Core-log integration

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Well Logging Principles and Applications
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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 (mbsf). After Goldberg, 1997
Core sample depth

Drilled interval

Recovered intervals

Core sample

Shallowest possible depth

Depth uncertainty

Missing interval

Deepest possible depth
Fig. 4 - Malinverno et al.
Fig. 5 - Malinverno et al.
in si·tu

in the natural or original position or place
Pronunciation: ("in-'sl-"t"tū, -'si-, -"tyū also
-'sē-, -"chū
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

$R_m$

$R_{mc}$

$R_{mf}$

$R_{xo}$

$S_{mc}$

$S_{mf}$

$S_{xo}$

$R_i$

$R_w$

$R_s$

$R_{co}$

$R_{co}$

Water wet sand

Oil wet sand

(a)

(b)

(c)

(d)

(e)

(f)

Water

Oil
Random close packing of spheres:
density $\approx 0.64$, porosity $\approx 0.36$
Effective stress

- Stress or pressure: $\rho gh$
- 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

$$\sigma_{\text{eff}} = gh_s(\rho_s - \rho_w)$$

$$= gh_s(1 - \phi)(\rho_g - \rho_w)$$
Multisensor track (MST)
Measurements on core samples

Measurements in the borehole

Sample

Sensors

“Sample”

Sensors
Wet bulk density measurement

$^{137}\text{Ce}$ source gamma-ray attenuation porosity evaluator (GRAPE)
P-wave velocity measurement

Transducer-receiver 500 kHz 2μsec pulse