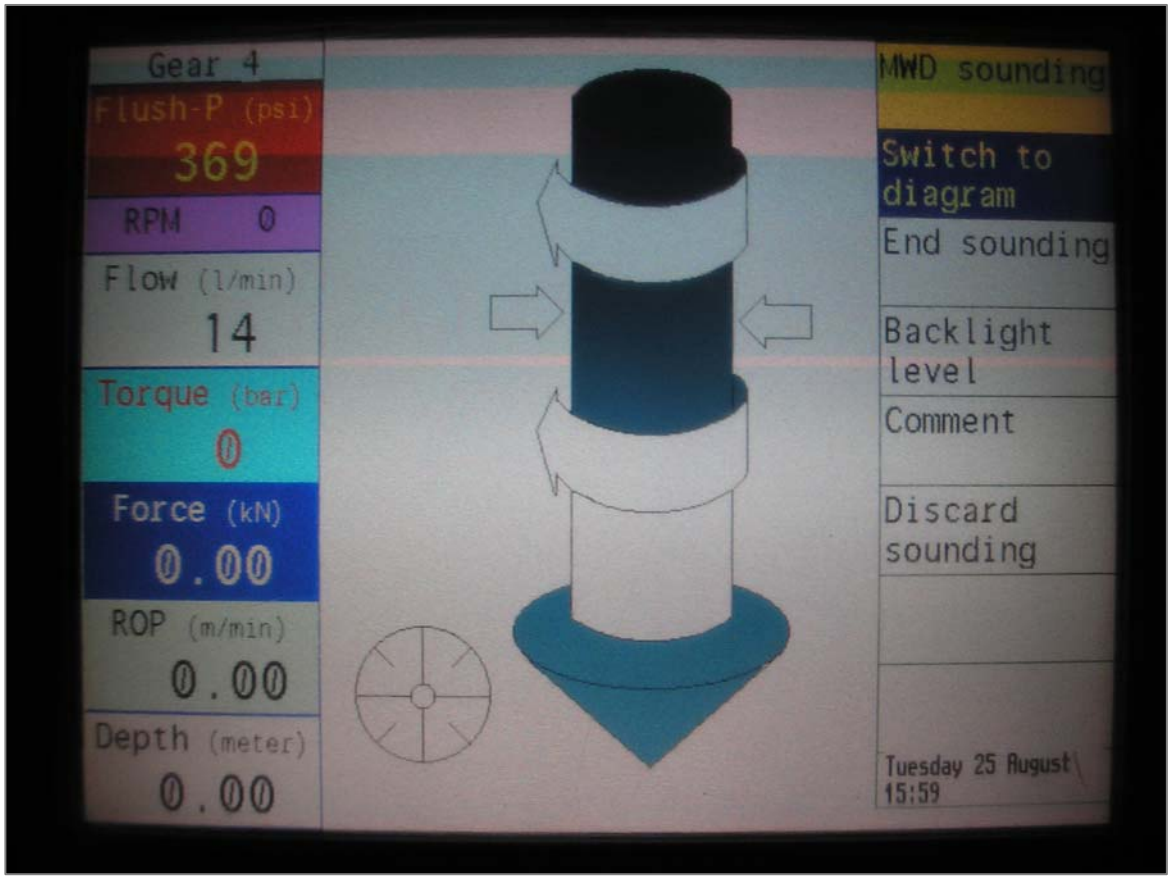
What is Displayed



- **Bit Load** – Directly influenced by ROP,
  - Check against variations in ROP;
- **Torque** – Heavily influenced by drill method.
- **Revolutions Per Minute.**
- **Flush pressure** – Directly influenced by rock mass characteristics;

How is it Recorded

Sounding N	573					
Date	02/09/2007					
Method	MWD					
Project	TYWARDREATH					
Id	BH1					
Depth (m)	ROP (m/min)	Force (kN)	Torque (MPa)	Flush pressure (psi)	Flow rate (l/min)	rpm
11.02	0.97	4.5	3.671	163.315	0	60
11.06	0.93	4.48	3.963	163.315	0	55
11.1	0.86	4.49	3.866	167.956	0	60
11.14	0.91	4.5	4.061	167.956	0	55
11.18	0.91	4.49	2.794	167.956	0	60
11.22	0.87	4.48	3.086	172.598	0	55
11.26	0.94	4.53	3.866	172.598	0	60
11.3	0.91	4.45	3.996	172.598	0	55
11.34	0.93	4.48	4.678	167.956	0	55
11.38	0.82	4.49	4.516	149.246	0	55
11.42	0.95	4.51	3.313	172.598	0	60
11.46	0.93	4.5	3.508	167.956	0	60
11.5	0.88	4.49	4.028	172.598	0	55
11.54	0.81	4.5	4.256	172.598	0	60
11.58	0.86	4.52	3.508	177.239	0	55
11.62	0.81	4.51	3.638	177.239	0	55
11.66	0.61	4.51	3.736	172.598	0	0
11.7	0.69	4.55	3.736	177.239	0	55
11.74	0.8	4.56	3.671	177.239	0	55
11.78	0.78	4.56	3.606	177.239	0	55
11.82	0.74	4.54	3.766	177.355	0	47
11.86	0.73	4.54	3.765	178.008	0	46

- Initially recorded as text file or STD file
- Floppy disk or USB

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Specific Energy?

Combination of all recorded parameters Specific Energy:

- Excellent method of clarifying plots and identifying voids.
- There have been attempts to correlate this to ground strength – so far without success.
- Manual interpretation of plots.

Underground coring rig, complete with MWD, allows remote operation from surface. Photograph courtesy of Atlas Copco

Specific Energy:

$$E_s = \frac{F}{A} + \frac{2 \pi N T}{A V}$$

F(kN) = Bit load

A (m^2) = Area of Bit

N = RPM

T (kN x m) = Torque

V (m/sec) = ROP

What are its uses and advantages (1)

Abandoned Limestone quarry face, Europe

Road cutting, West Africa

- Voids identification, dissolution or man made cavities.
- Identification of fracture zones including where zones of core loss encountered.
- Probe drilling.
- Combined with coring reduce the number of cored holes required.
- Detecting contrasts between materials e.g. flint bands, mineral exploration, coal.

Open joint from Lincolnshire Limestone, Ketton Quarry. Photo graph courtesy of P. del Strother

What are its uses and advantages (2)

Man made cavities in Chalk. Photograph courtesy of CIRIA.

- Depth control - Very accurate depth readings.
- Near continuous data profile of ground.
- More efficient coring operations.
- Assists drillers in gaining a feel for the ground – beneficial for training.
- Scandinavian drillers are now able to determine rock type from sounding plots.

HQ core recovery voided Limestone

- Consistent between drilling techniques.
- Quality control & monitoring.

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Limitations

Rotary coring supplemented by MWD for geotechnical investigations for potential nuclear waste depository sites, Sweden. Photograph courtesy of Environmental Mechanics, SE

- Set-up cost.
- Driller influence.
- Requires experienced and trained drillers and those that are interested in development and training.
- Requires sensors for each rig.

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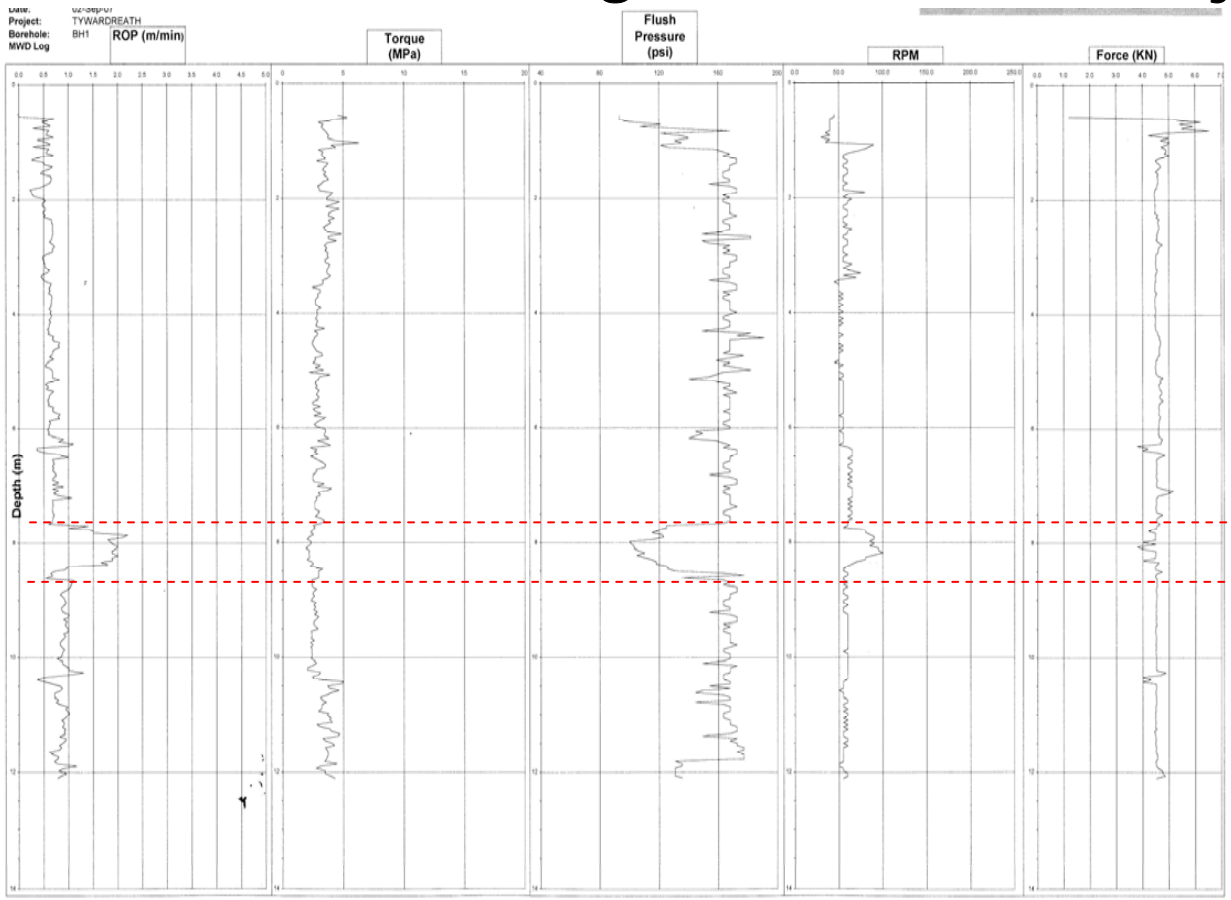
Case Study 1 – Identification of mines workings beneath railway

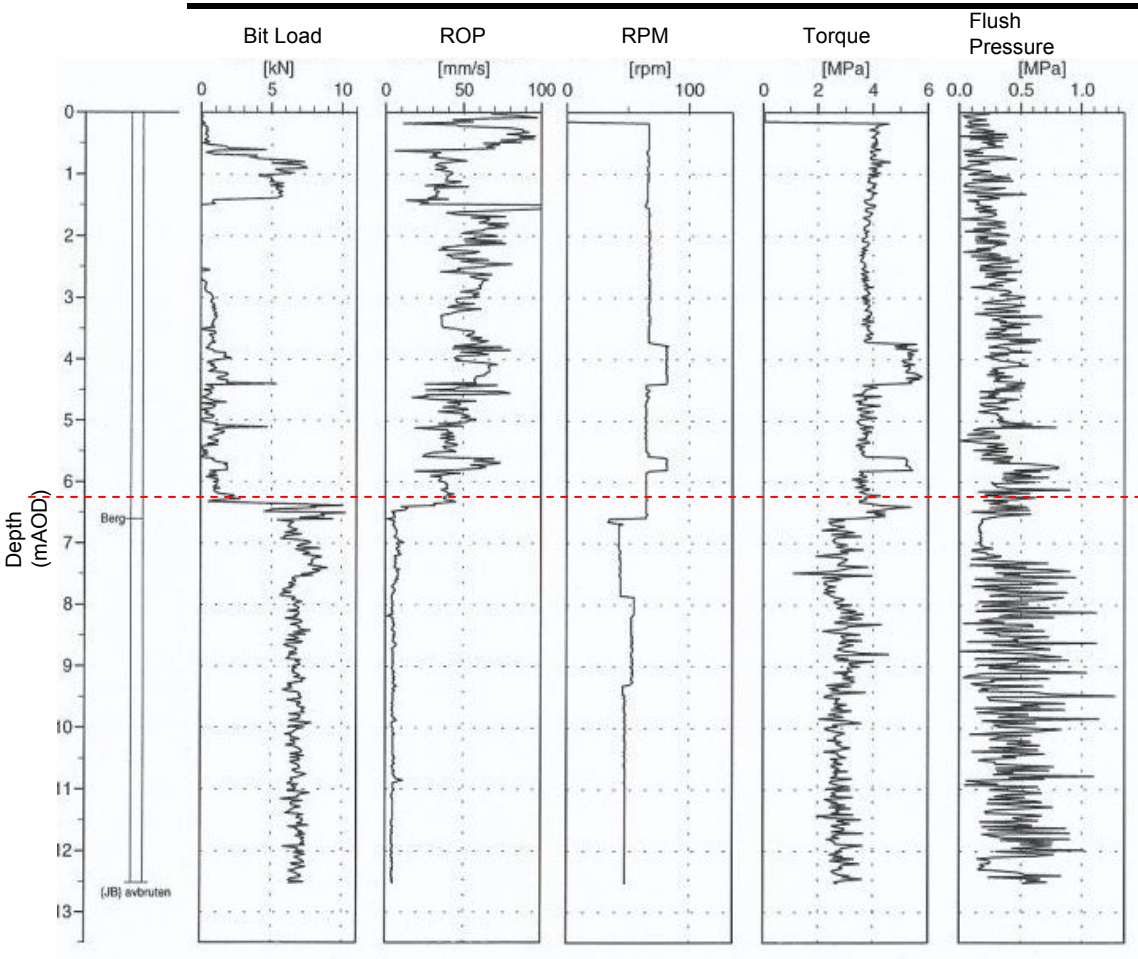


Techniques included:

- Overburden casing system;
- Rotary open-hole follow on;
- Voids identified

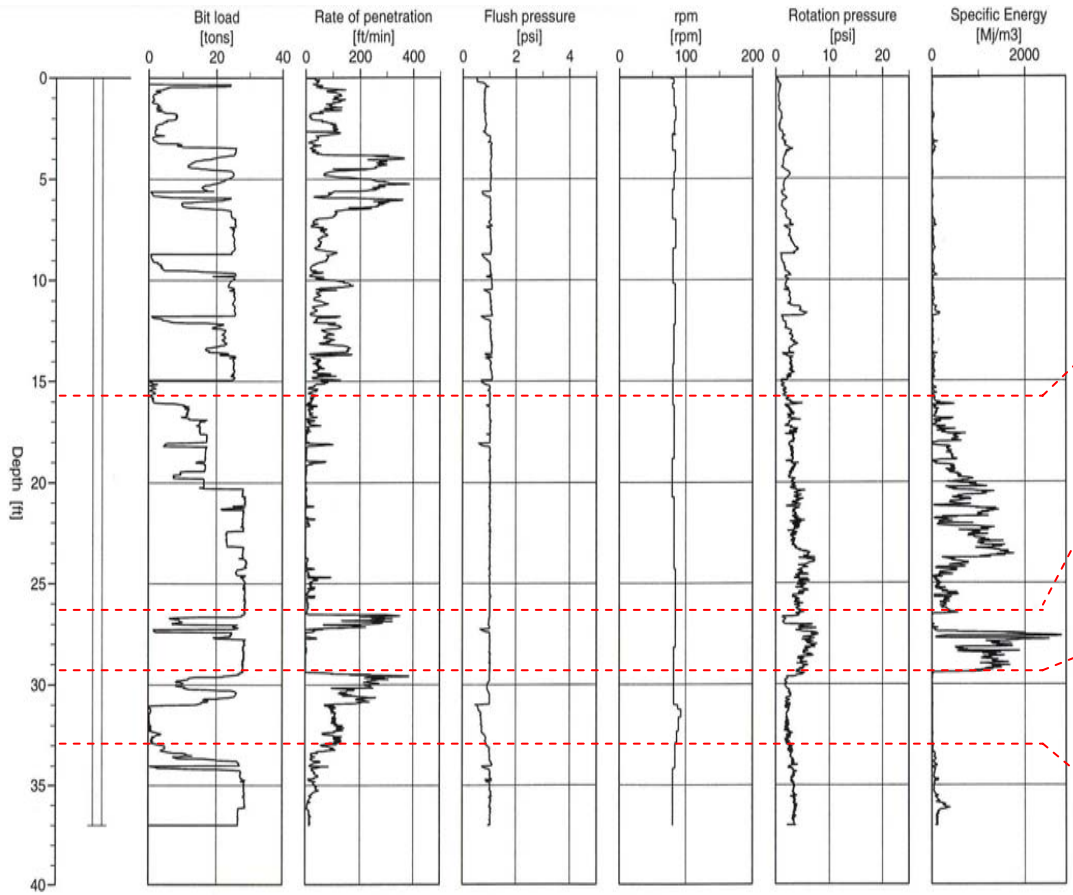
- 7.75m to 8.65m - VOID, rapid drop in flush pressure large increase in ROP.

Case Study 2 – Identification of material boundaries and zones of core loss



- Variable recoveries (70 to 80%);
- Core loss identification
- Change of drill parameters clearly defines material boundary;
- Good core recovery, high RQD
- You would not expect bad recovery in this material – quality control

Case Study 3 - Probing for voids



Ground conditions, made ground over ground identified as containing voids.

- 0m to 16m - Variable weak materials. Note rapid variations ROP, fractured zones
- 16m to 26m – Material boundary, bit load increases ROP decreases
- 26m to 29m - VOID between 26m and 27m.
- 29m to 33m - VOID, rapid drop in flush pressure with slow increase as void fills.

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The Future

Mine control room, Zinkgruvan, Sweden, including automated drill rigs. Photograph courtesy of Atlas Copco

- Potential future inclusion in Eurocode Standards, it is already proposed as a Work Item.
- MWD plots become common-place in ground investigations.
- Improved
- Automated Drill systems.
- These are already in operation in mining sector, underground and blast hole.
- Determination of classical rock properties such as strength???

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Director
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