Core-log integration

Alberto Malinverno

Well Logging Principles and Applications
G9947 - Seminar in Marine Geophysics
Spring 2008

Core-log integration issues

1. Measurement resolution

2. Depth matching

3. In situ versus laboratory conditions

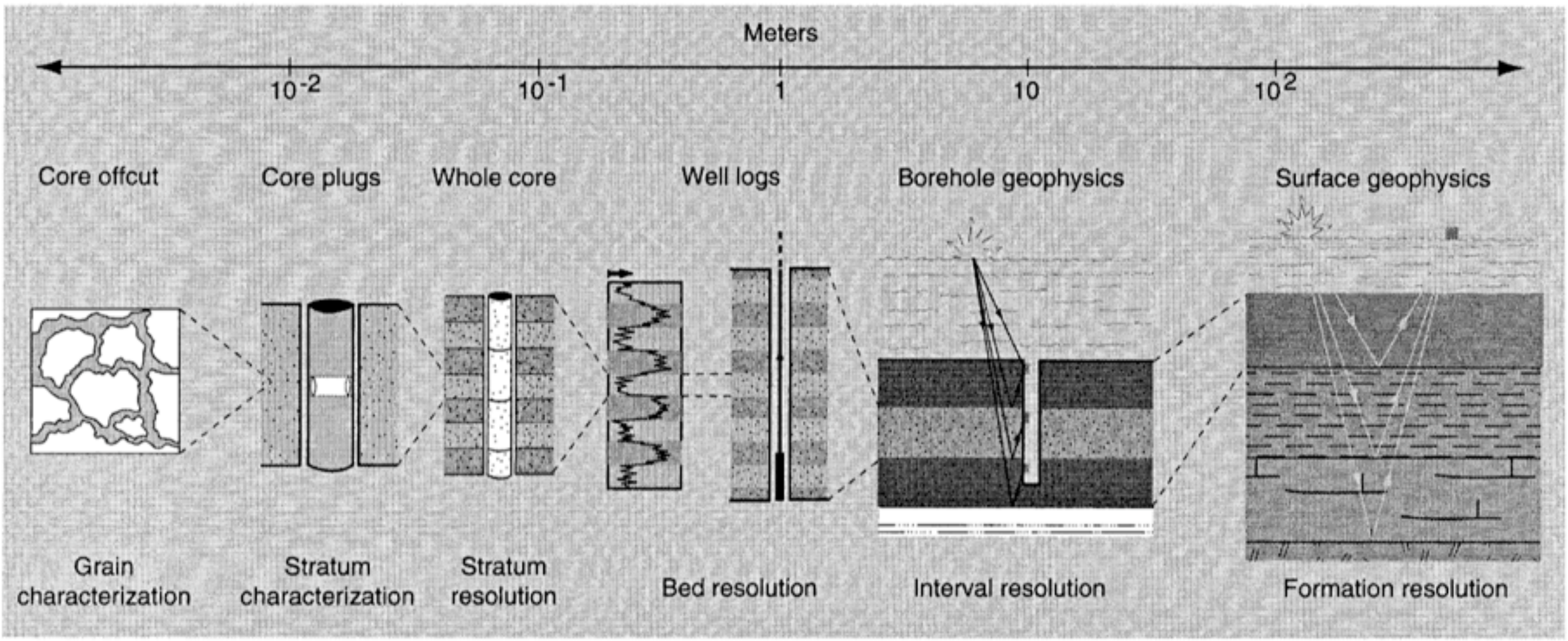


Figure 1. Schematic diagram illustrating the different scales of measurement in geophysics [after *Worthington et al.*, 1991]. The span of measurements from core samples to seismic surveying is greater than 10^4, complicating the interpretation of data from samples to regional geology without intermediate-scale logging and borehole measurements.

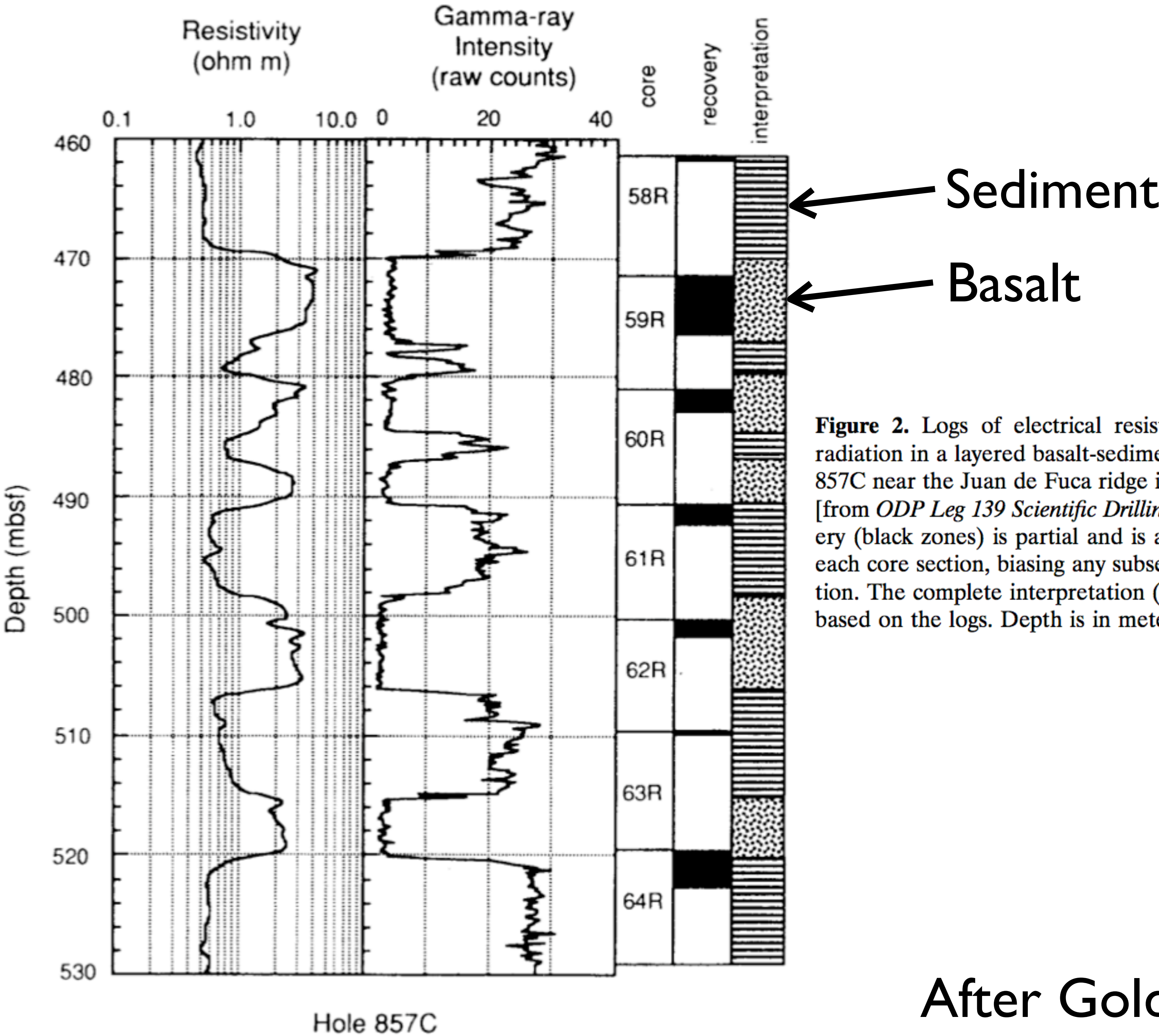
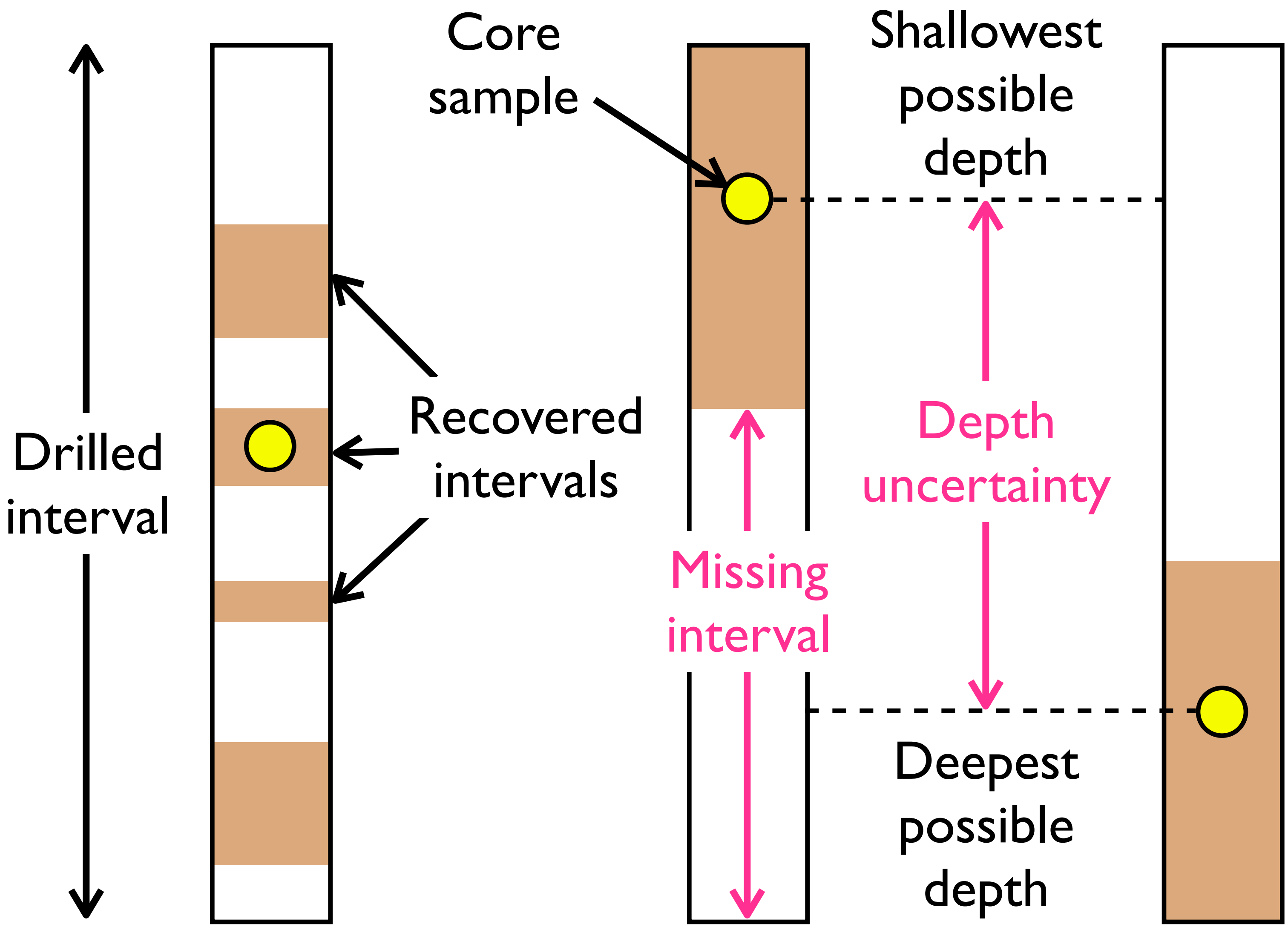
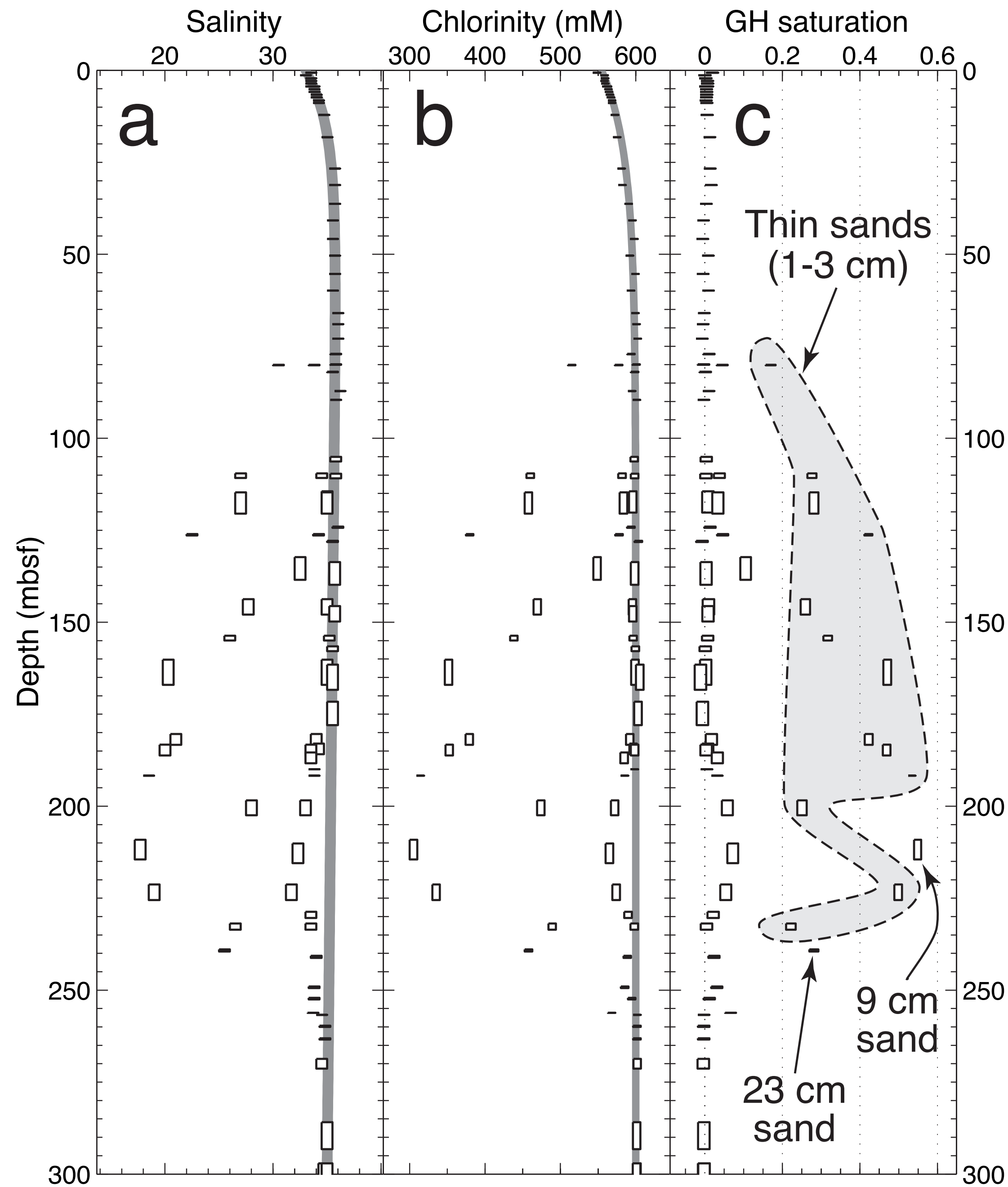


Figure 2. Logs of electrical resistivity and natural gamma radiation in a layered basalt-sediment sequence in ODP Hole 857C near the Juan de Fuca ridge in the north eastern Pacific [from *ODP Leg 139 Scientific Drilling Party*, 1992]. Core recovery (black zones) is partial and is arbitrarily set at the top of each core section, biasing any subsequent geologic interpretation. The complete interpretation (dotted zones are basalt) is based on the logs. Depth is in meters below sea floor (bsf).

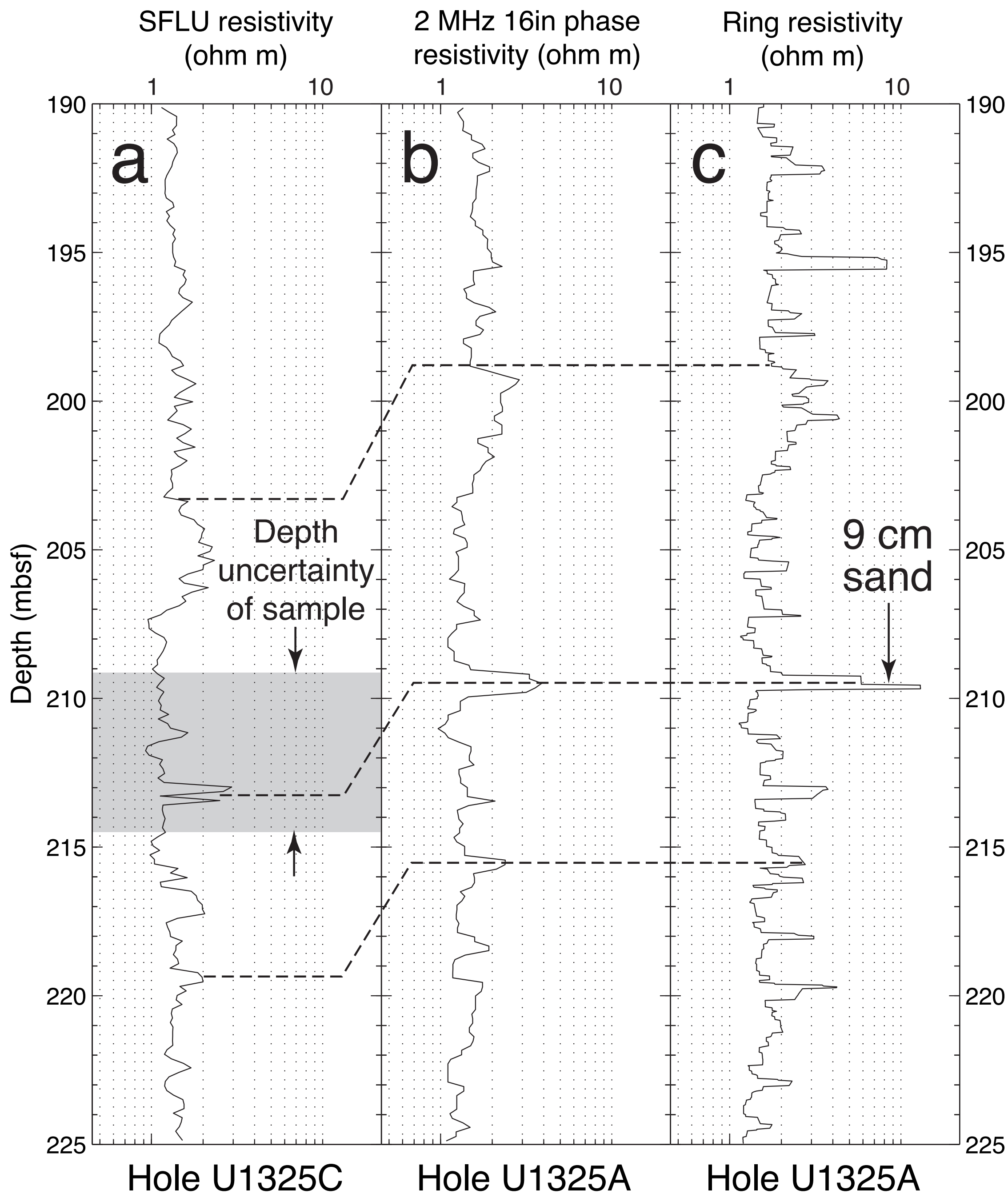
After Goldberg, 1997

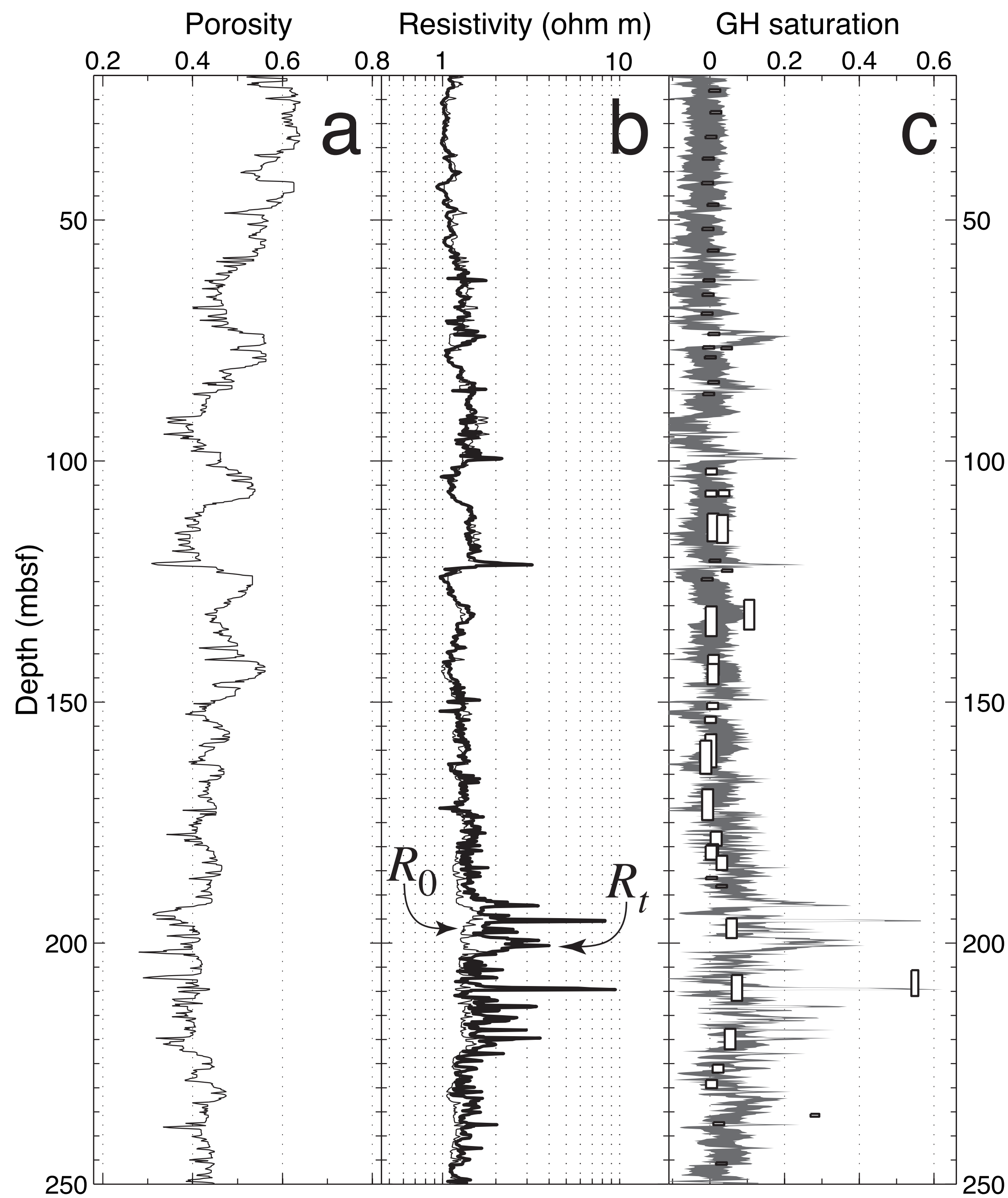
Core sample depth





Salinity
20
30
Chlorinity (mM)
300
400
500
600
GH saturation
0
0.2
0.4
0.6
a
b
c
Depth (mbsf)
0
50
100
150
200
250
300
Thin sands
(1-3 cm)
9 cm
sand
23 cm
sand


SFLU resistivity (ohm m)
2 MHz 16in phase resistivity (ohm m)
Ring resistivity (ohm m)
1
10
Depth (mbsf)
190
195
200
205
210
215
220
225
a
b
c
Depth uncertainty of sample
9 cm sand
Hole U1325C
Hole U1325A
Hole U1325A



Porosity
Resistivity (ohm m)
GH saturation
0.2
0.4
0.6
0.8
1
10
0
0.2
0.4
0.6
a
b
c
Depth (mbsf)
50
100
150
200
250
R_0
R_t

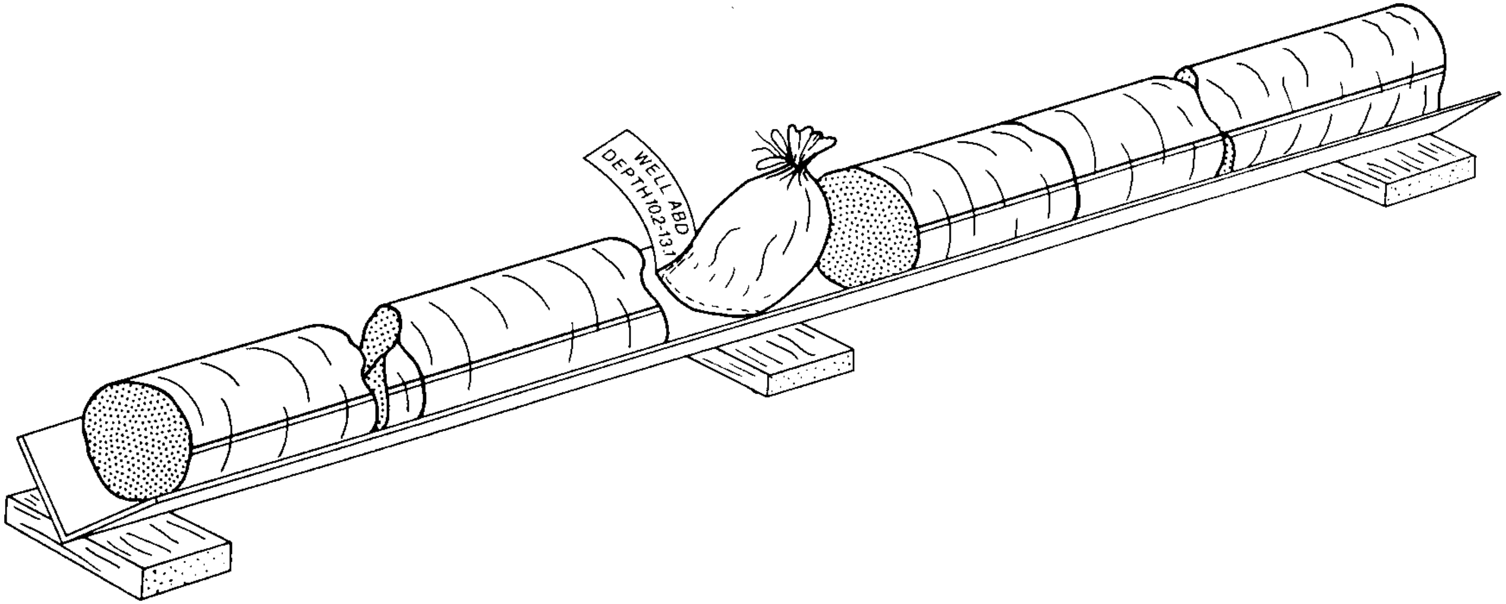


Fig. 3.2 Core pieces fitted together on a length of angle-iron. A rubbly section is contained in the bag. The parallel lines marked on the core, which would be in contrasting colours, indicate the way up.

in si·tu

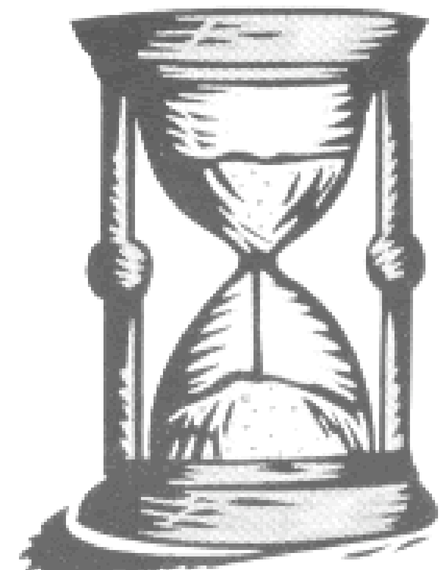
in the natural or original position or place

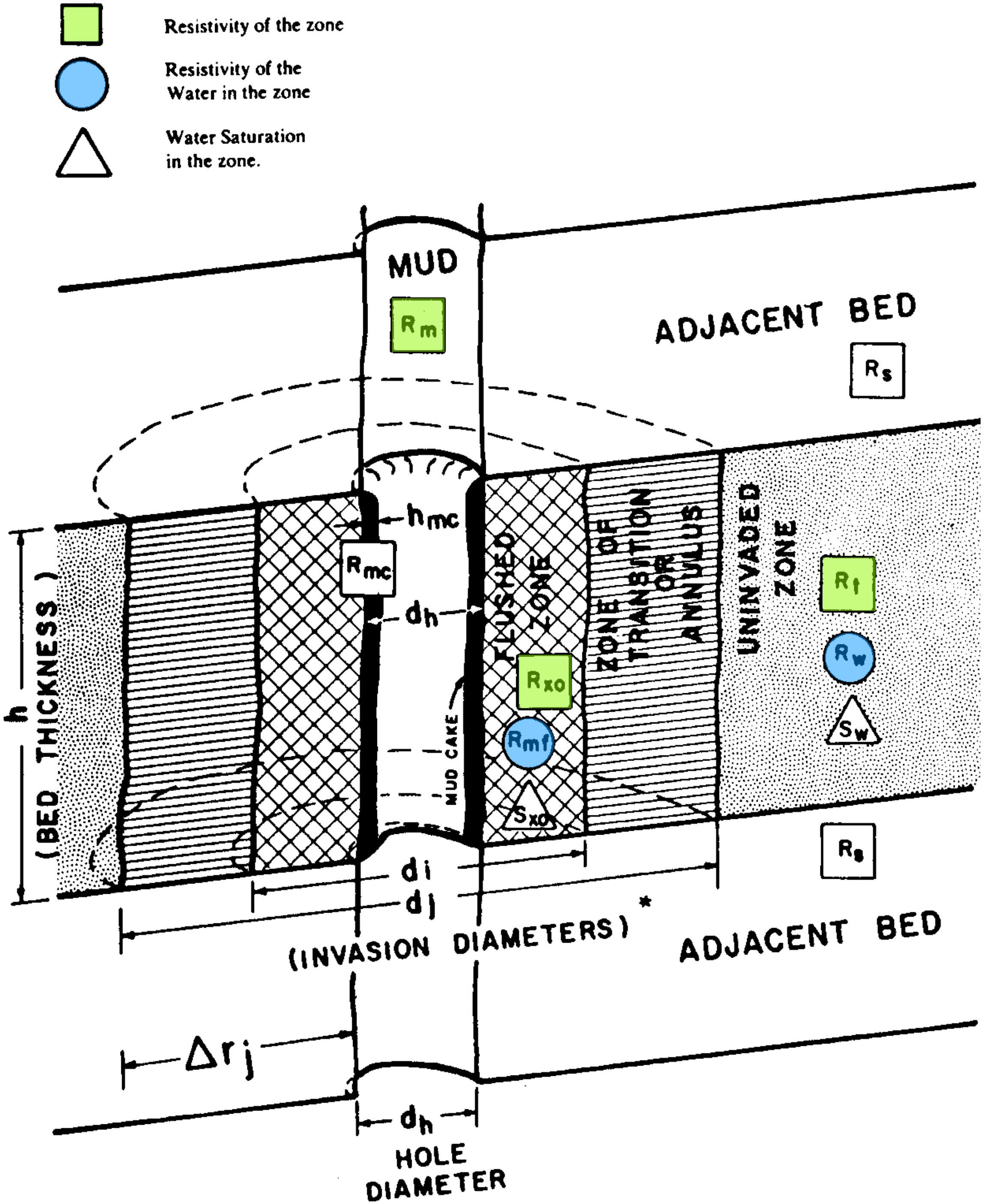
Pronunciation: (")in-'sI-(")tü, -'si-, -(")tyü *also* -'sE-, -(")chü

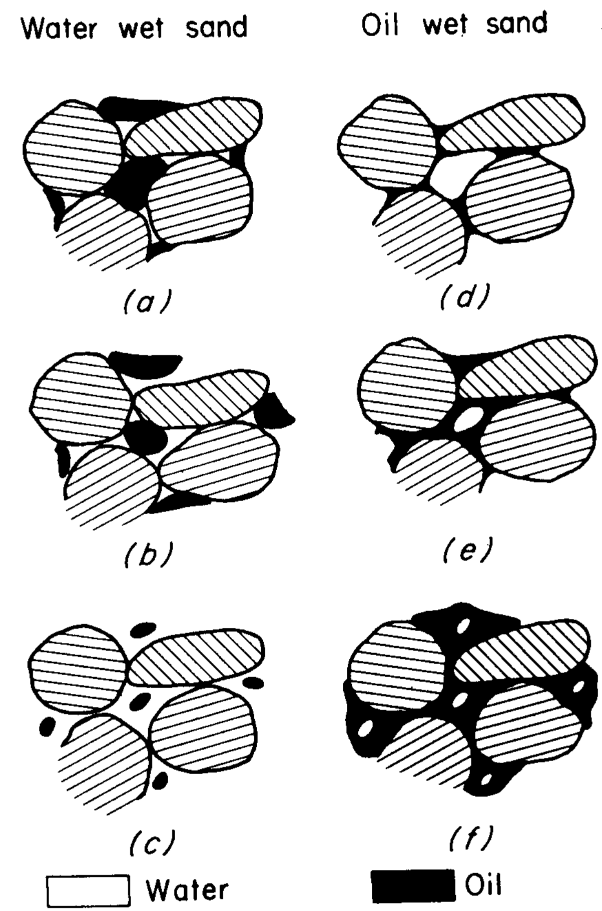
Function: adverb or adjective

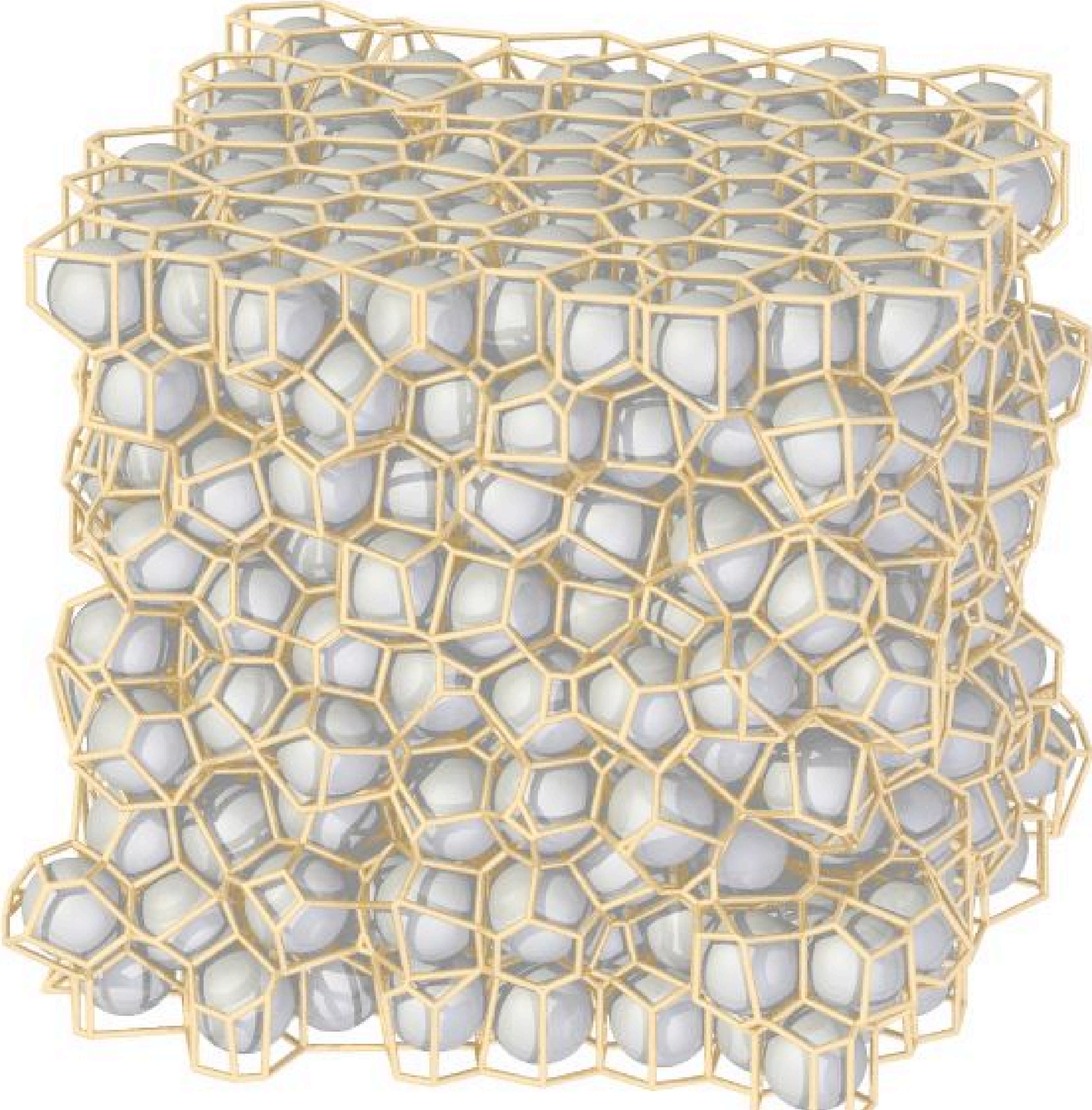
Etymology: Latin, in position

Date: 1740

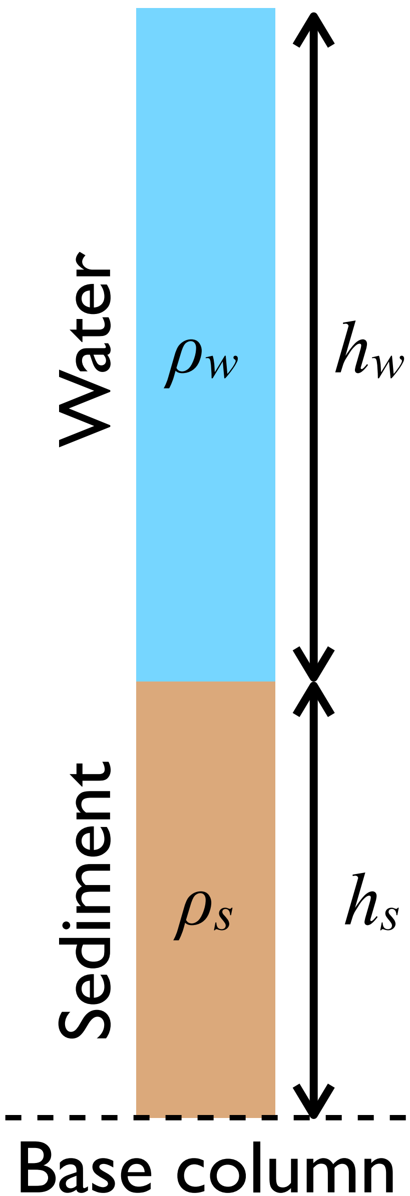



Resistivity of the zone
Resistivity of the Water in the zone
Water Saturation in the zone.
MUD
Rm
ADJACENT BED
Rs
hmc
Rmc
dh
FLUSHED ZONE
Rxo
Rmf
Sxo
MUD CAKE
ZONE OF TRANSITION OR ANNULUS
UNINVADED ZONE
Rt
Rw
Sw
h (BED THICKNESS)
di
dj
(INVASION DIAMETERS) *
ADJACENT BED
Rs
Δrj
dh
HOLE DIAMETER


Water wet sand
Oil wet sand
(a)
(d)
(b)
(e)
(c)
(f)
Water
Oil



Random close packing of spheres: density ≈ 0.64, porosity ≈ 0.36

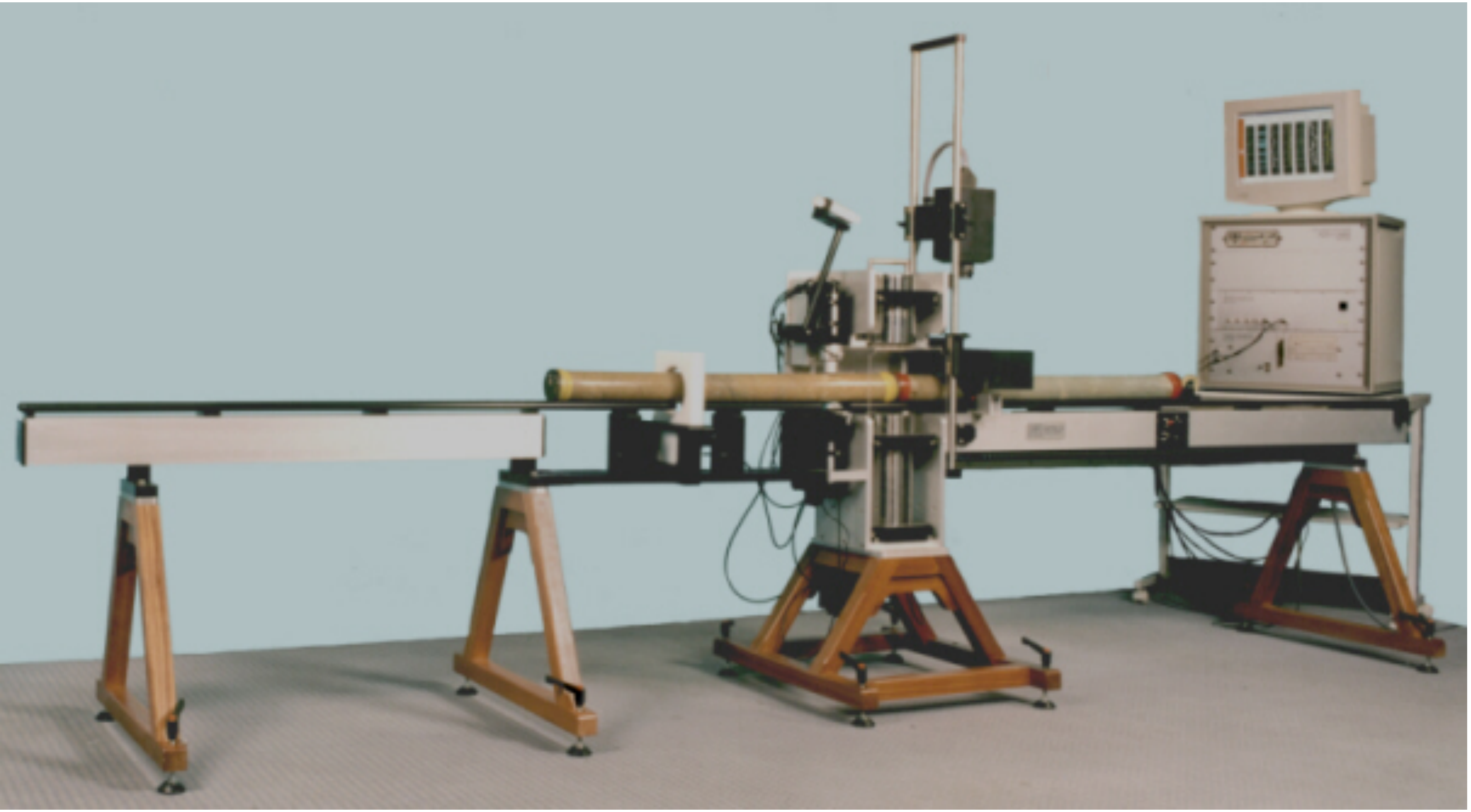


Effective stress

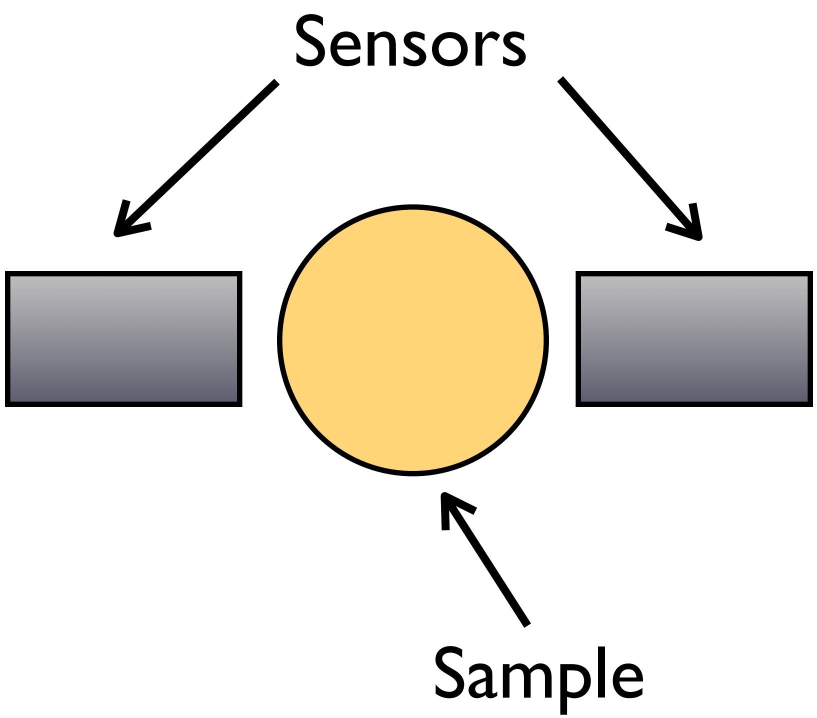
- Stress or pressure: $\rho g h$
- Lithostatic stress at base column: $g(\rho_w h_w + \rho_s h_s)$
- Hydrostatic pore pressure at base column: $g\rho_w(h_w + h_s)$
- Effective stress (Terzaghi, 1936): lithostatic stress – pore pressure

$$\begin{aligned}\sigma_{\text{eff}} &= g h_s(\rho_s - \rho_w)\\ &= g h_s(1-\phi)(\rho_g - \rho_w)\end{aligned}$$

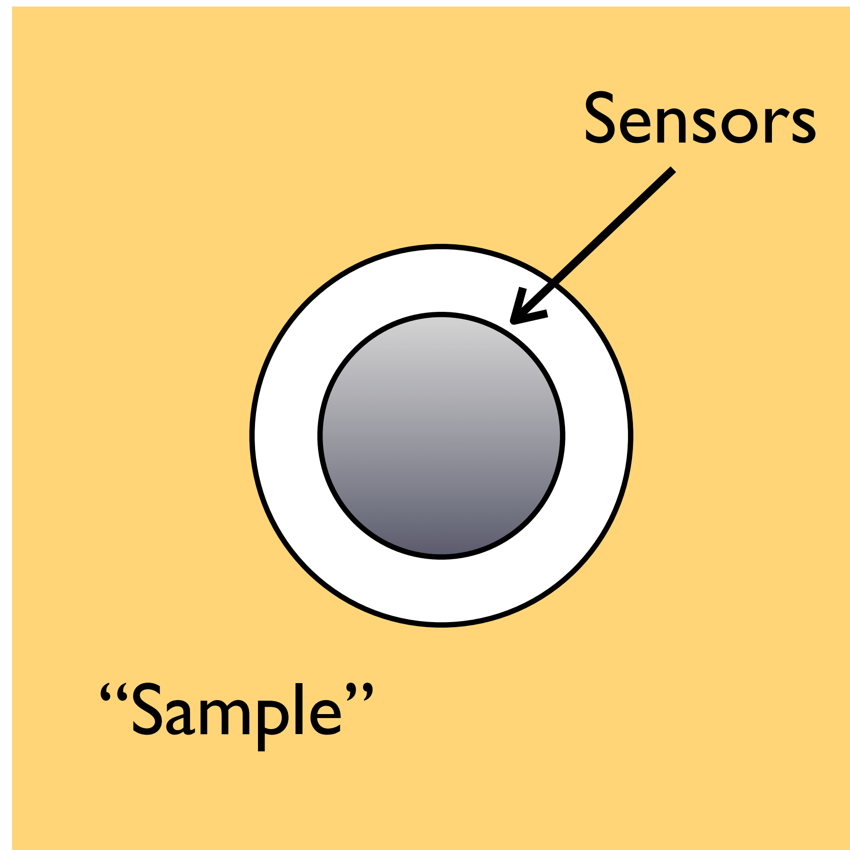
Multisensor track (MST)



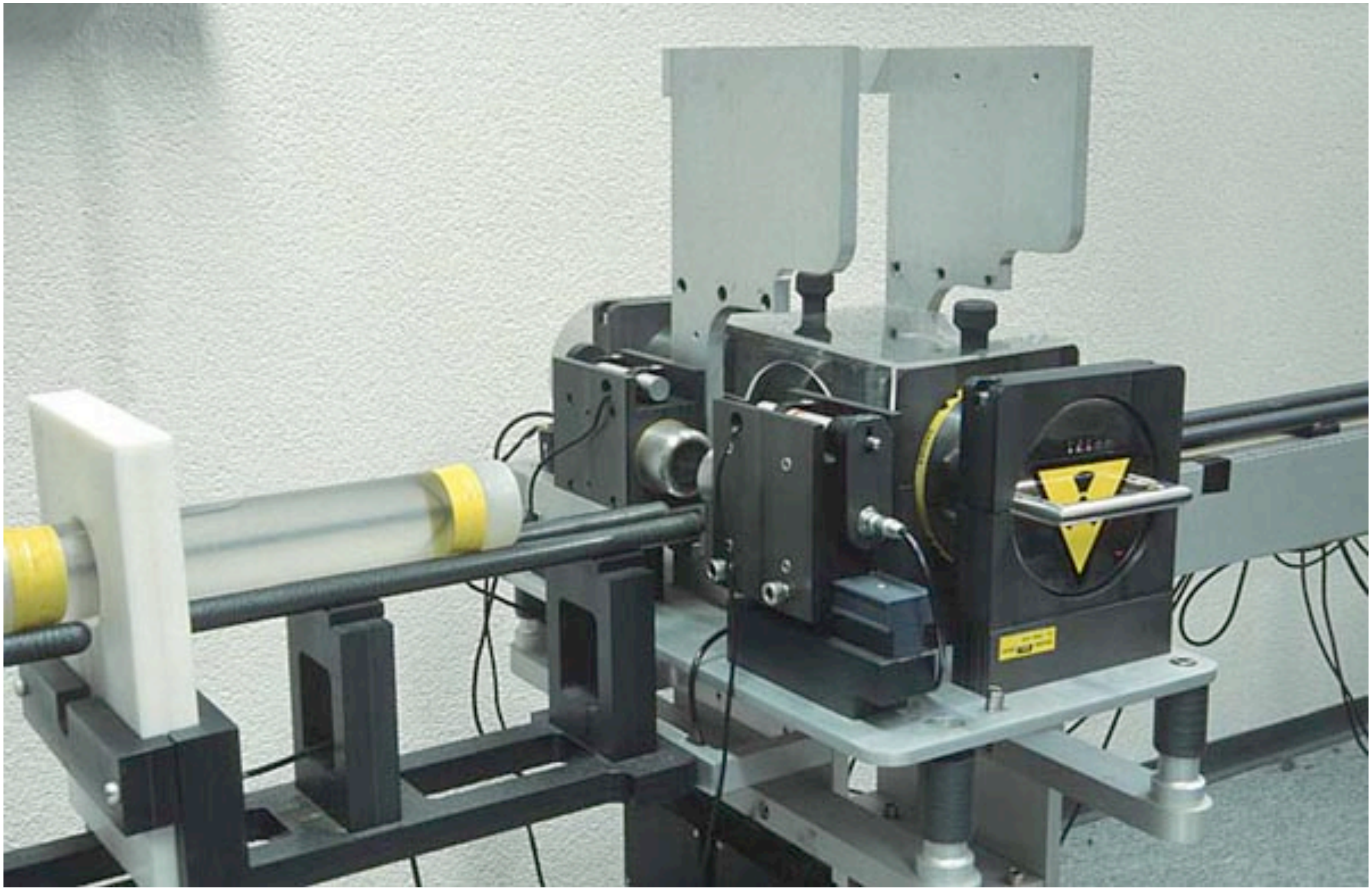
Measurements on core samples



Measurements in the borehole

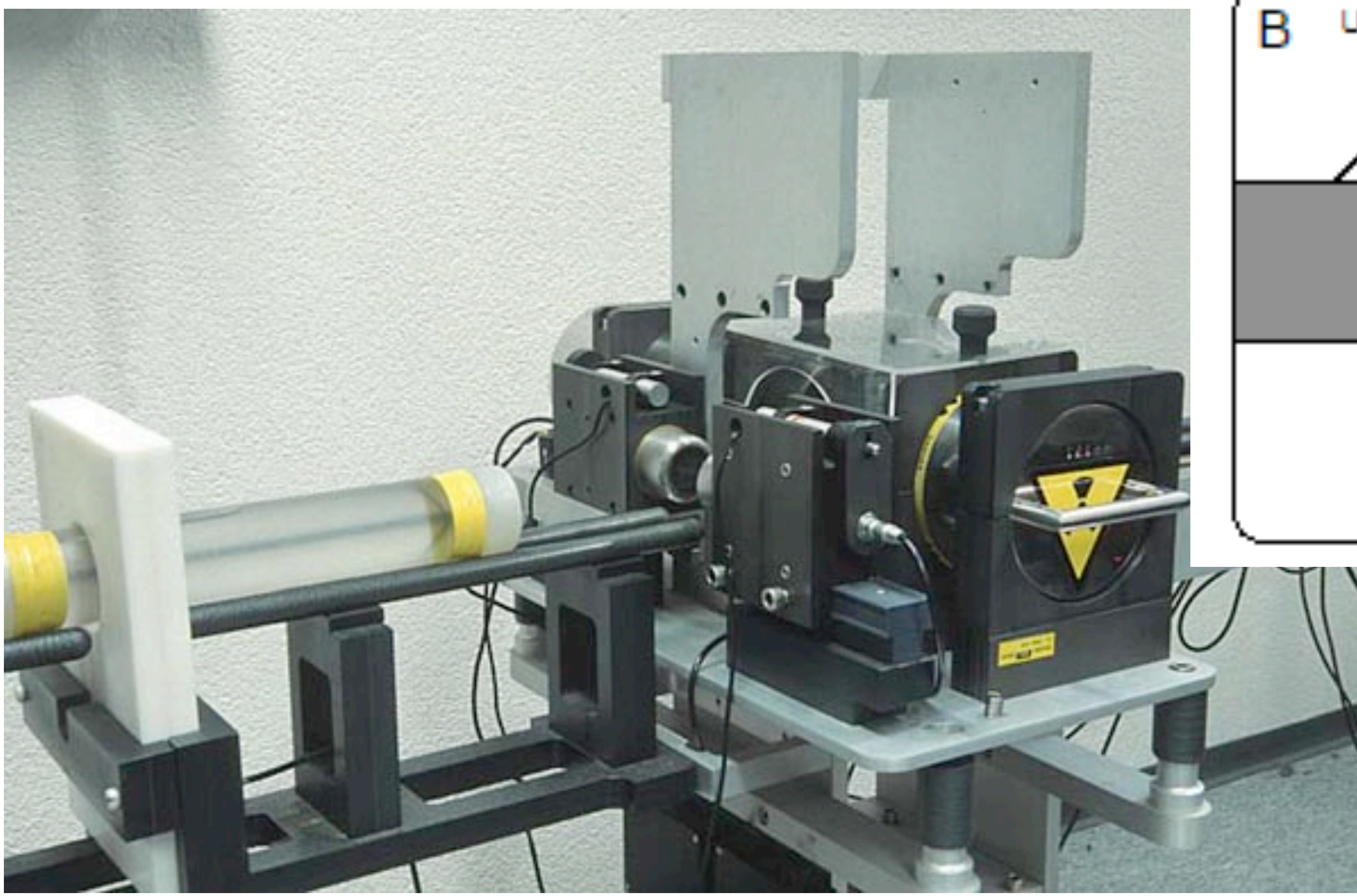


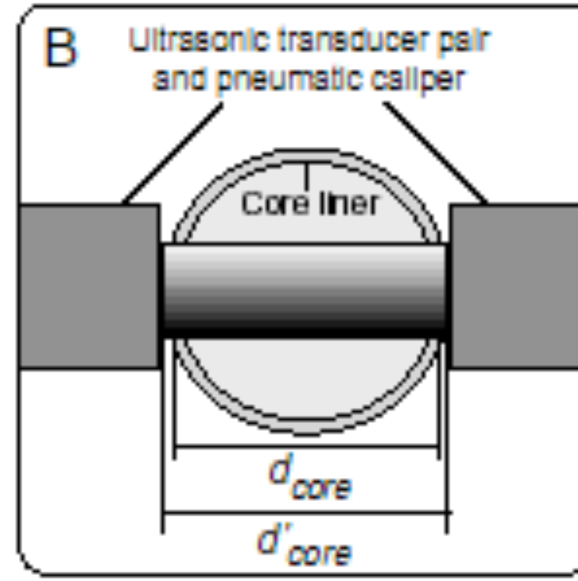
Wet bulk density measurement



^{137}Ce source gamma-ray attenuation porosity evaluator (GRAPE)

P-wave velocity measurement





Transducer-receiver 500 kHz 2μsec pulse