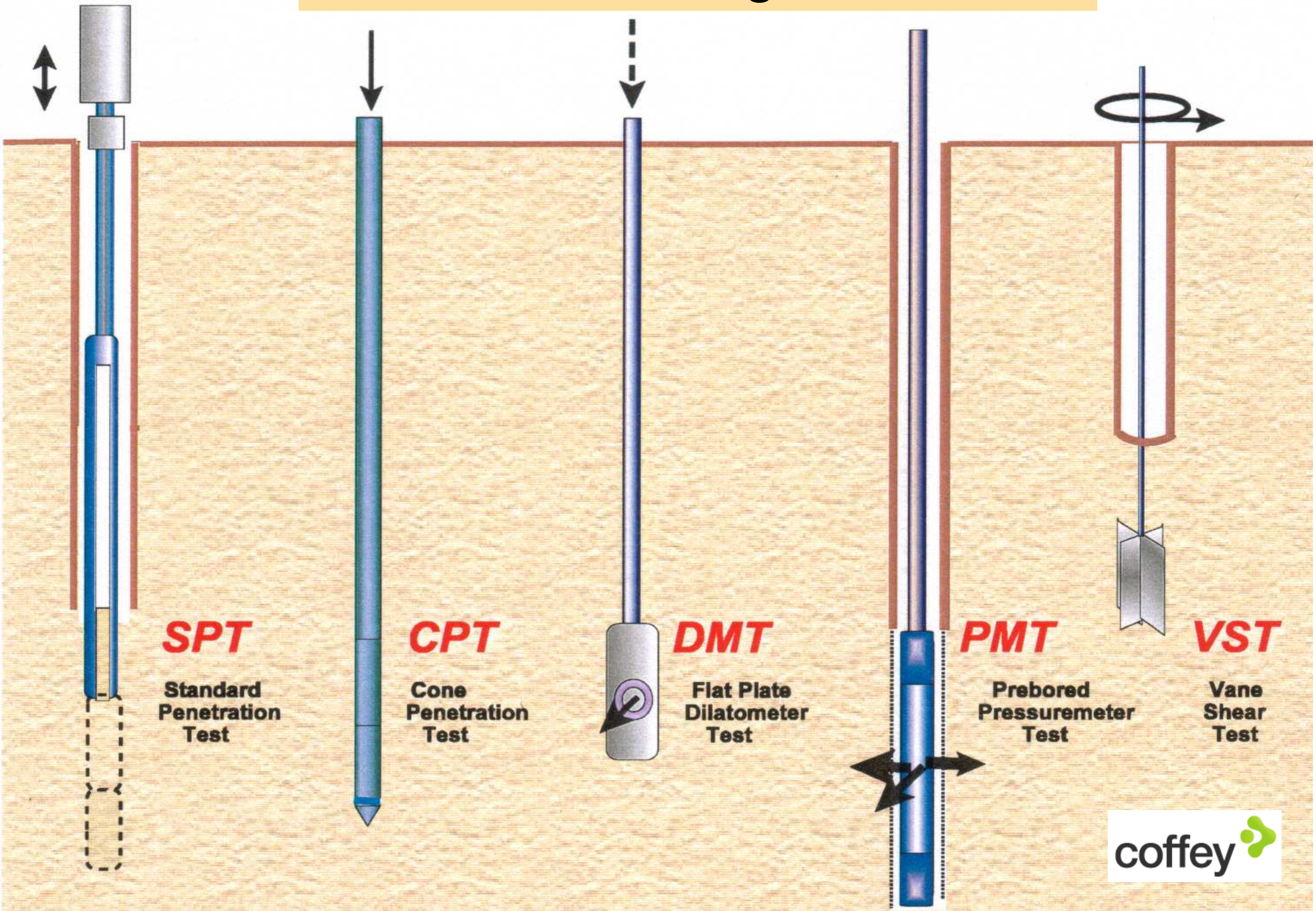
Geophysics Case Studies: Soft Soils & Fills

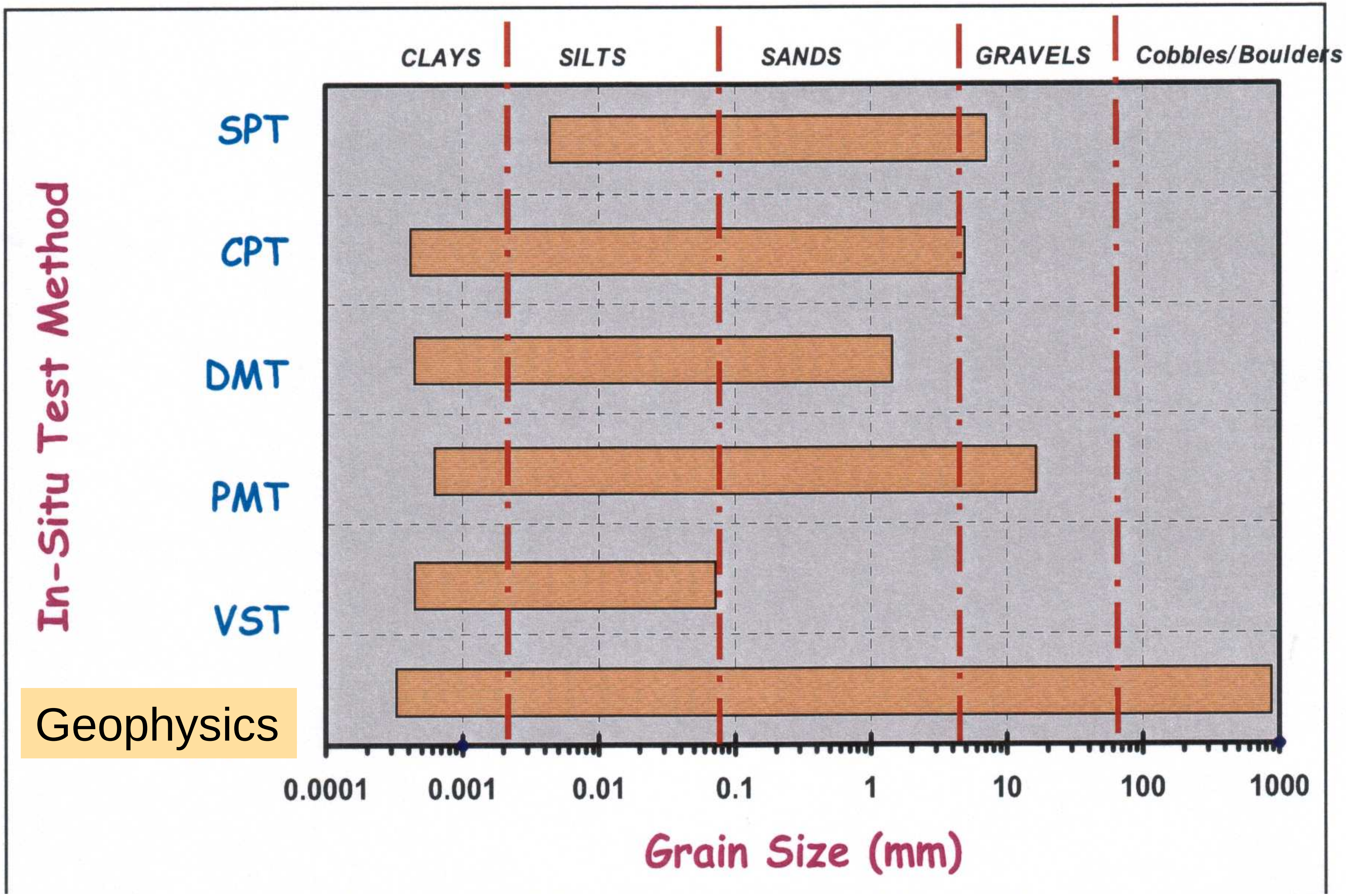
Prof. Bob Whiteley

Senior Principal

In Situ soil testing methods



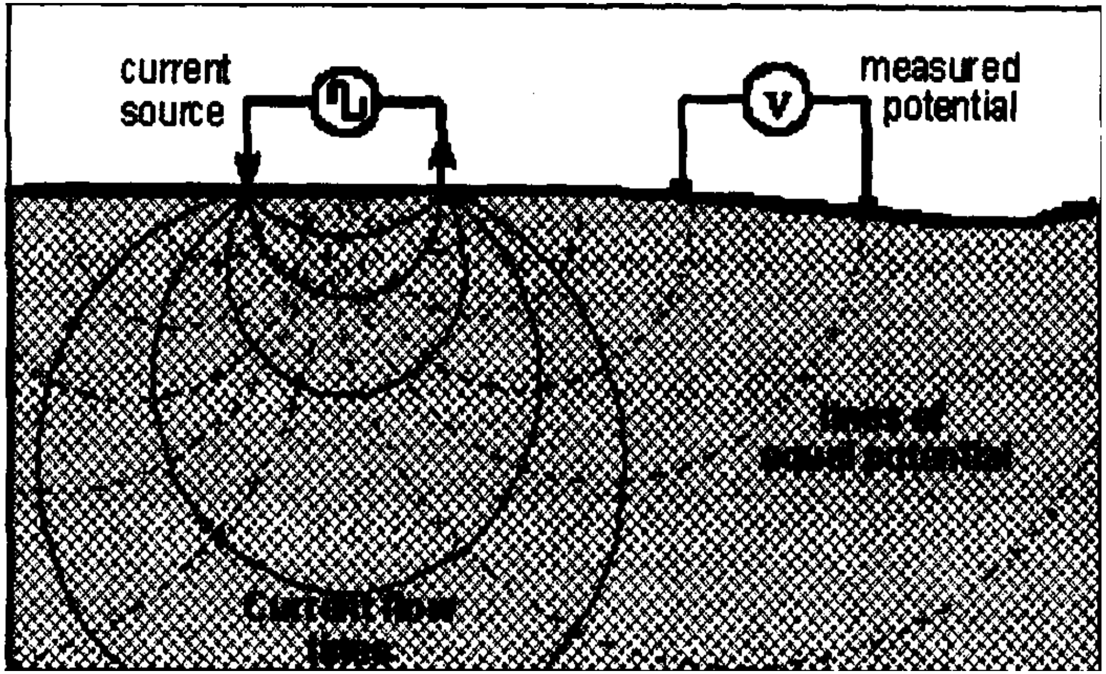
RELEVANCE OF IN-SITU TESTS TO DIFFERENT SOIL TYPES



Useful Geophysical Technologies

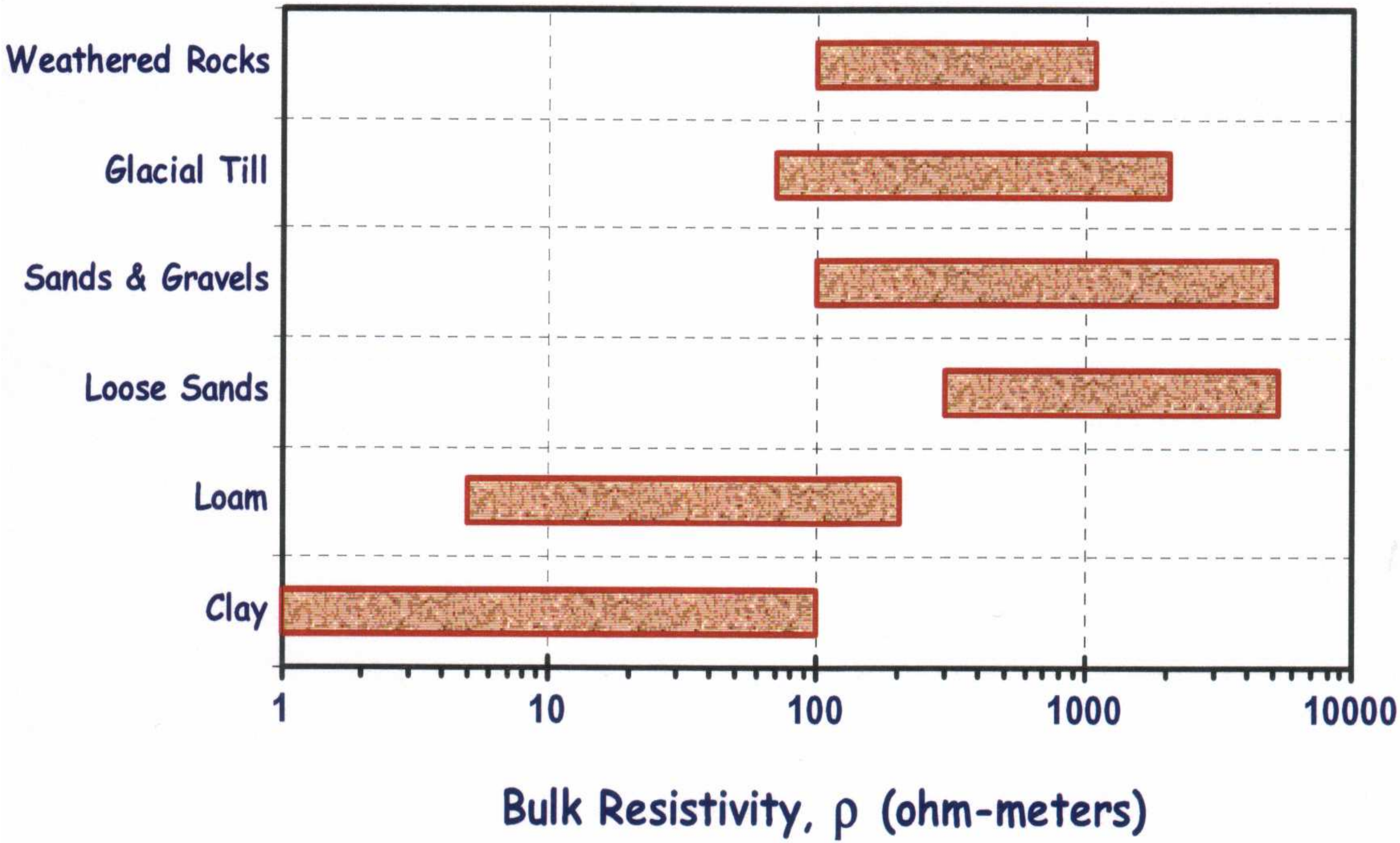
- Electrical Resistivity Imaging
- Seismic Refraction
- MASW
- Resistivity & Gamma ray logging
- VSSP
- Borehole seismic imaging

Resistivity Field Operations



Apparent Resistivity = Electrode Geometry x Resistance

Resistivity Values



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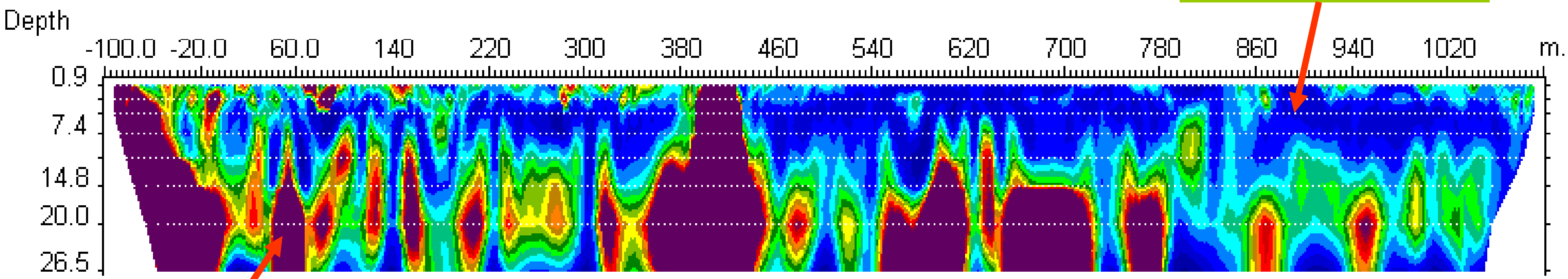
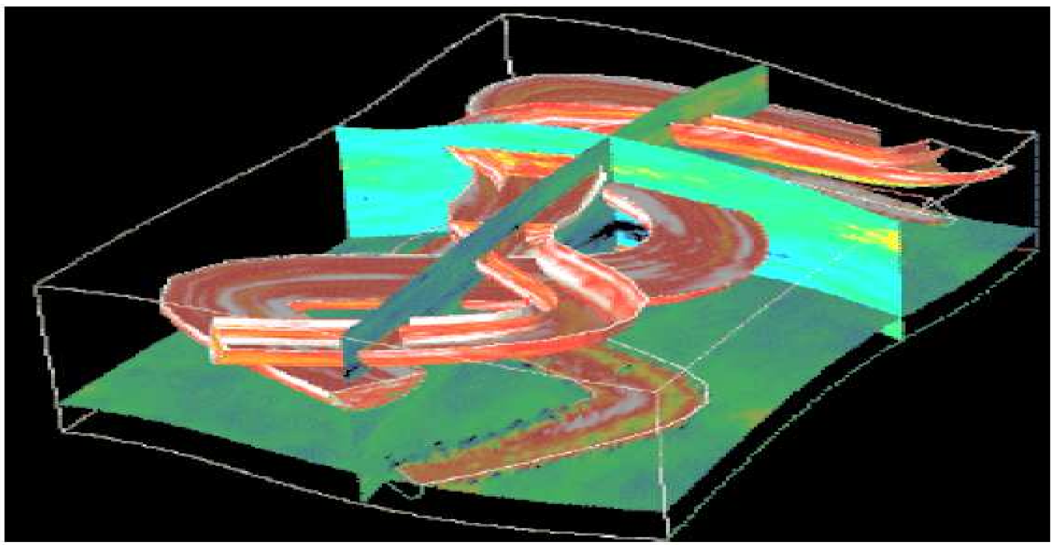
Electrical Resistivity Image Section showing repeated crossings of shallow and deep channels

Silts and clays low resistivity



Sands/gravels high resistivity

Schematic of meandering channels



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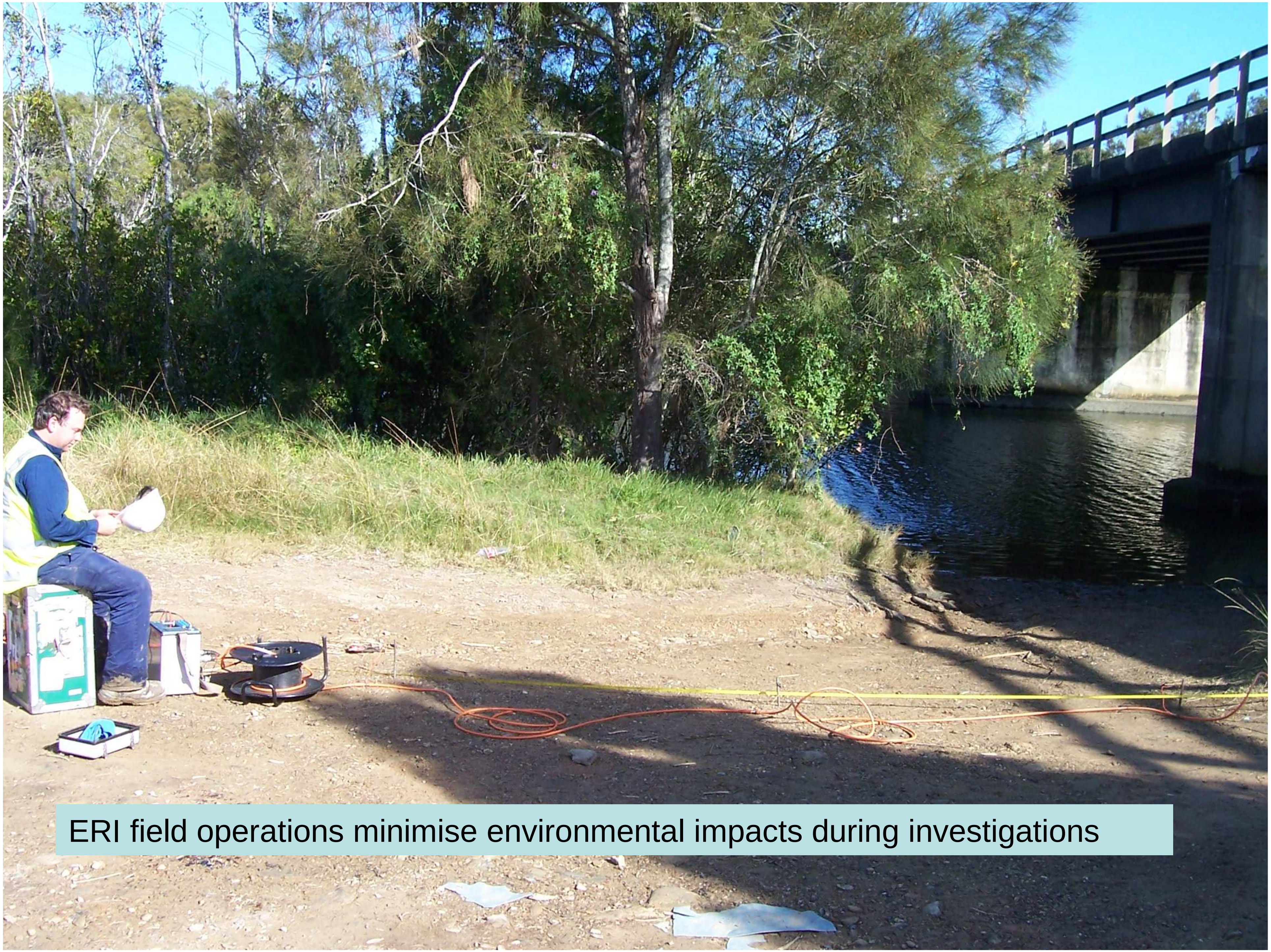
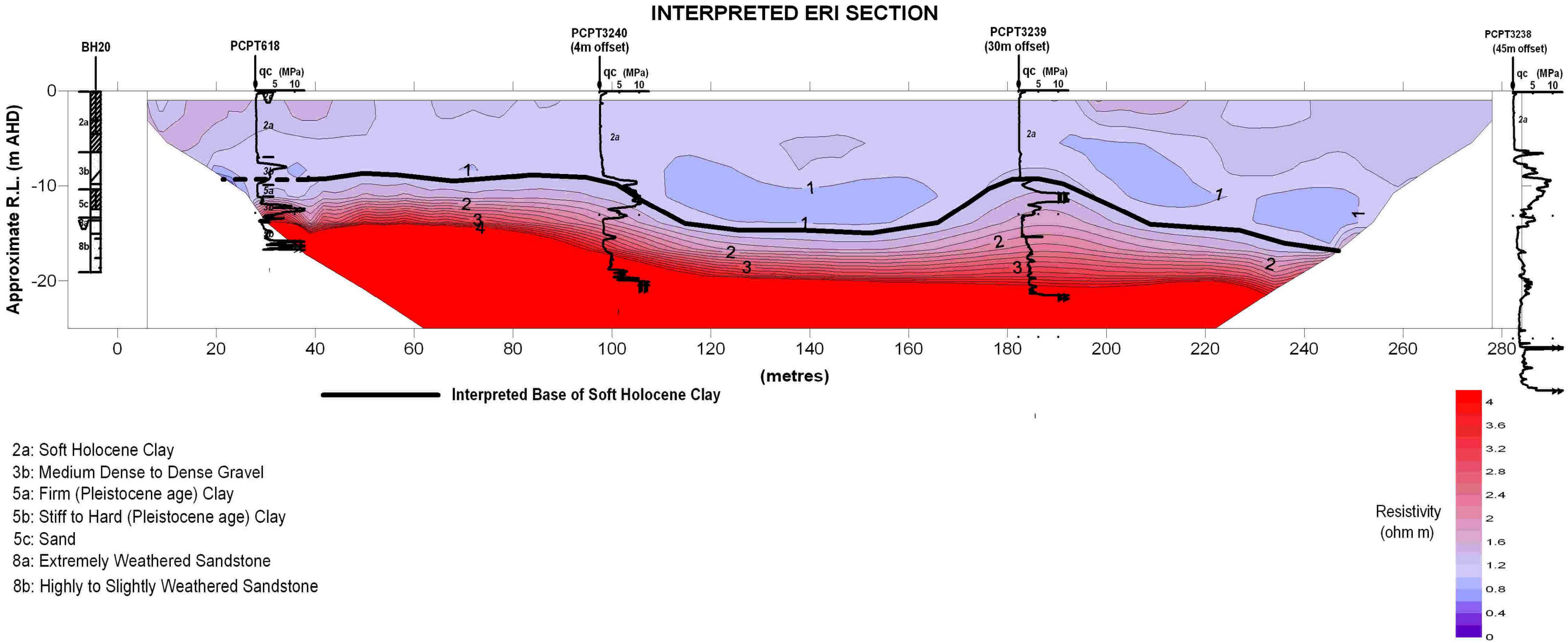
Highway duplication on soft soils

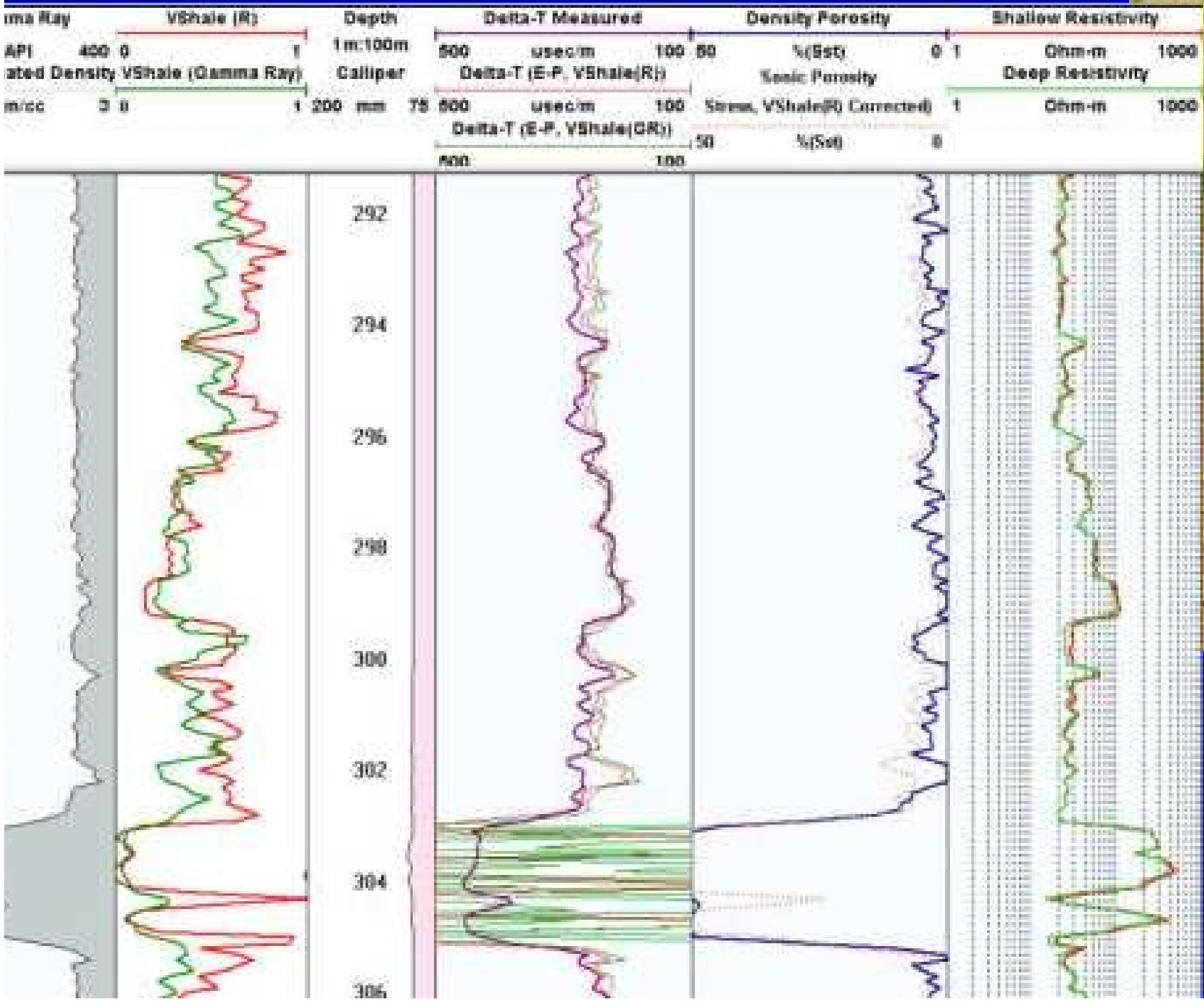


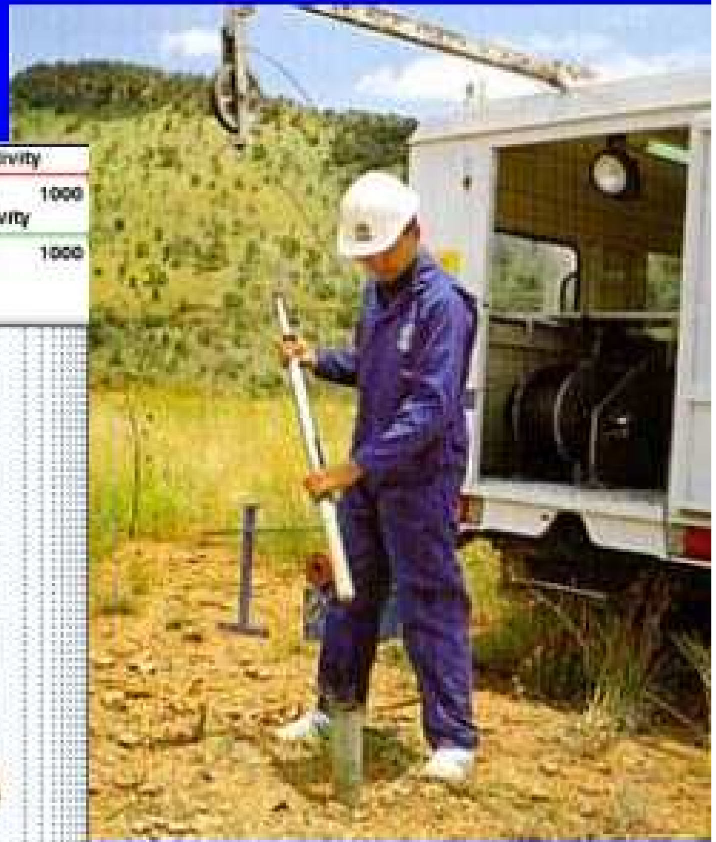
ERI field operations minimise environmental impacts during investigations

Mapping base of Holocene Clays



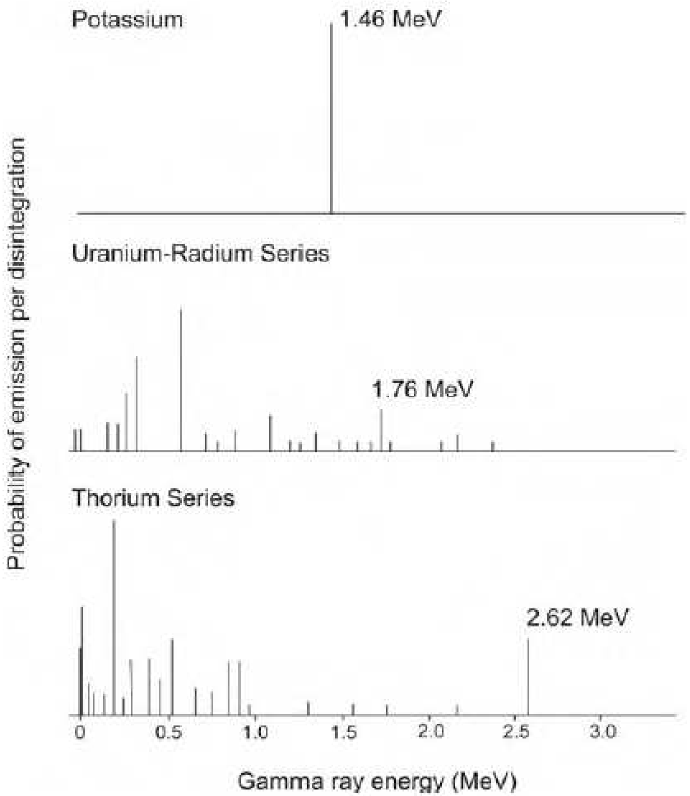
Geophysical or Wireline Logging

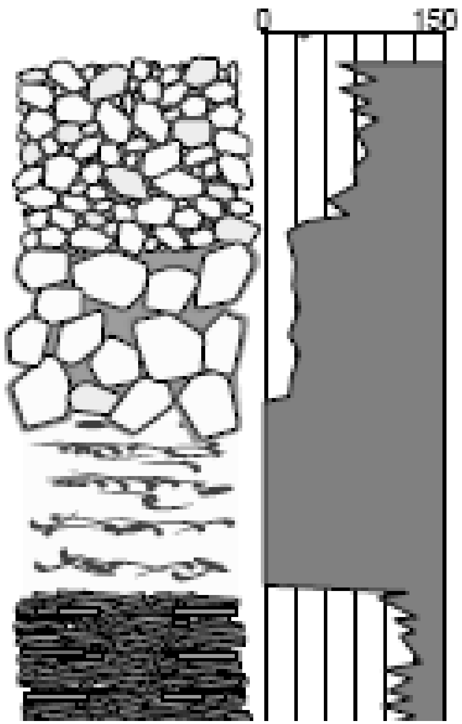




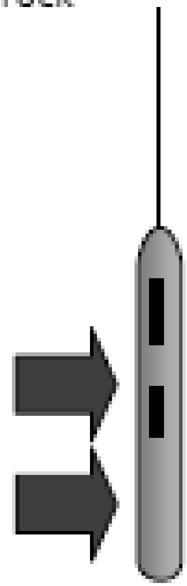
Gamma Ray Logging

Passive instrument; measures natural radioactivity of rock





- Mostly K^{40}
- K-rich rocks.



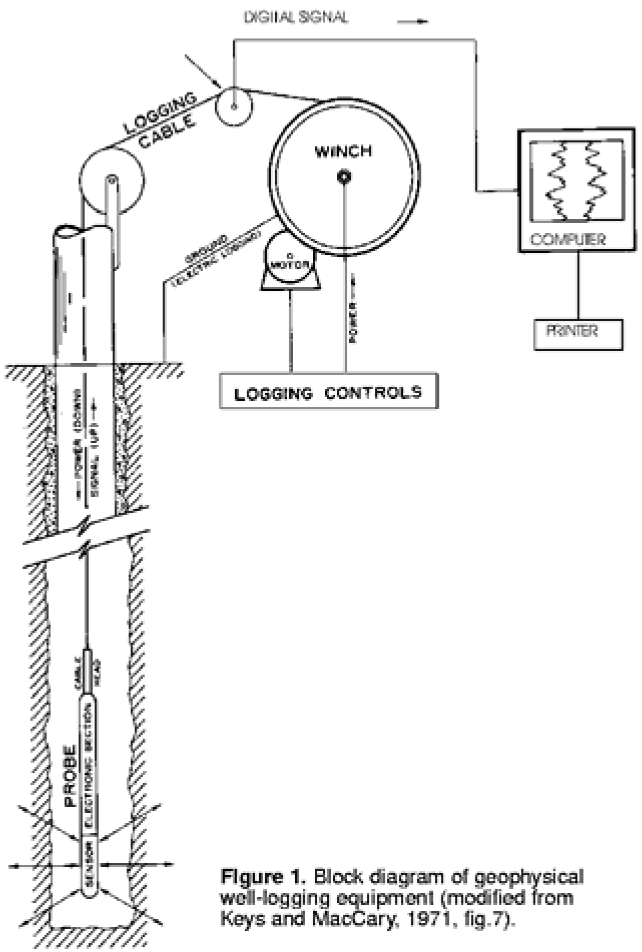
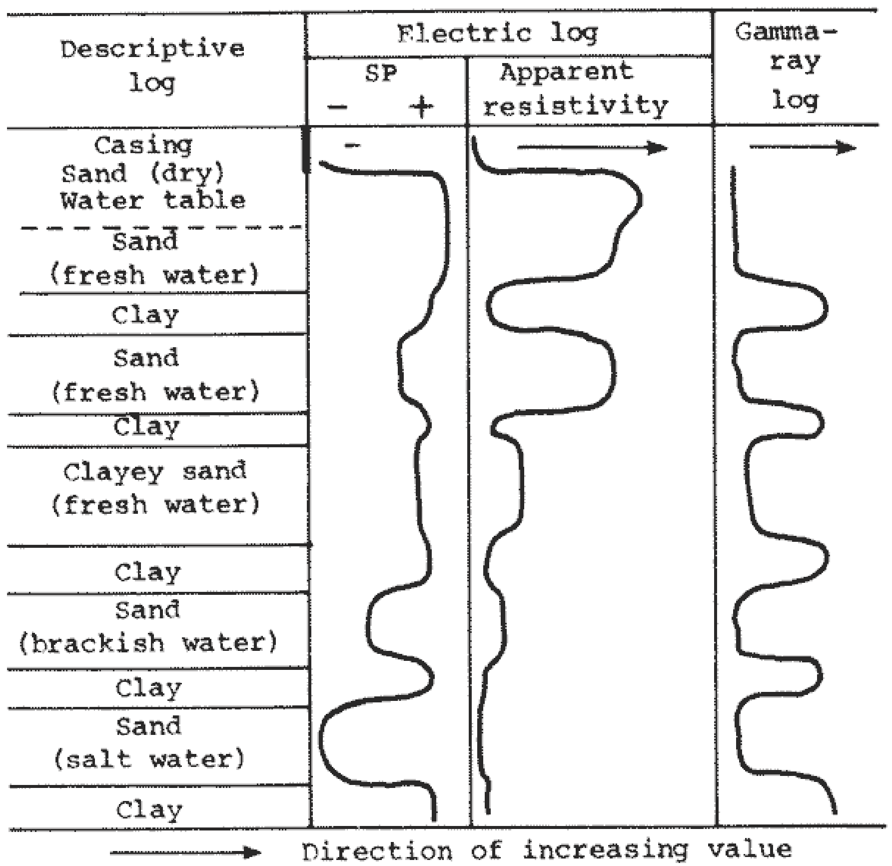
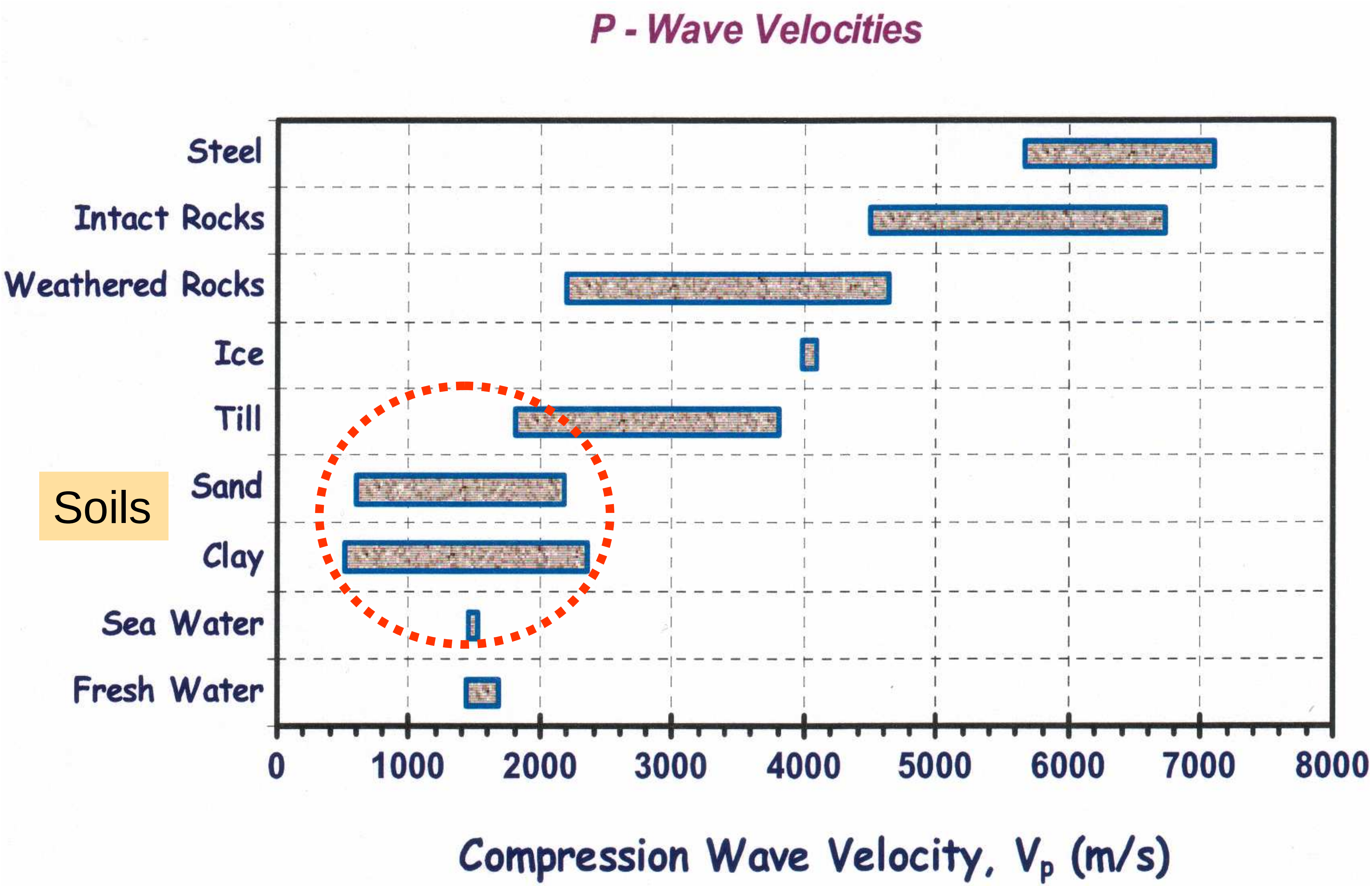


Figure 1. Block diagram of geophysical well-logging equipment (modified from Keys and MacCary, 1971, fig.7).

Idealized geophysical logs



- Seismic Refraction
- Multiple Analysis of Surface Waves


P - Wave Velocities
Steel
Intact Rocks
Weathered Rocks
Ice
Till
Sand
Clay
Sea Water
Fresh Water
Soils
0
1000
2000
3000
4000
5000
6000
7000
8000
Compression Wave Velocity, Vp (m/s)

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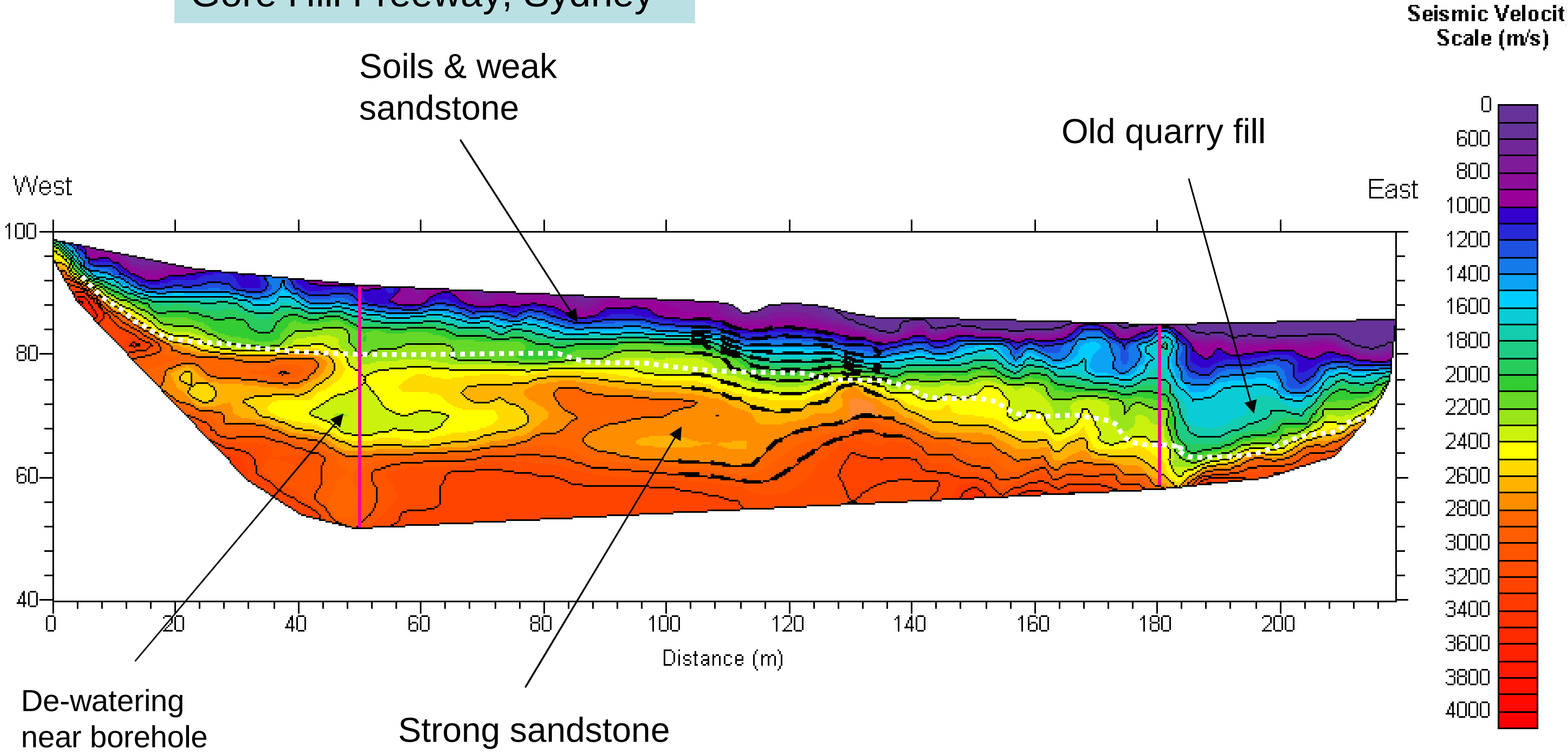
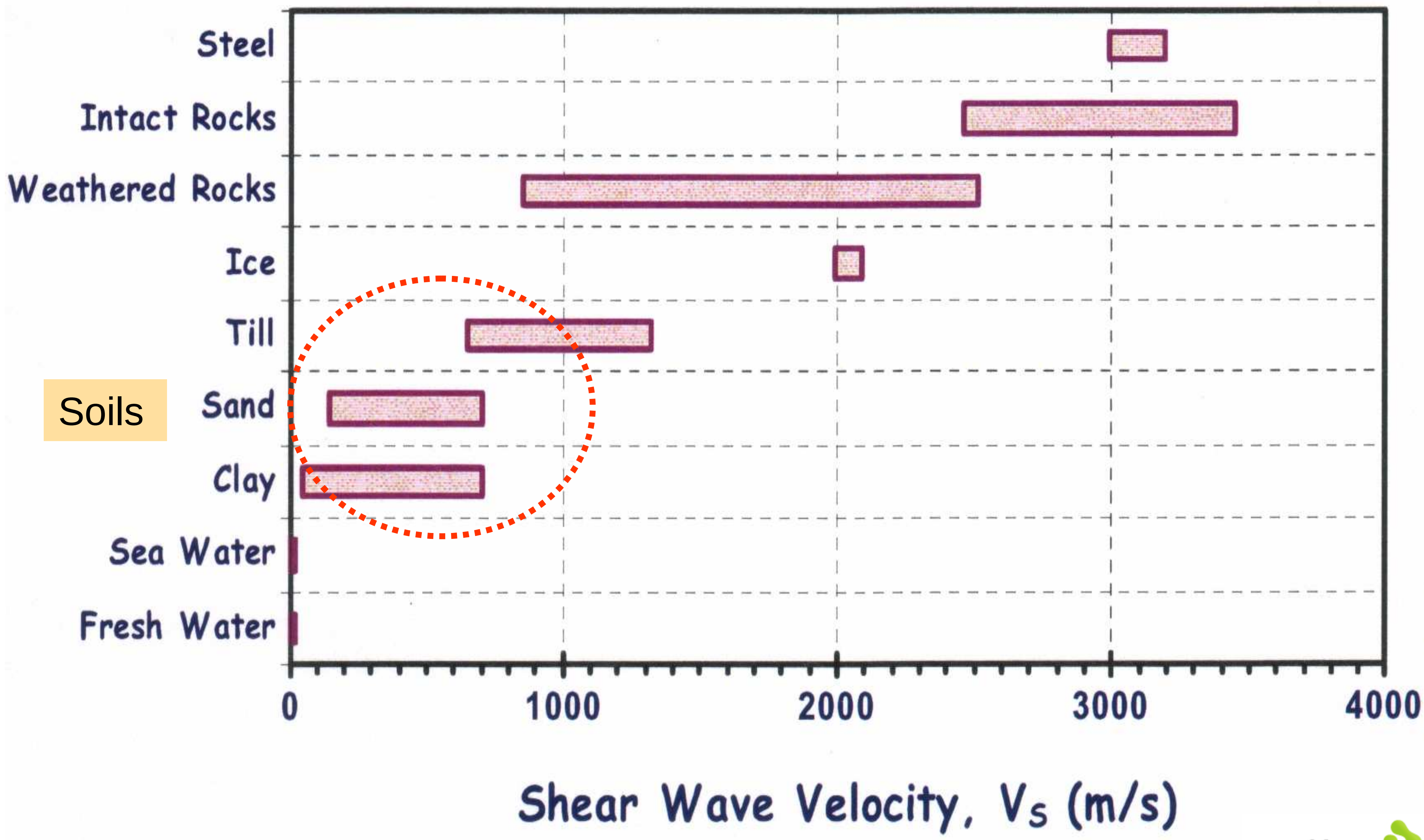
Gore Hill Freeway, Sydney



Borehole

Seismic images of soils and weak sandstone

S - Wave Velocities



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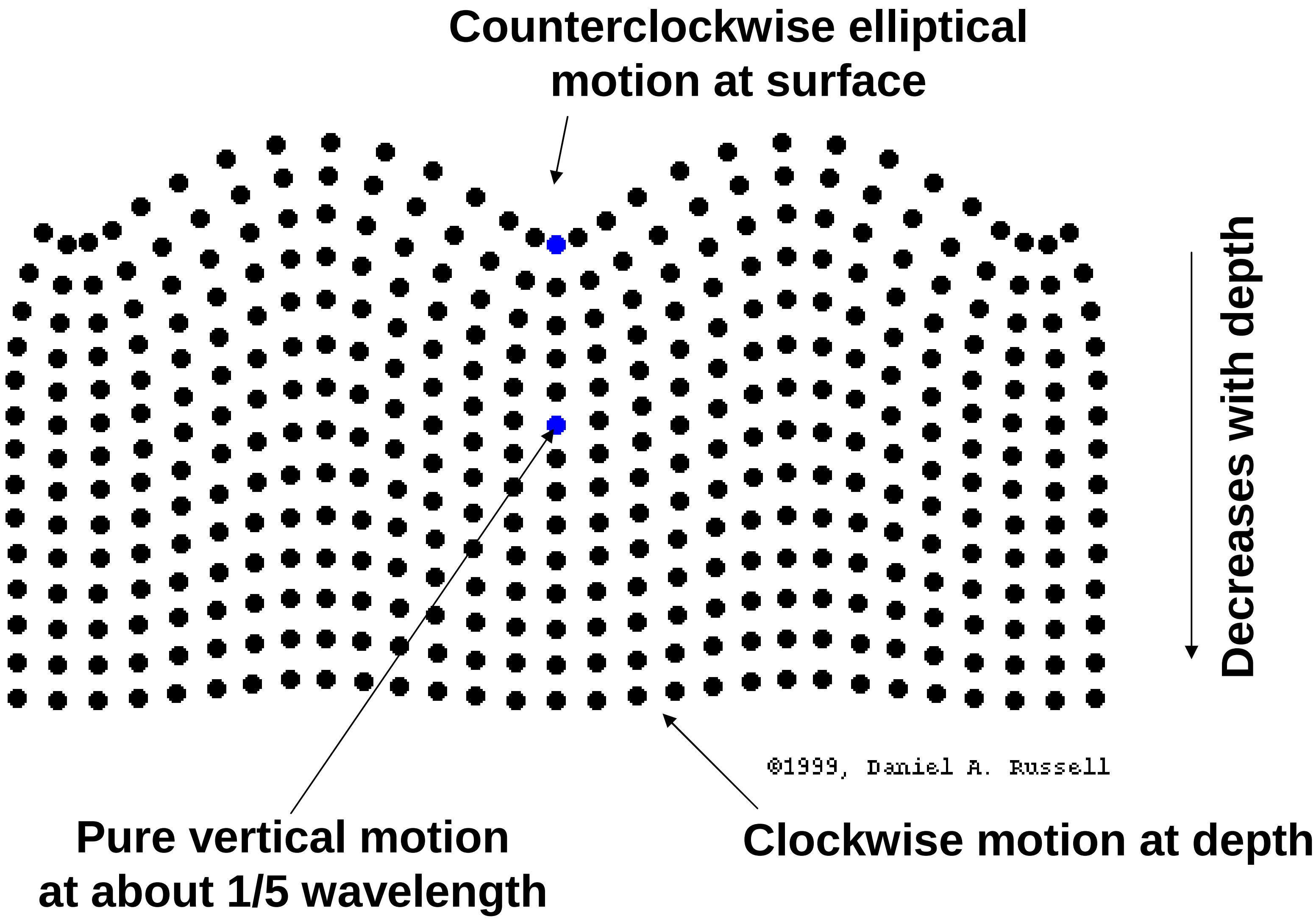
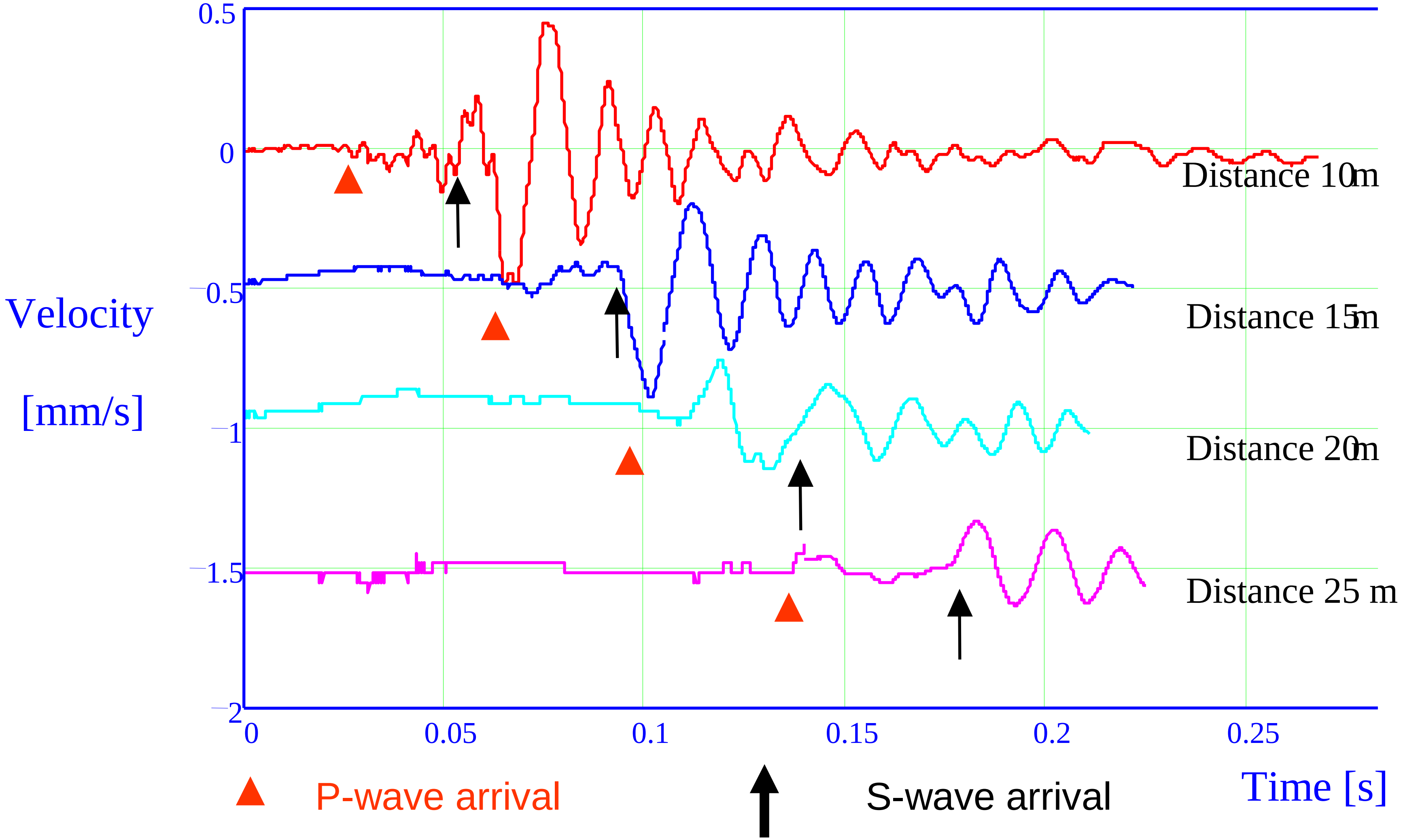
Rayleigh (R) wave motion



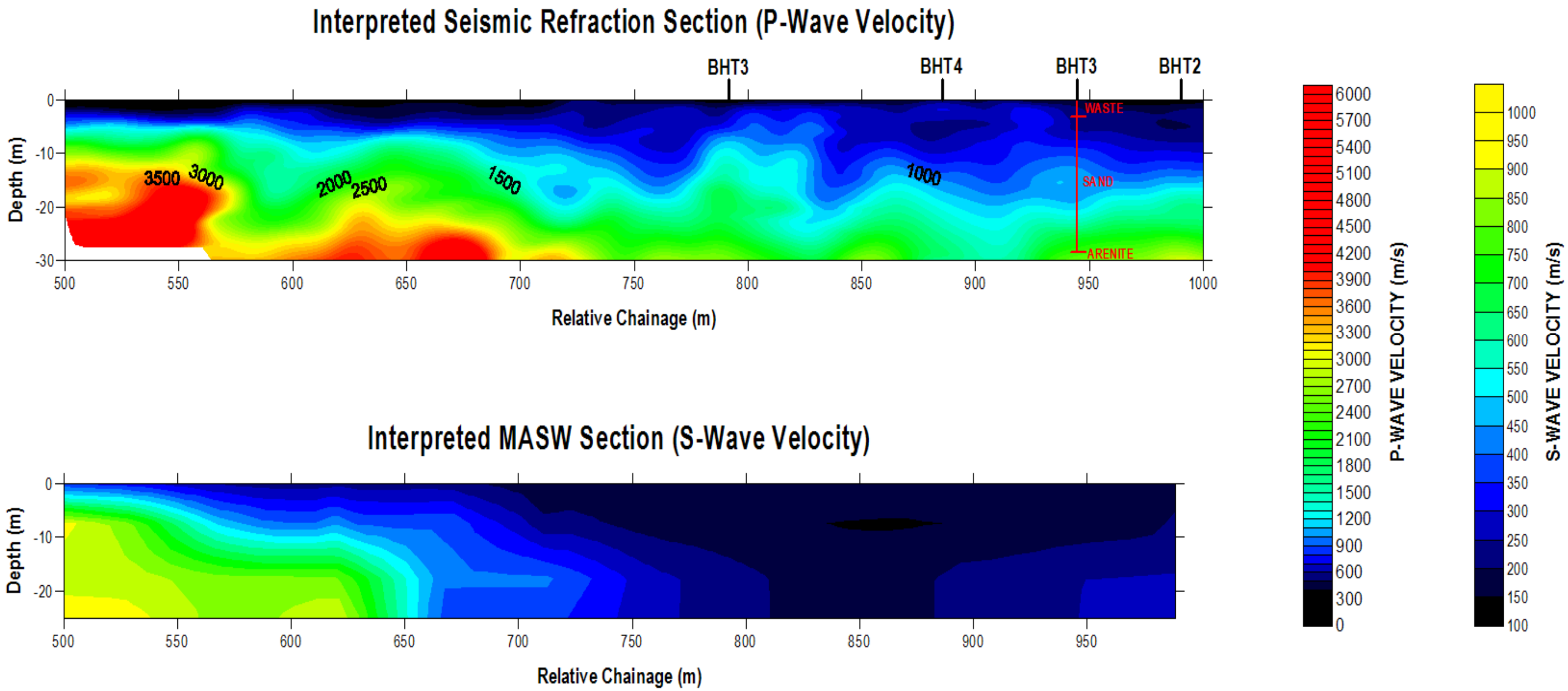
http://www.kettering.edu/~drussell/Demos/waves/wavemotion.html

Shear wave velocities from R-waves



Geotechnical Classification	S-Wave Seismic Velocity (m/s)
Very soft soils	<100
Soft soils	100 to 300
Stiff soils	200 to 500
Very Stiff soils	500 to 900
Rock	>900

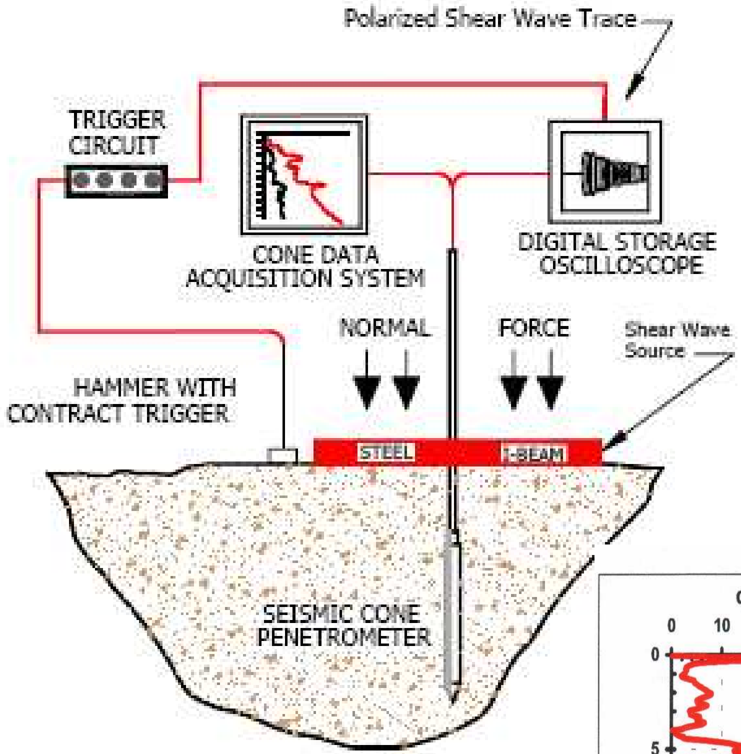
Combining Seismic Refraction & MASW Technologies

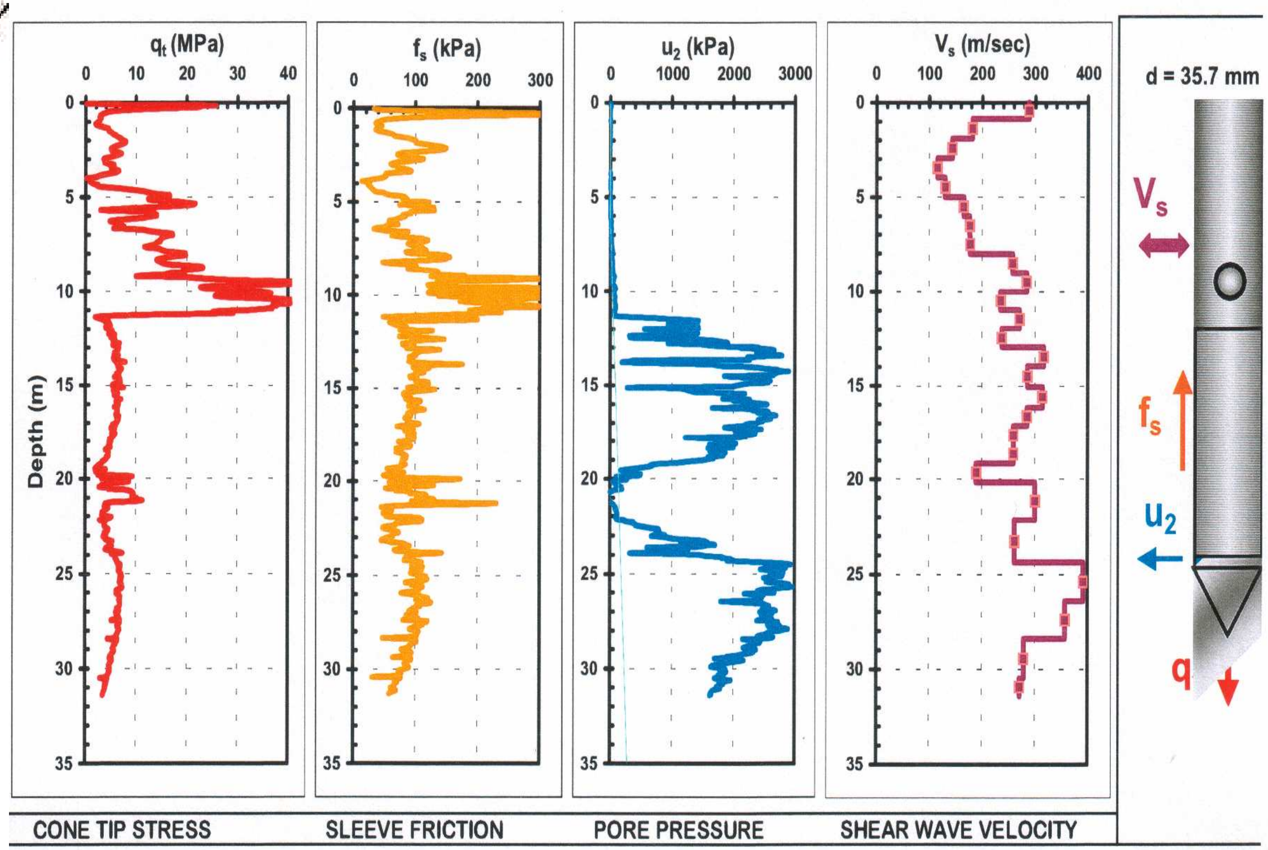


Material Property Determinations with Downhole Geophysics

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

Seismic Cone Penetrometer (SCPTu)





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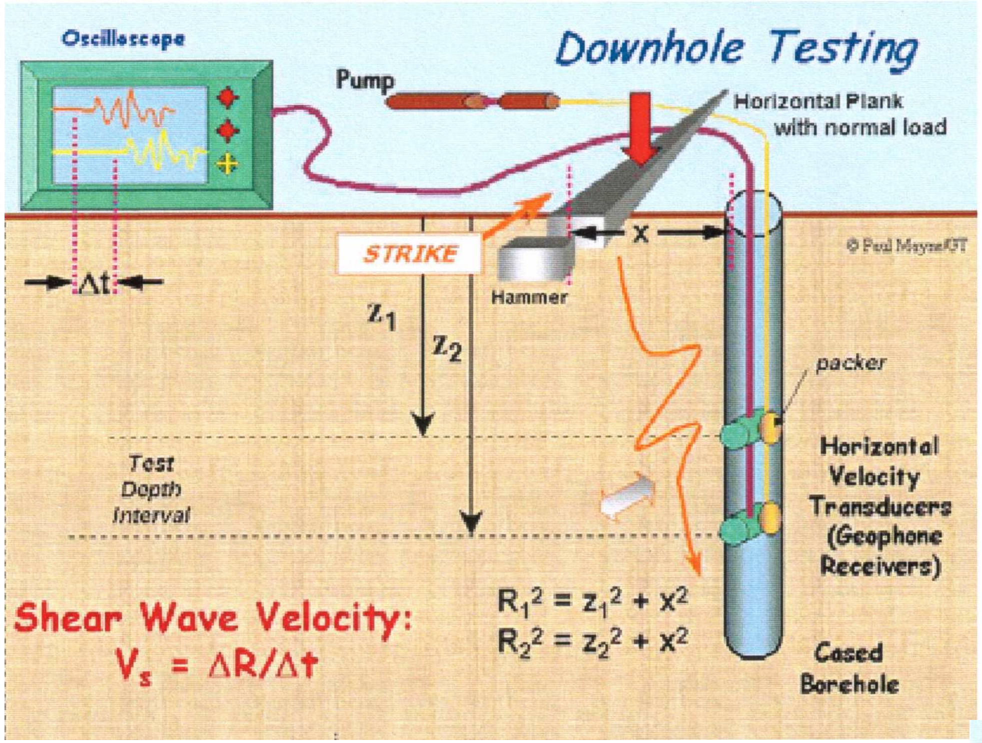
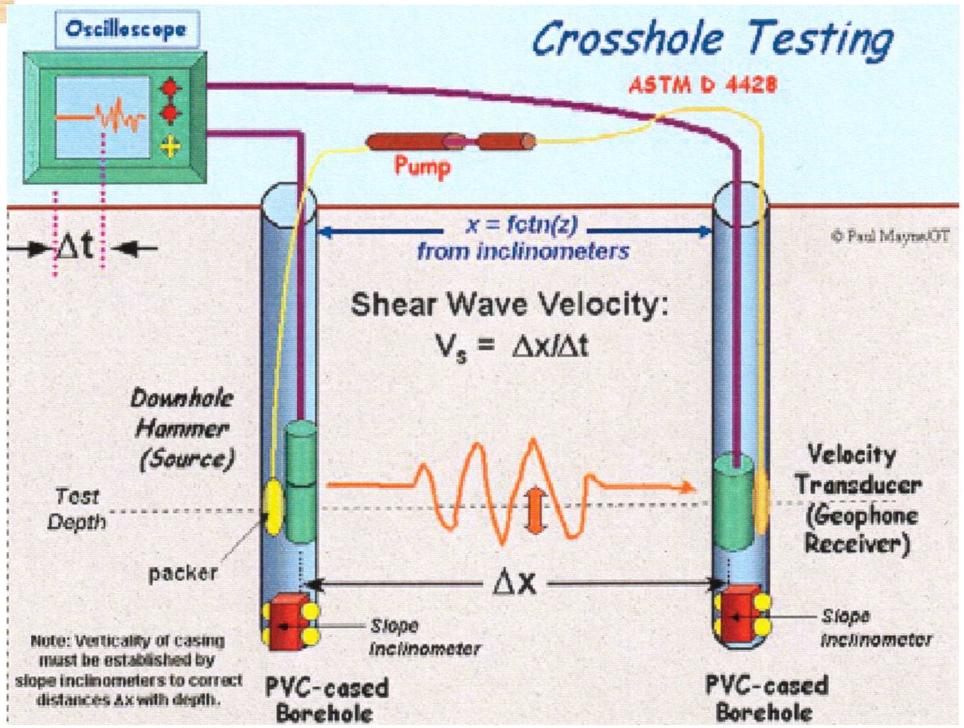


Vertical Seismic Shear Wave Profiling (VSSP)

Crosshole Shear Wave Testing (CHST)



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Geotechnical classifications in soils & fills

N = Number of blows to drive a split-sample tube 30 cm into the ground

Geotechnical Classification	SPT N-value (Field)	Relative Density (%) (Lab.)
Very Loose	<4	<15
Loose	4 - 10	15 - 35
Medium Dense	10 - 30	35 - 65
Dense	30 - 50	65 - 85
Very Dense	>50	85 - 100

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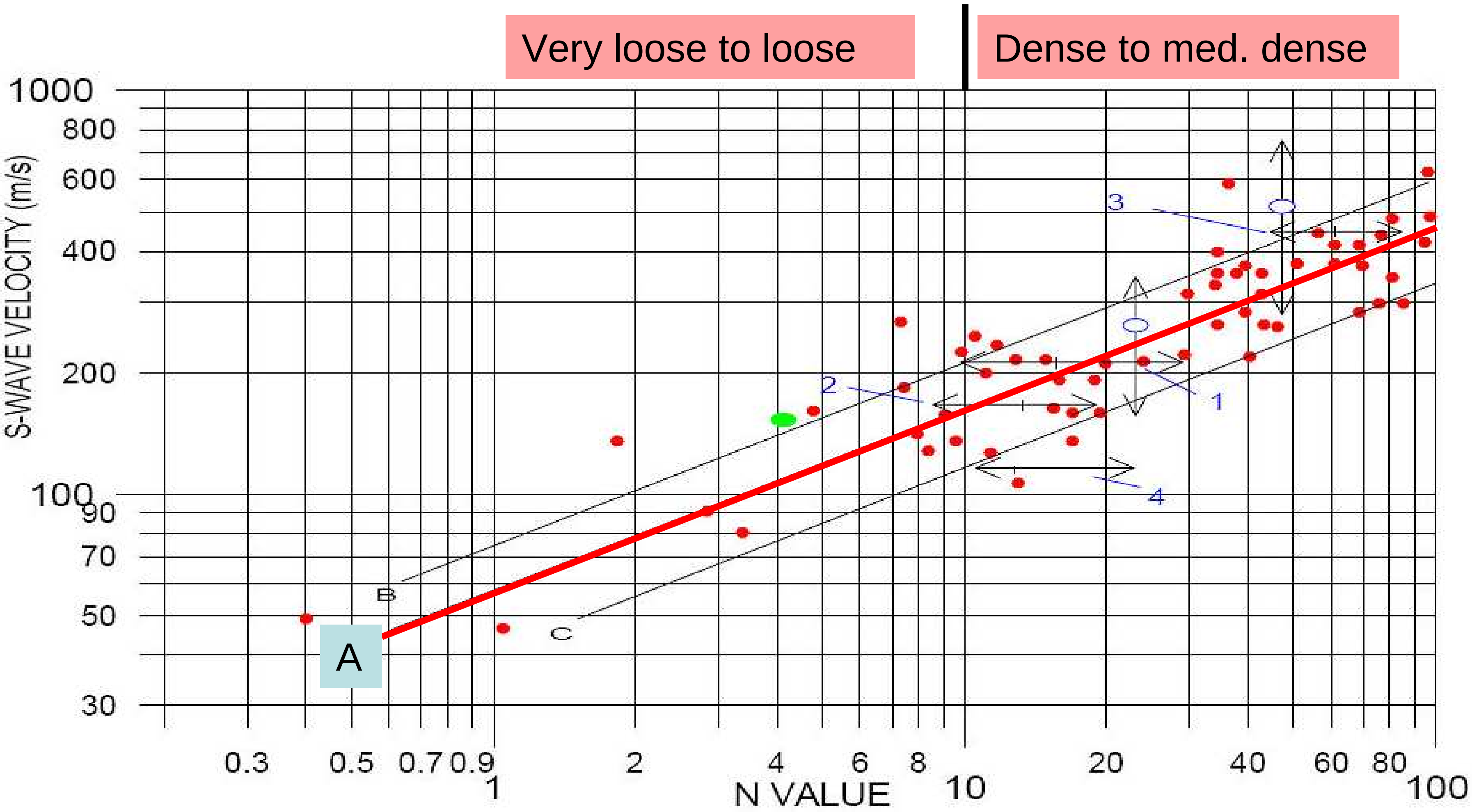


NOTE: 1. Base and plots from "The relation of Mechanical properties of soils to P. and S. wave velocities for Soil Ground in Japan. T. Imai and M. Yoshimura (1975). Only alluvial and gravel values plotted.

2. Range of velocites measured, average value of S-wave velocities of San Francisco Bayshore Sediment.

3. Value from measured relative density;

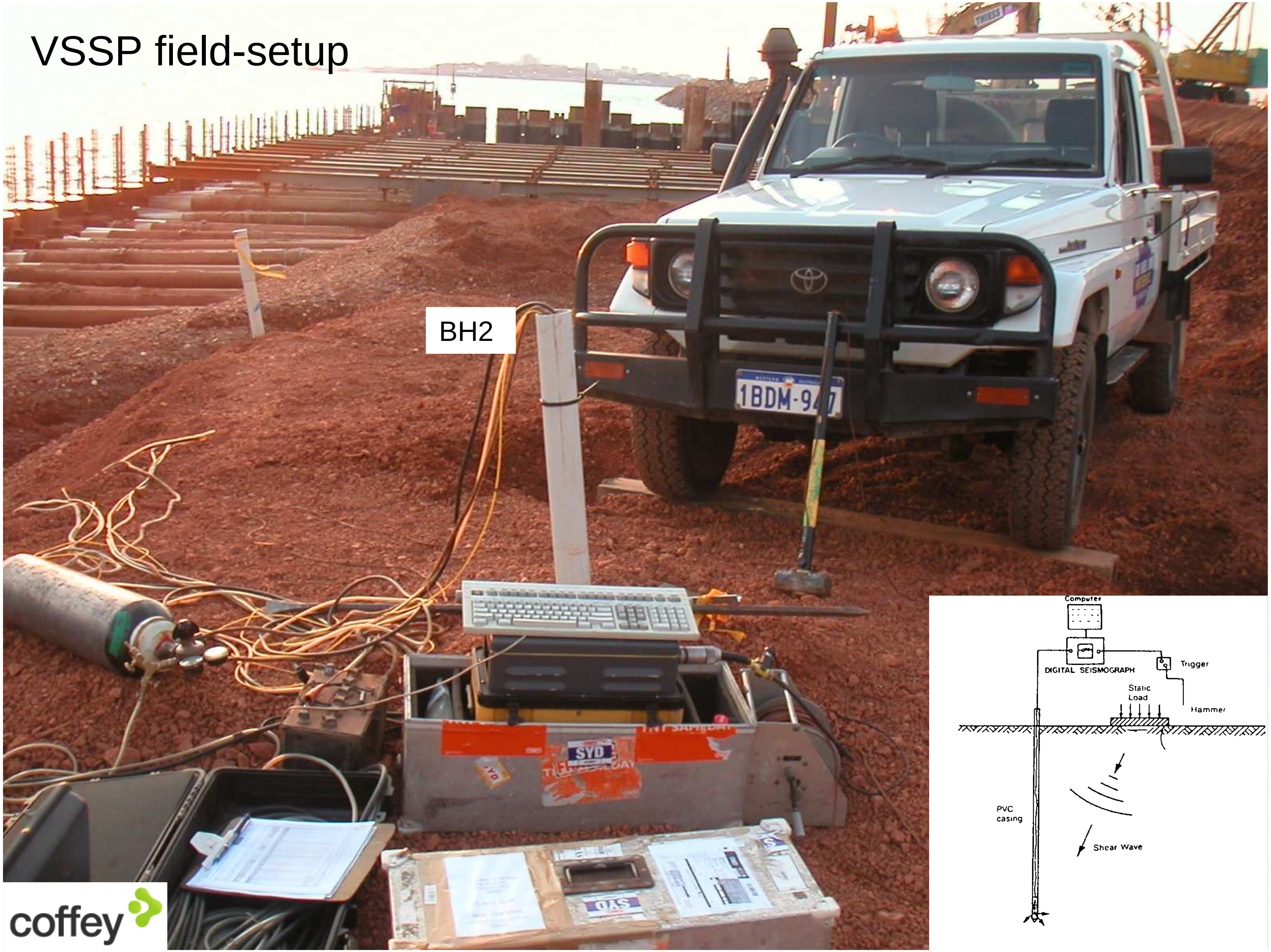
(1) Lower San Fernando Dam hydraulic fill.
(2) Upper San Fernando Dam hydraulic fill.
(3) Upper San Fernando Dam foundation, lower alluvium.
(4) Upper San Fernando Dam foundation, upper alluvium.

4. Value from density in place tests at Lunnga dam site, Solomon Is.

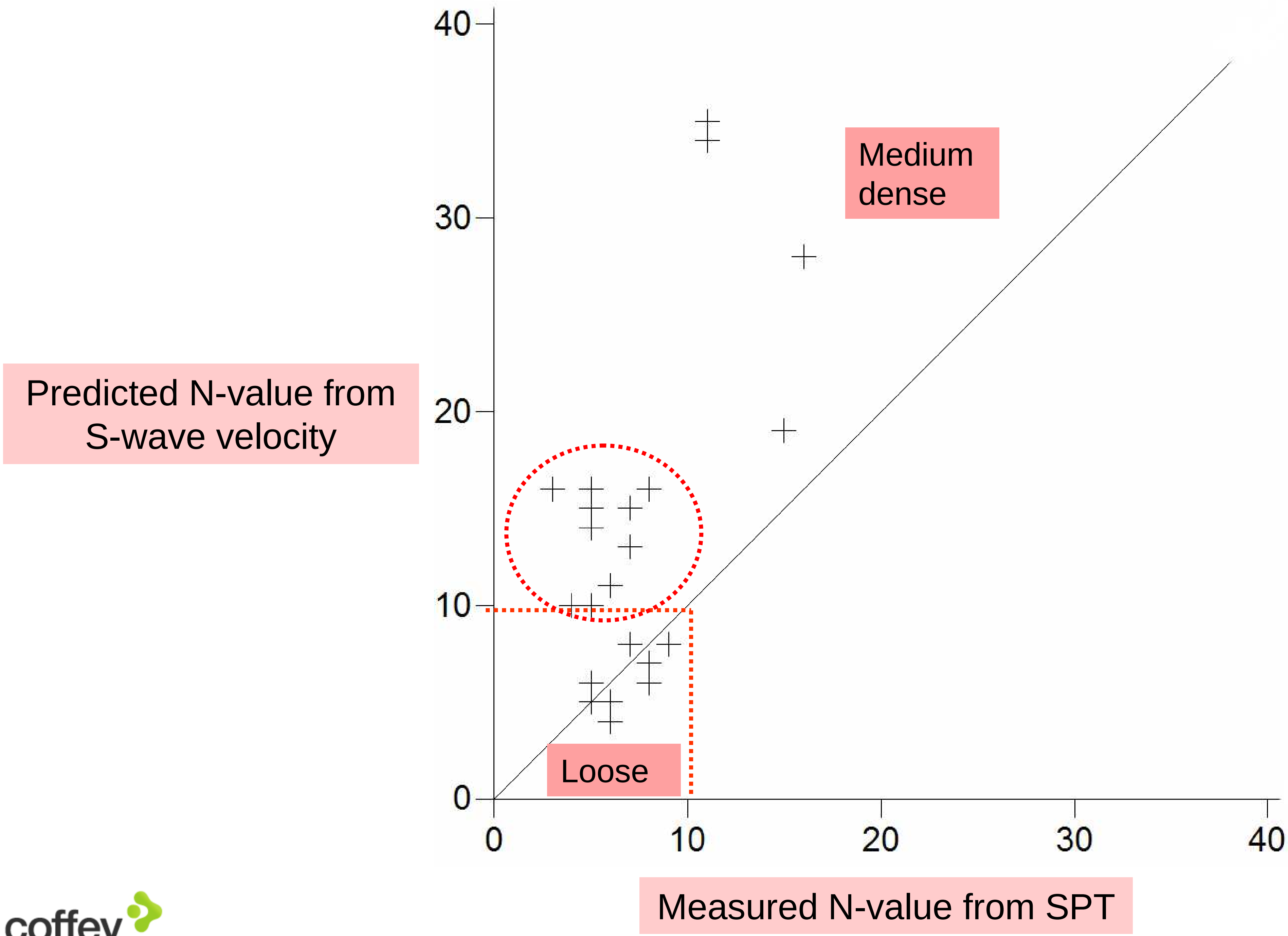
5. 'A' Line is line of best fit, 'B' and 'C' line exclude 10% of the highest and 10% of lowest values (of Imai and Yoshimira, 1975)

SPT N-Value and S-wave velocity in gravels & sands

VSSP field-setup




BH2
BH4
BH5



Predicted N-value from
S-wave velocity
Medium
dense
Loose
Measured N-value from SPT
0
10
20
30
40

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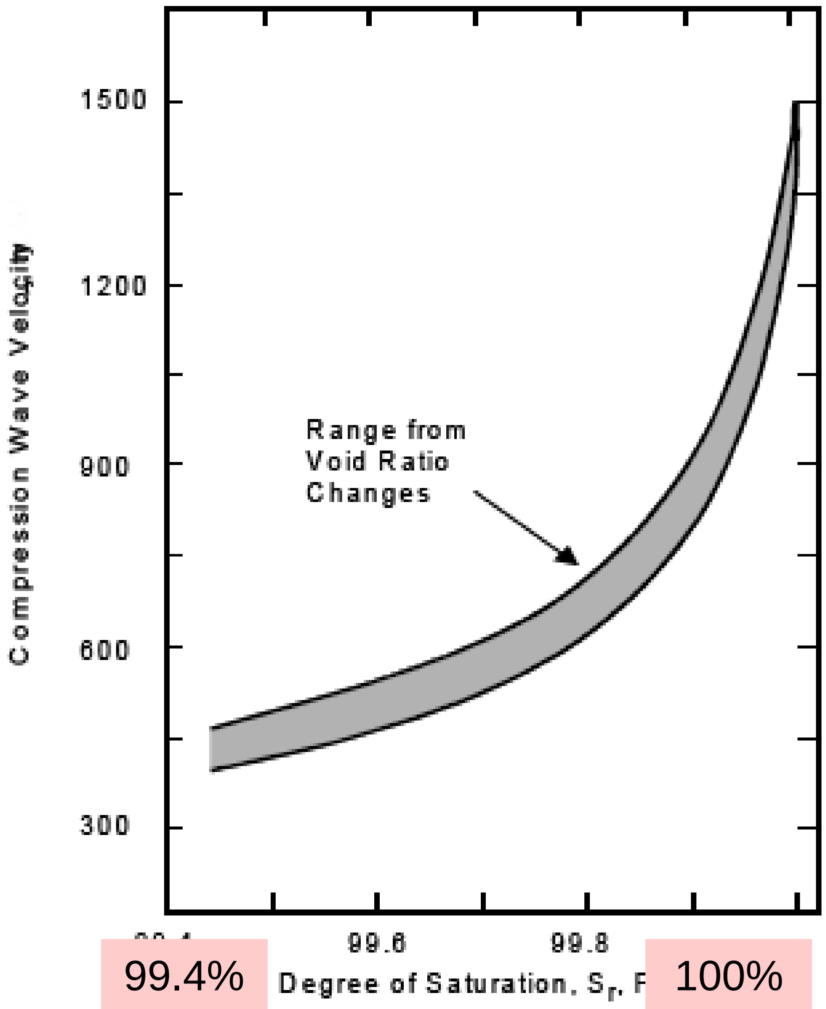
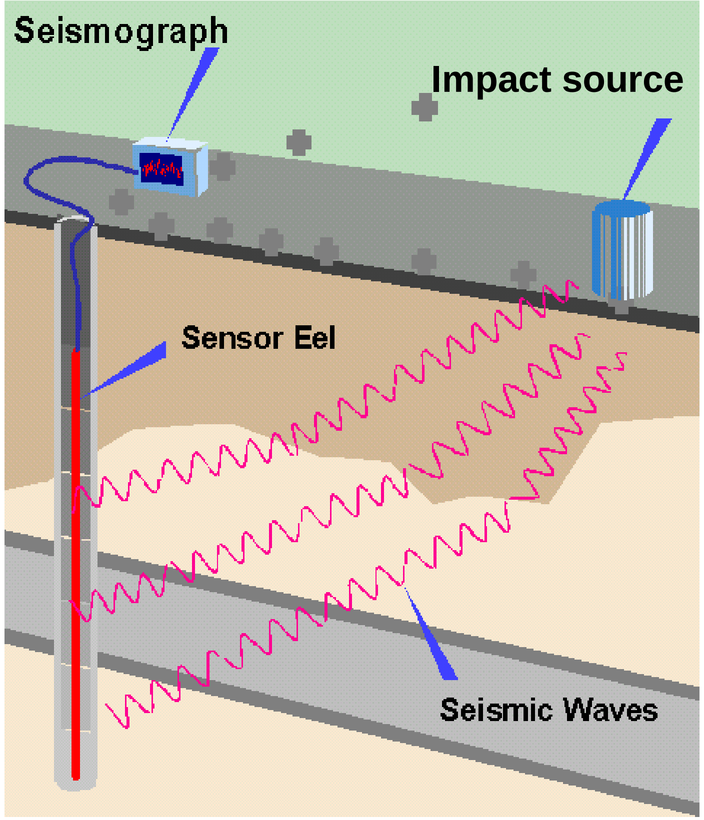
Material Parameters: Unsaturated Sands, Silts & Fills

P-wave velocity and saturation

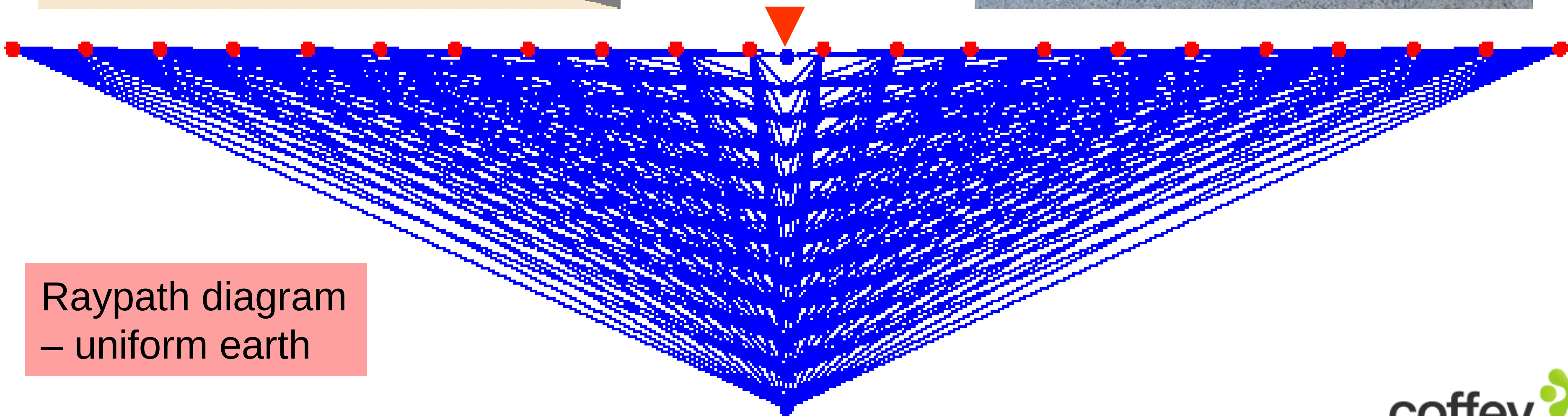


SPT N-value	Geotechnical Classification	P-Wave Velocity (m/s)
0 – 4	**Very loose**	**<350 - 430**
4 – 10	**Loose**	**430 - 520**
10 – 30	**Medium dense**	**520 - 730**
30 - 50	**Dense**	**730 - 1680**
>50	**Very dense**	**>1680**

Site Uniformity Borehole Seismic (SUBS) Testing



borehole



Raypath diagram
– uniform earth

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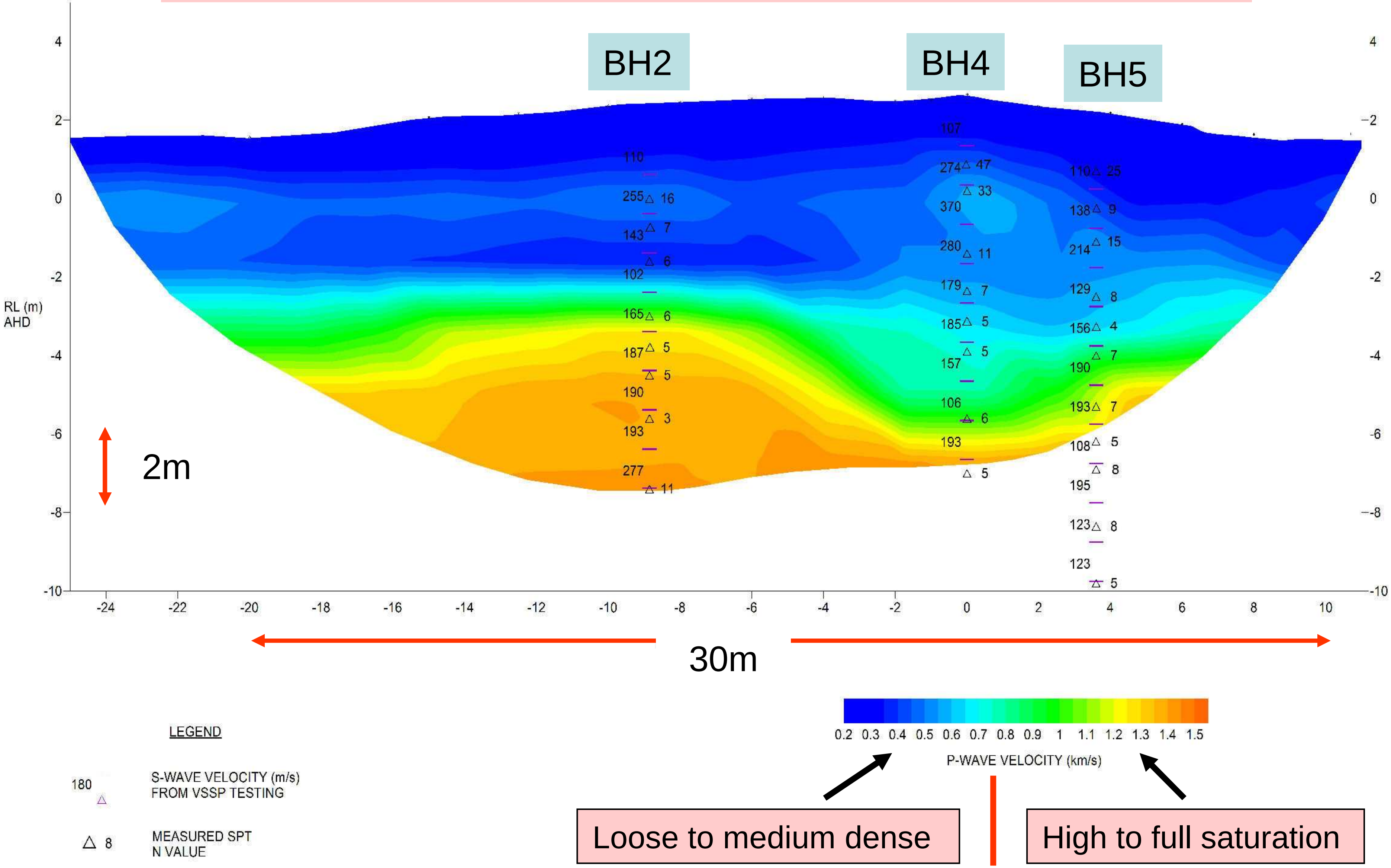
Combined P-wave SUBS seismic image



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