Cairo University
Faculty of Engineering
Public Works Department
Soil Mechanics and Foundations Research Laboratory

Engineering Geology

Lecturer:

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Acknowledgement

- Herbert Einstein
- Richard Bateman
- Mark Zoback
- Kshitija Nadgouda
- Earth and Science Teachers Association
- Attaullah Shah
- Pedram Rostami
- Frederick Ennin
- An introduction to Geophysical Methods
- www.geoengineer.org
- Erik Eberhardt
- Western Carolina University

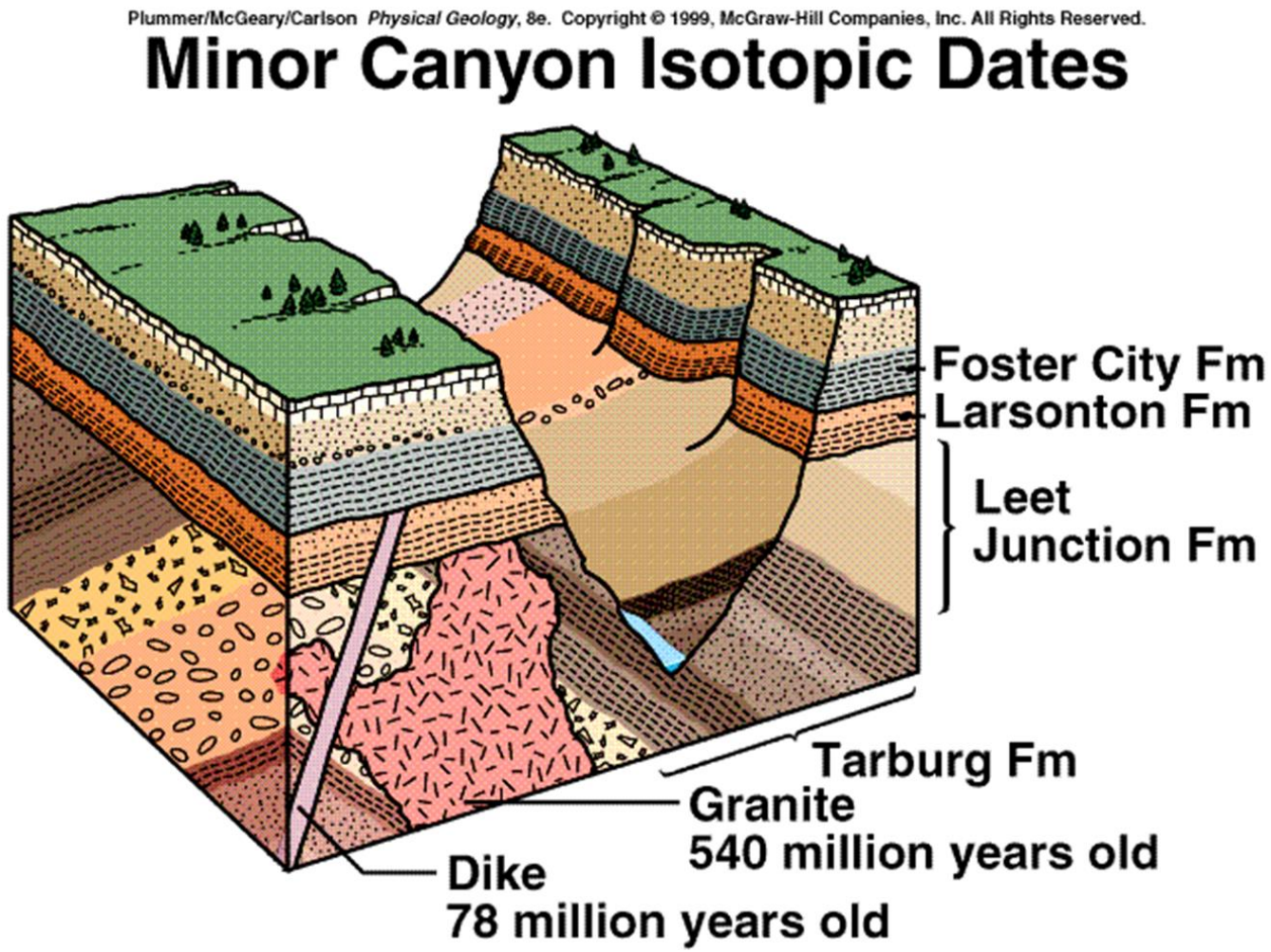
Site Investigation

Lecture 6

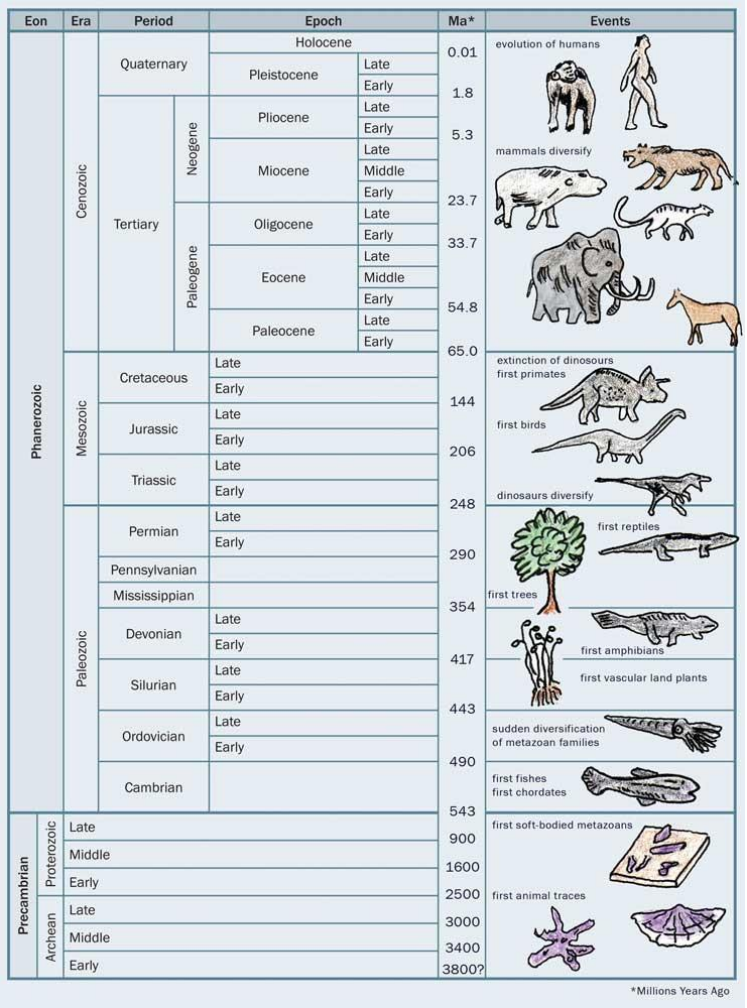
Outline

- A brief mention for geologic times.
- What do engineers and geologists do for site investigation?

Absolute Time



Standard Geologic Time



SOIL INVESTIGATION

- **Determination of surface and subsurface soil conditions and features in an area of proposed construction that may influence the design and construction and address expected post construction problems.**

SCOPE OF INVESTIGATION

Direct Methods: Grabbing Cores and examining them in the lab.
Indirect Methods: Measuring physical properties like wave velocity or electric resistivity and inferring rock properties.

DIRECT METHODS

Methods of Boring

There are several types of boring; open pits, Augers, Wash borings, Manual Drilling, Rotary Drilling, Coring, Percussion Drilling.

- Core drilling
  - Used for obtaining rock cores.
  - A core barrel is fitted with a drill bit is attached to hollow drill rods.
  - Examples: diamond coring, calyx or shot core drilling

Coring

Drill Bits

Tricone drill bit

Diamond Drill Bit

Rotary Drilling

- Hollow drill rods with a drill bit is rotated into the soil. Drilling mud is continuously pumped into the hole. The bit grinds the soil and the return flow brings the cuttings to the surface.

  - Water/drilling fluid Cycle
  - Cooling
  - Lubrication
  - Side Support

Drilling Fluid

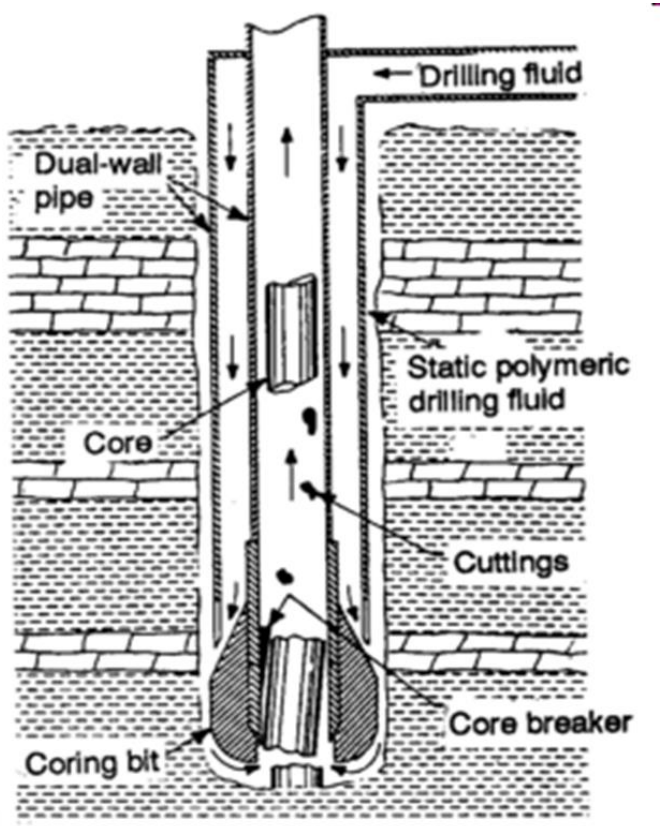


Figure 11-1. Core-drilling equipment

- Triple tube core barrel
- Wire line

Percussion Drilling

- Grinding the soil by repeated lifting and dropping of heavy chisels or drilling bits.
- Water is added to form slurry of cuttings.
- Observe mineralogy
- Observe penetration rate

Installations & Instrumentation

Boreholes also enable the installation of instrumentation for the measurement of various factors. Instrumentation may include

a) extensometers / inclinometers for the measurement of ground movement;

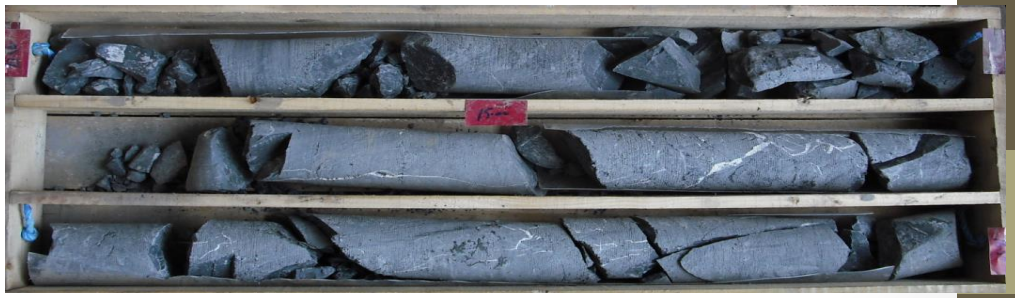
b) standpipes and piezometers allowing the monitoring of ground water and gas regimes.

Rock cores

Testing for core for rock strength to left.

Selection rock cores to right.

Storage of rock cores bottom right



Measurements

- $Core\ Recovery\ (CR) = \frac{length\ of\ core\ recovered}{length\ of\ rock\ cored\ (drill\ length)}$

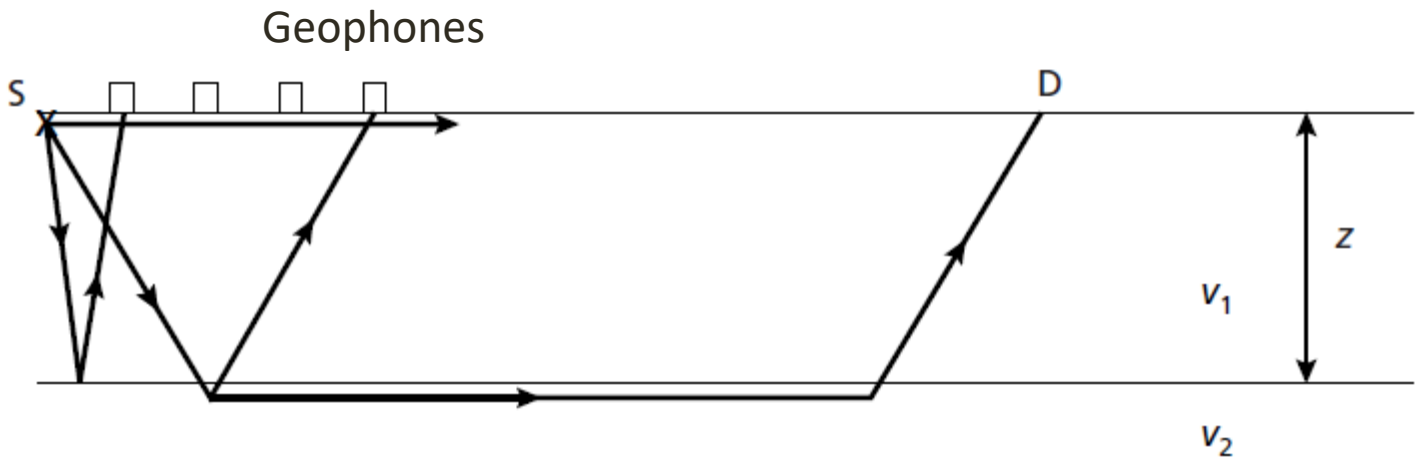
- $Rock\ Quality\ Designation = \frac{\sum length\ of\ recoverred\ pieces > 10cm}{Length\ of\ rock\ cored}$

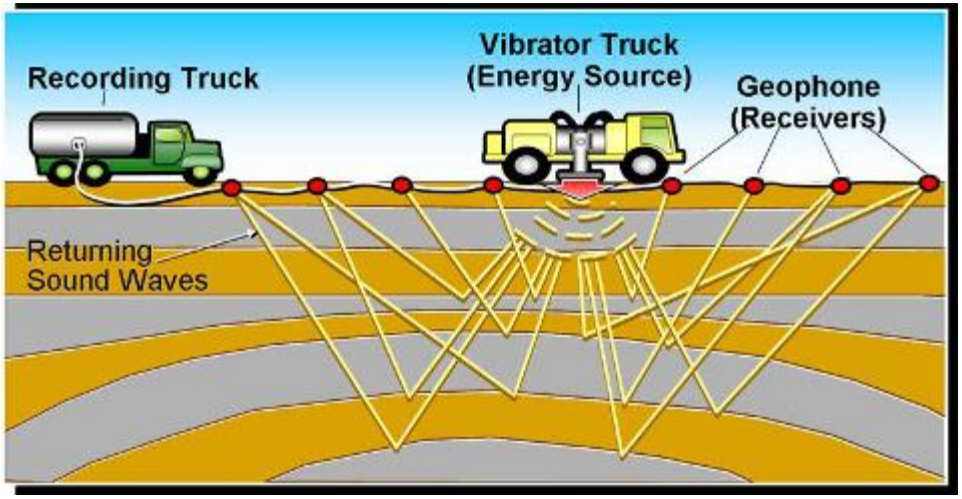
Grading

RQD	Quality
0 - 0.25	Very Poor
0.25 - 0.5	Poor
0.5 - 0.75	Fair
0.75 - 0.9	Good
0.9 - 1.0	Excellent

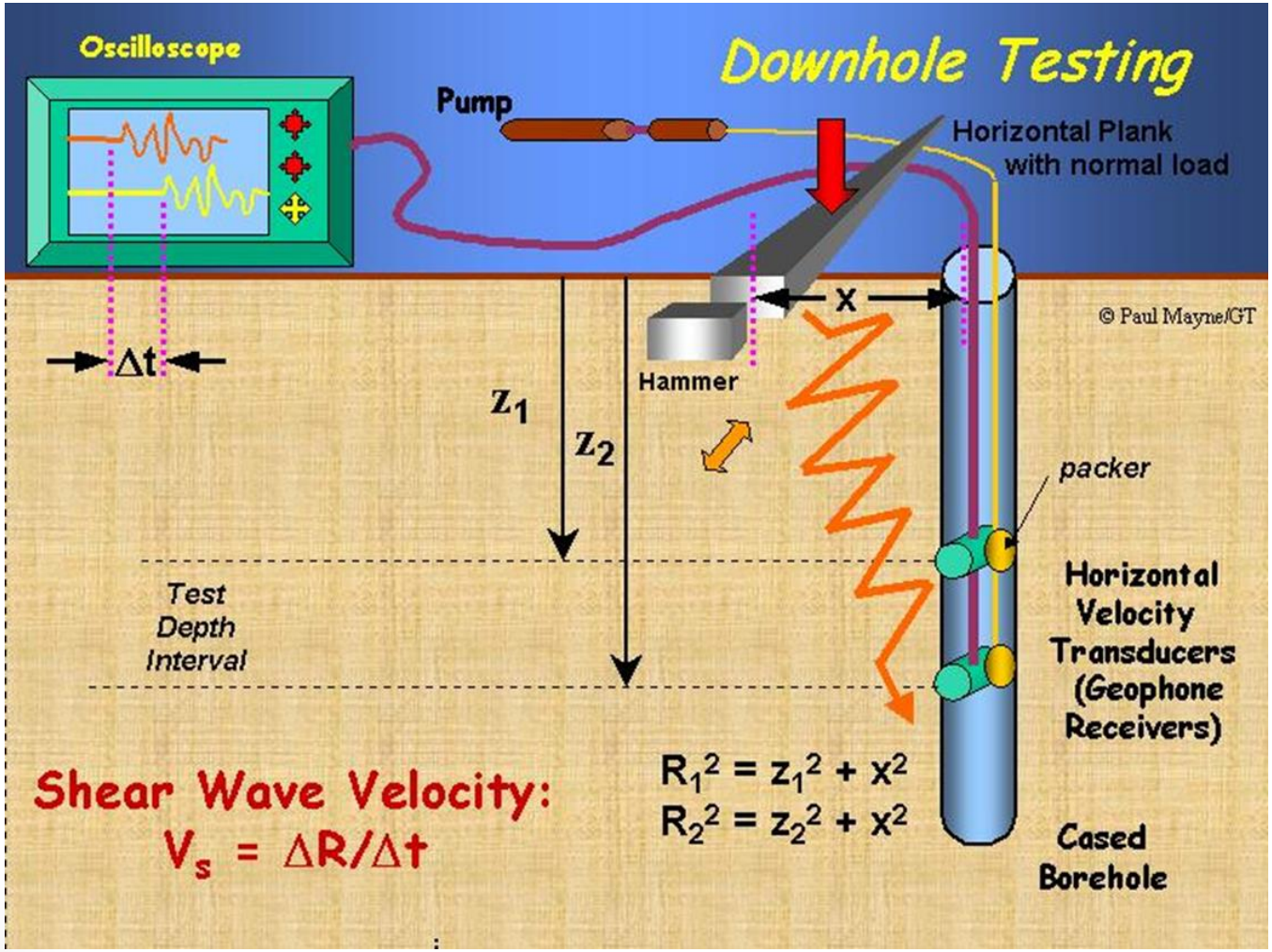
INDIRECT METHODS

Geophysical Methods

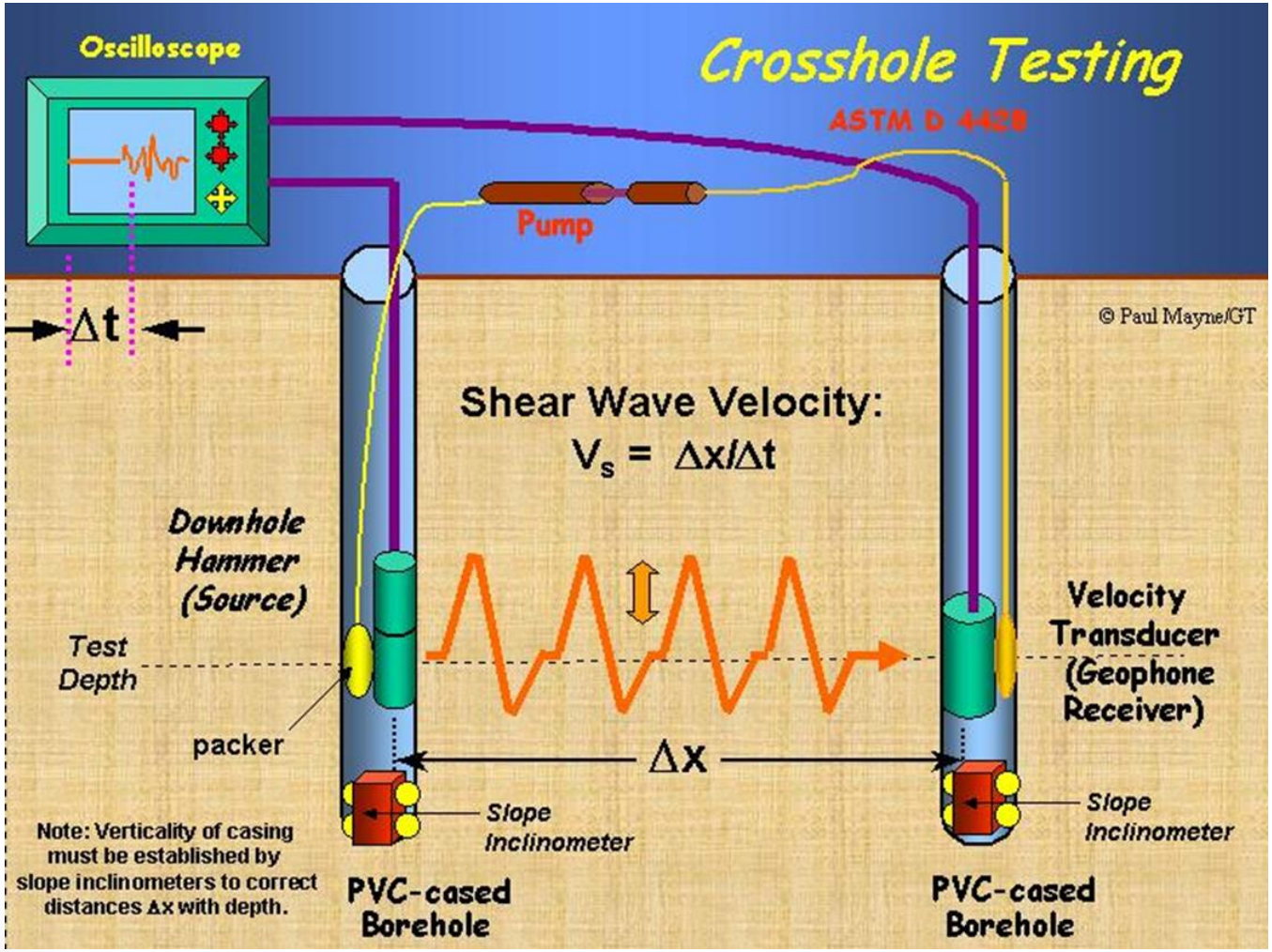




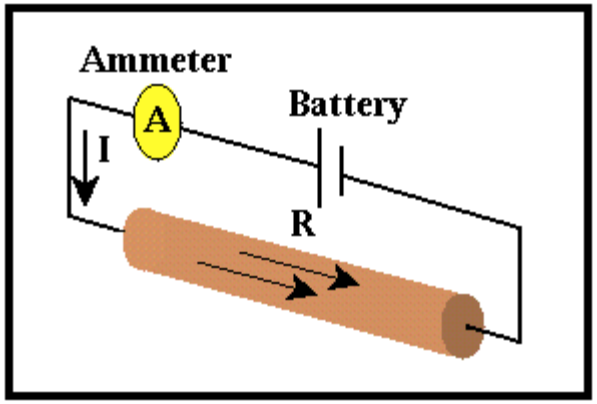
Down-hole and Cross-hole

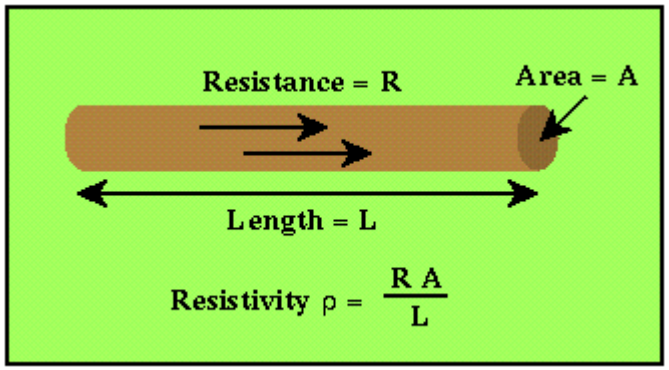


Down-hole and Cross-hole



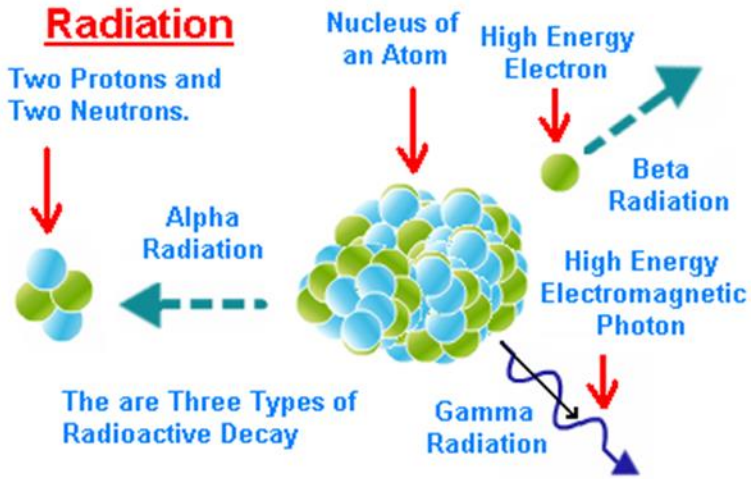
Electric Logs





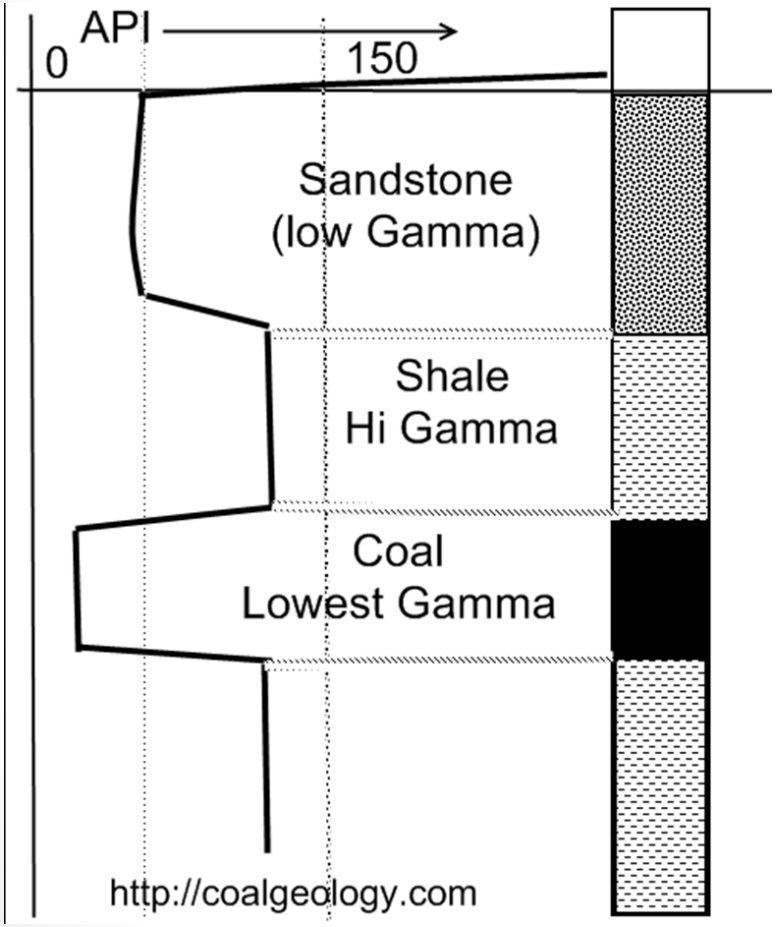
- You can correlate resistivity to type of rock, degree of saturation, type of fluid filling the pores.

Radiometric Logs



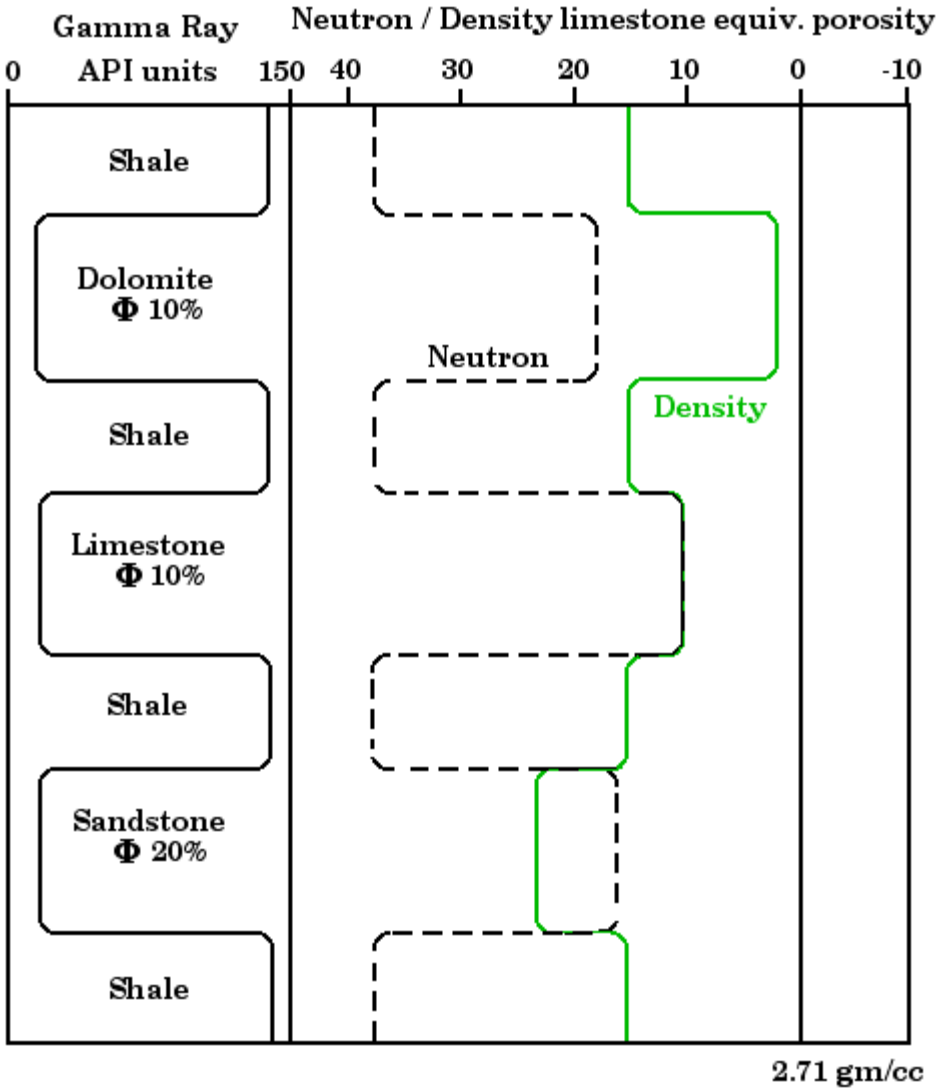
- Gamma Logs
- Density Logs
- Neutron Logs
- Correlations with porosity

Radiometric logs: Gamma Logs



- Detect emissions from Potassium (K), Thorium (T), and Uranium (U)
- Most clay minerals are rich with potassium.
- All Clay minerals adsorb Thorium

Neutron and Density Logs

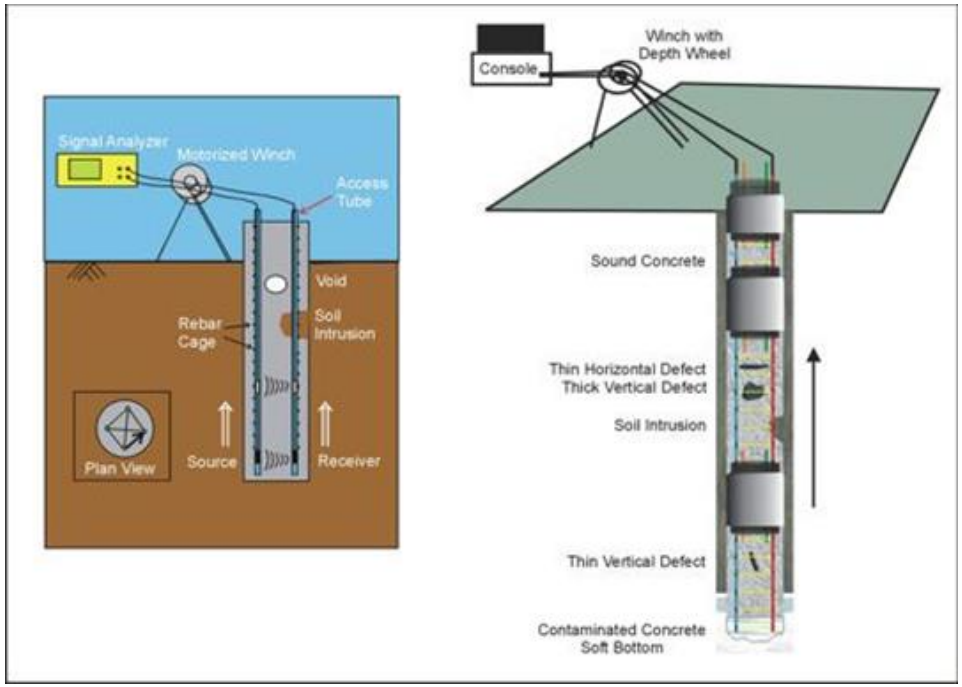


Sonic Logs

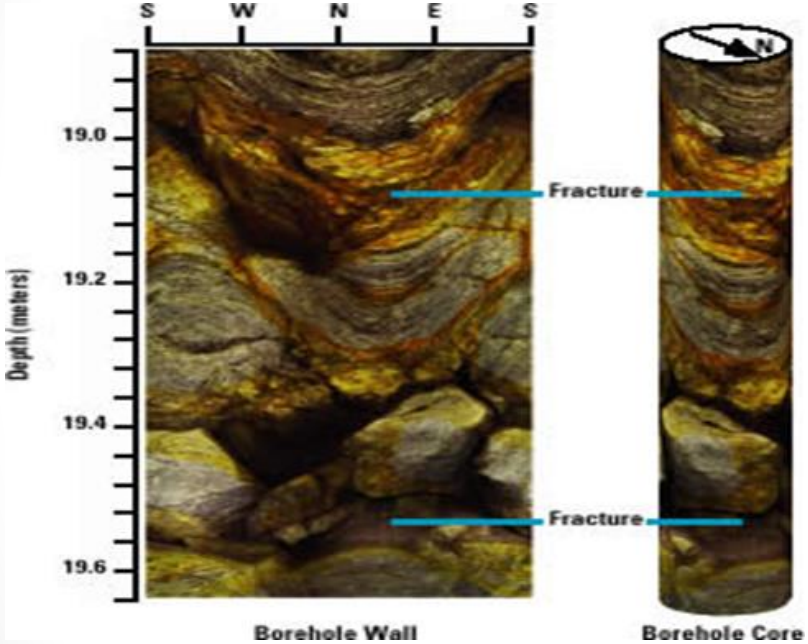
works by transmitting a sound through the rocks of the borehole wall

Consists of two parts:

transmitter and receivers separated by rubber connector to reduce the amount of direct transmission of acoustic energy along the tool from transmitter to receiver



Borehole Images



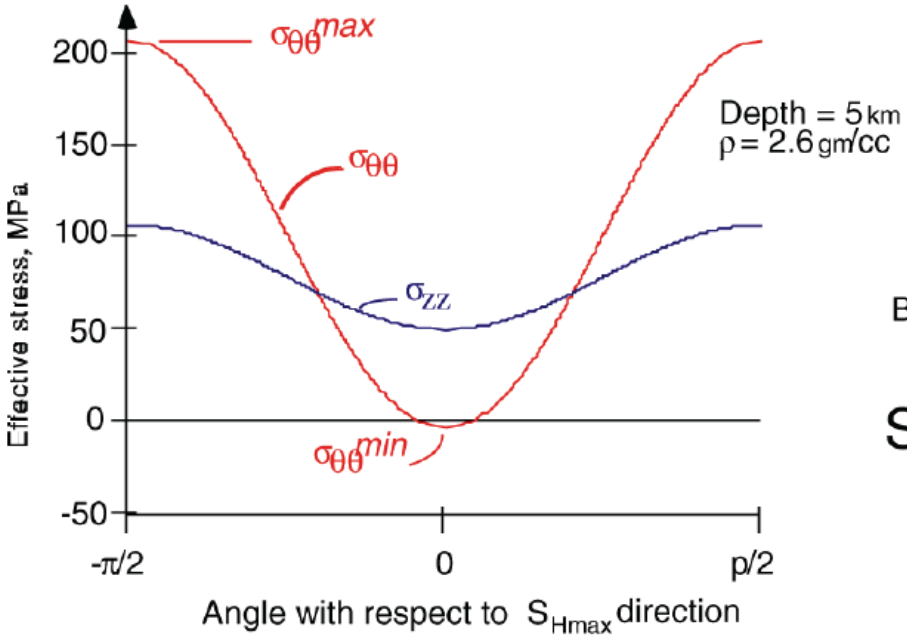
- Borehole scanner using acoustic beams
- Borehole images using reflective cones

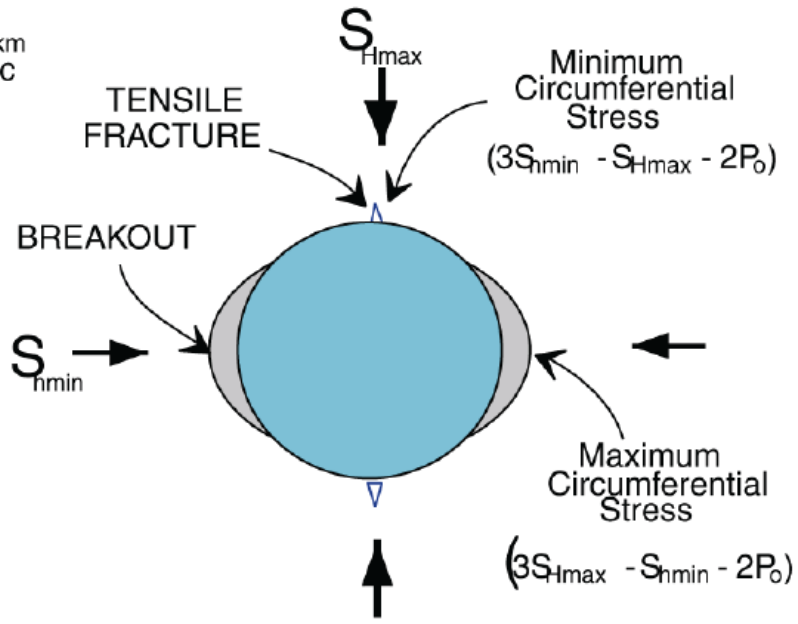
Calipers

caliper used to measure the diameter of a borehole and its variability with depth.

motion in and out from the borehole wall is recorded electrically and transmitted to surface recording equipment

Importance


200
150
100
50
0
-50
Effective stress, MPa
$\sigma_{\theta\theta}^{max}$
$\sigma_{\theta\theta}$
σ_{ZZ}
$\sigma_{\theta\theta}^{min}$
Depth = 5 km
ρ = 2.6 gm/cc
-π/2
0
p/2
Angle with respect to S_{Hmax} direction


S_{Hmax}
TENSILE FRACTURE
Minimum Circumferential Stress
$(3S_{hmin} - S_{Hmax} - 2P_o)$
BREAKOUT
S_{hmin}
Maximum Circumferential Stress
$(3S_{Hmax} - S_{hmin} - 2P_o)$

PLANNING TIPS

Methods of Sampling

- Requirements to minimize disturbance to samples
  - Area ratio = $\frac{(D^2_w - D^2_e)}{D^2_e} \times 100\%$
  - Area ratio should be as low as possible. (<10%).
  - It represents the amount of soil displaced.
  - Inside clearance = $\frac{(D_s - D_e)}{D_e} \times 100\%$

    ratio

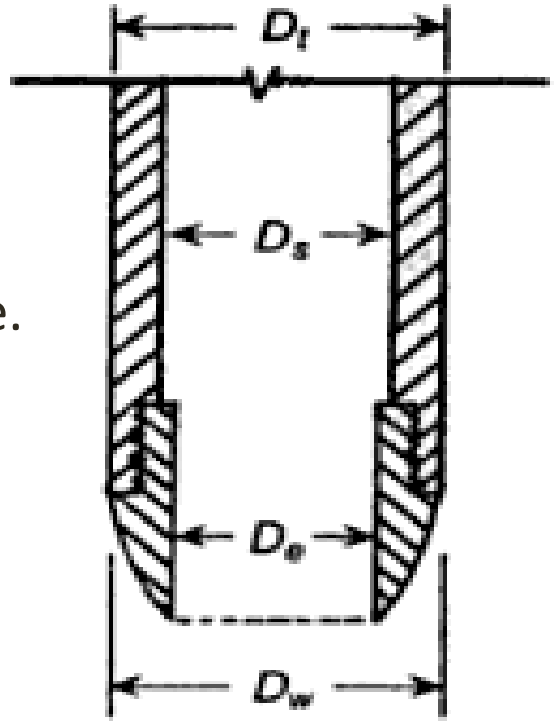
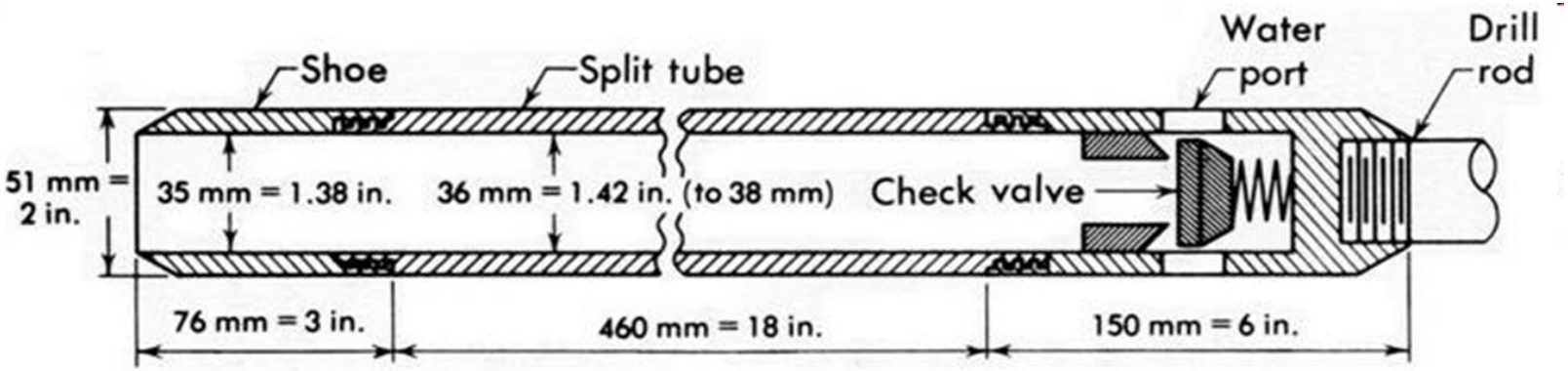


Fig. 2.8 Sampling tube.

For Soils: SPT



- Very High Area Ratio
- Very Disturbed Sample$_s$

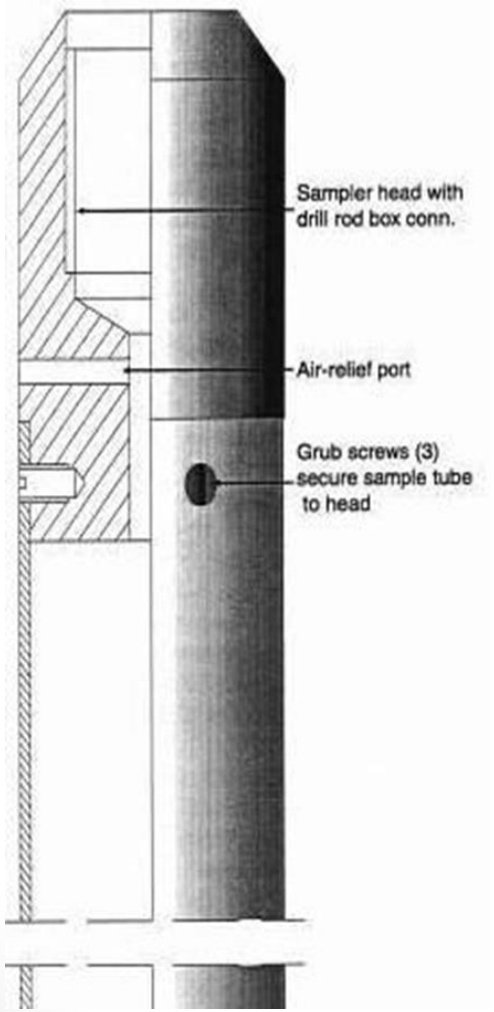
Correlations between N values and soil properties

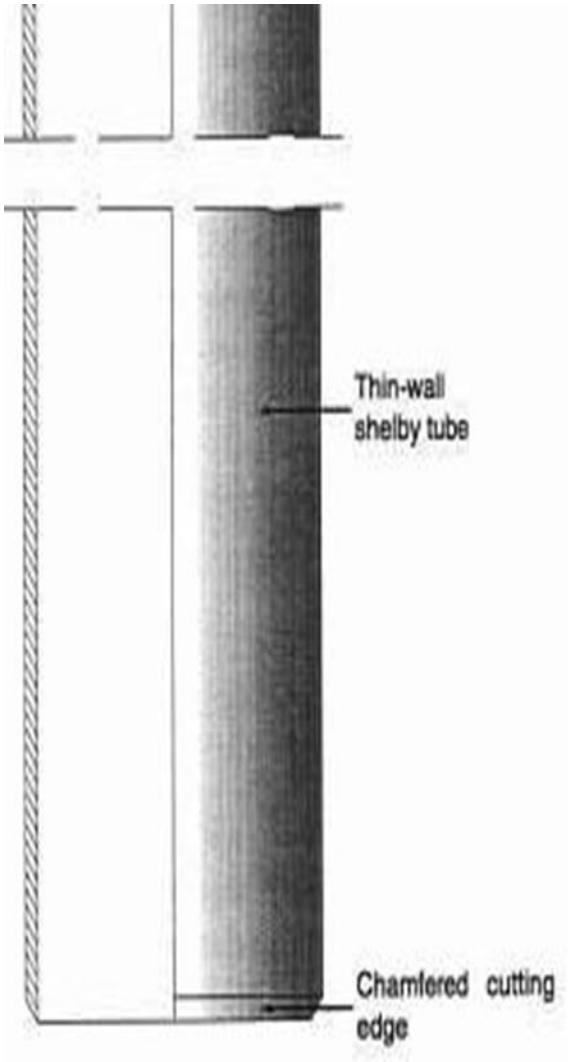
N	Compactness	Relative Density (%)	ϕ^o
0 to 4	Very Loose	0-15	< 28
4 to 10	Loose	15 - 35	28 -30
10 to 30	Medium Dense	25 - 65	30 -36
> 50	Very Dense	> 85	> 41

Correlations between N values and soil properties

Consistency	N	qu (kPa)
Very Soft	0 to 2	< 25
Soft	2 to 4	25 to 50
Medium Stiff	4 to 8	50 to 100
Stiff	8 to 12	100 to 200
Very Stiff	15 to 30	200 to 400
Hard	> 30	> 400

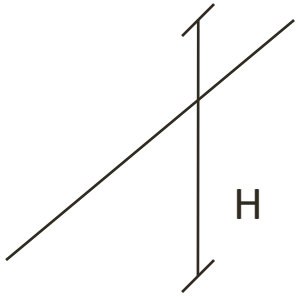
For Soils: Shelby Tube





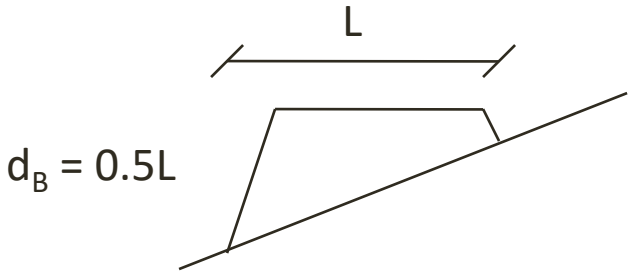
Boring Depth Recommendations

SLOPE

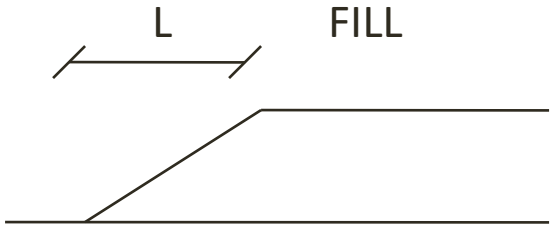


$0.75H < d_B < 1.5H$

Embankment

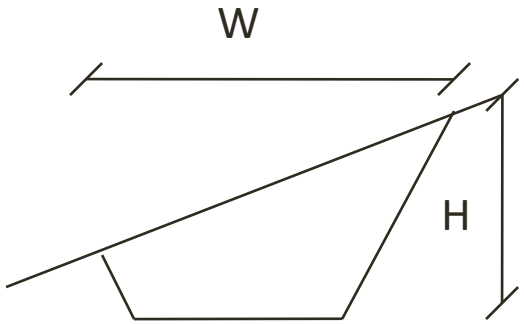


$d_B = 0.5L$



$d_B = 1.25L$

CUT



$d_B = H + 0.5W$

THANK YOU