भारतीय प्रौद्योगिकी संस्थान
(भारतीय खनि विद्यापीठ)
धनबाद

IIT ISM

INDIAN INSTITUTE OF TECHNOLOGY
(INDIAN SCHOOL OF MINES)
DHANBAD

GPC510 - Well logging

Semester - Winter 2024; Lecture - 13

Partha Pratim Mandal
Assistant Professor
Department of Applied Geophysics
E: partham@iitism.ac.in / partha87presi@gmail.com

TEACHING OUTLINE

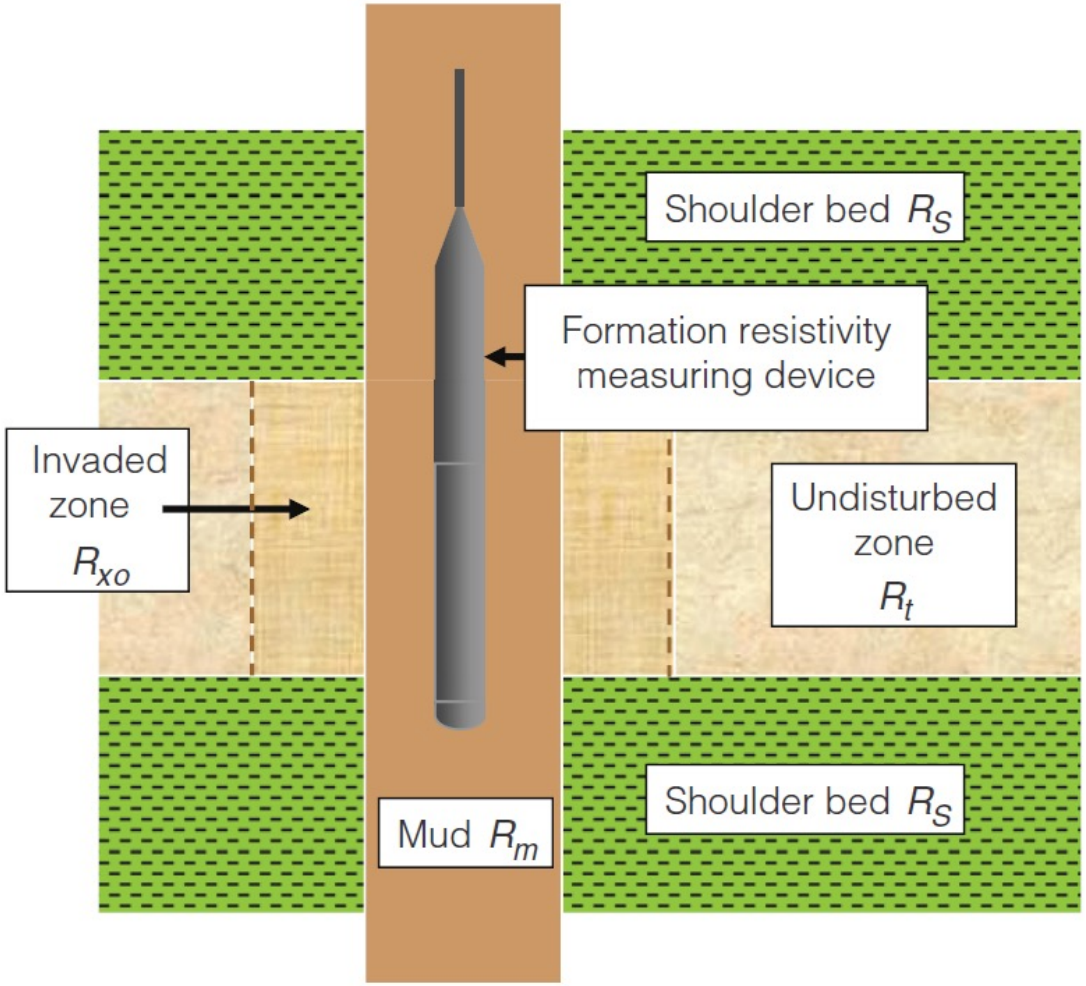
Week 8

Tutorial 17 – Dual Laterolog, different correction

AGENDA

- Dual Laterolog
- Necessary corrections

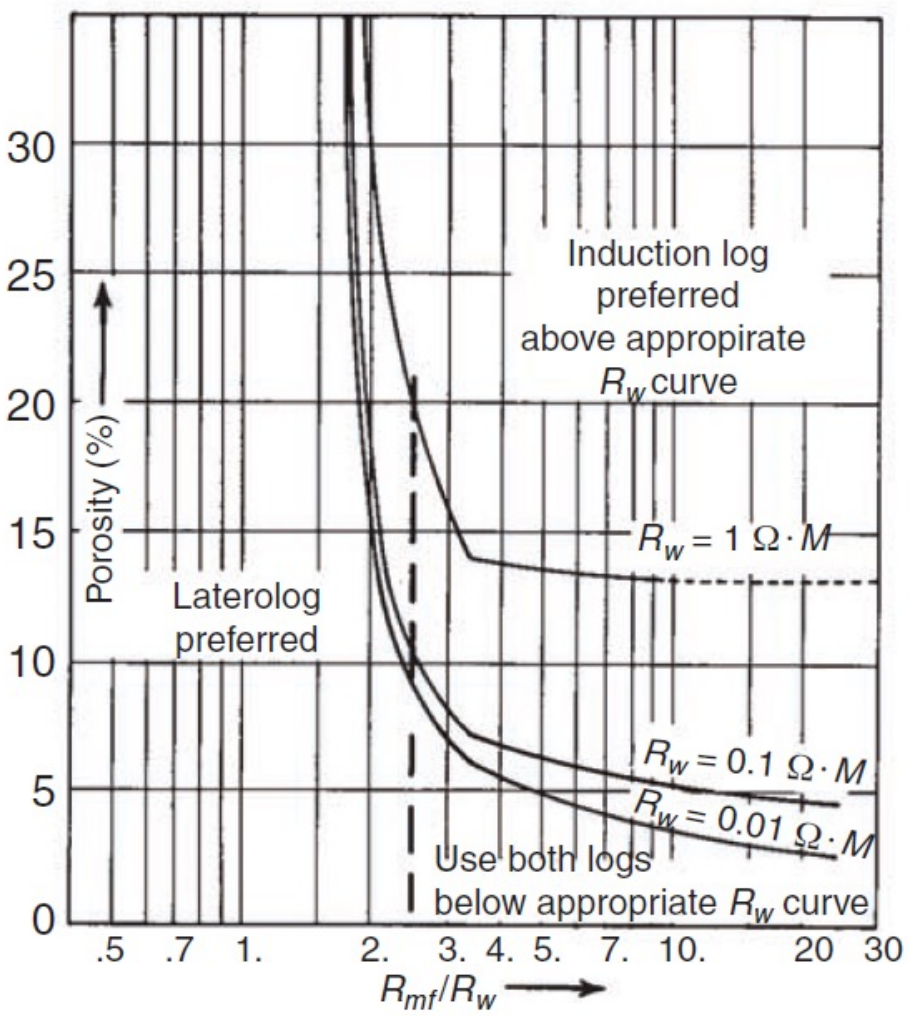
FACTORS AFFECTING RESISTIVITY



Bateman, 2012

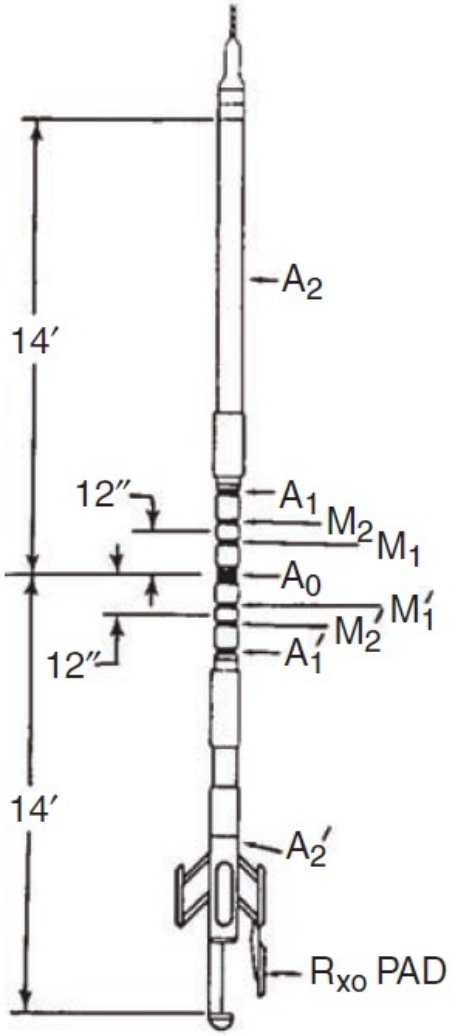
CONDITION OF USE: LATEROLOG

- Seawater or brine mud is in the hole
- The R_{mf}/R_w ratio is less than 3
- Hole size is less than 16 inch



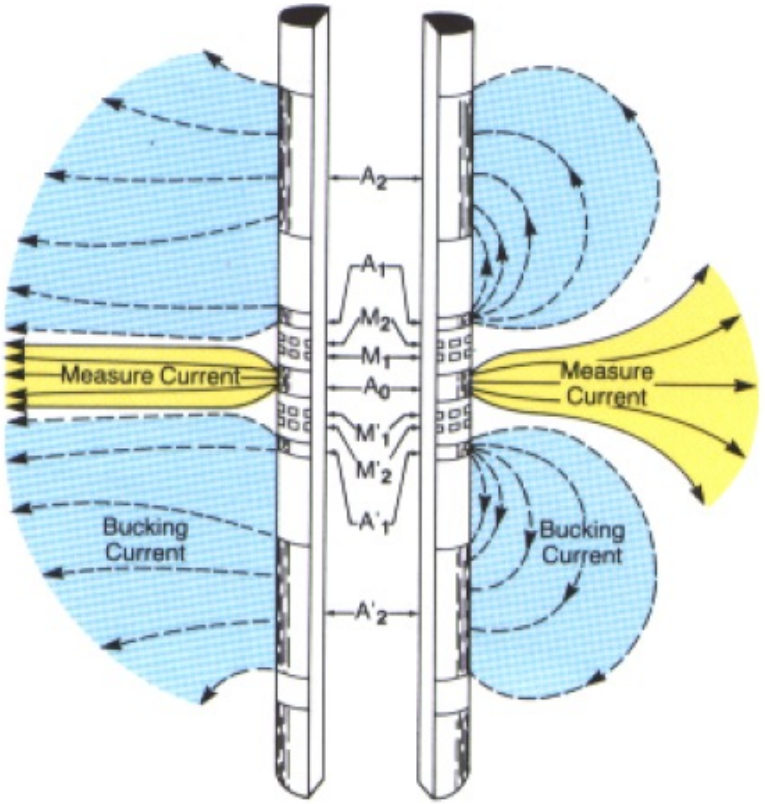
DUAL LATEROLOG

- The DLL records three resistivity curves: the laterolog deep (*LLD* or *LLd*), the laterolog shallow (*LLS* or *LLs*), and a microspherically focused log (*MSFL*).
- Auxiliary curves such as caliper, gamma ray, and spontaneous potential may also be recorded.
- Once the tool is at the bottom of the well, arms with contact pads are extended to fit against the sides of the borehole.



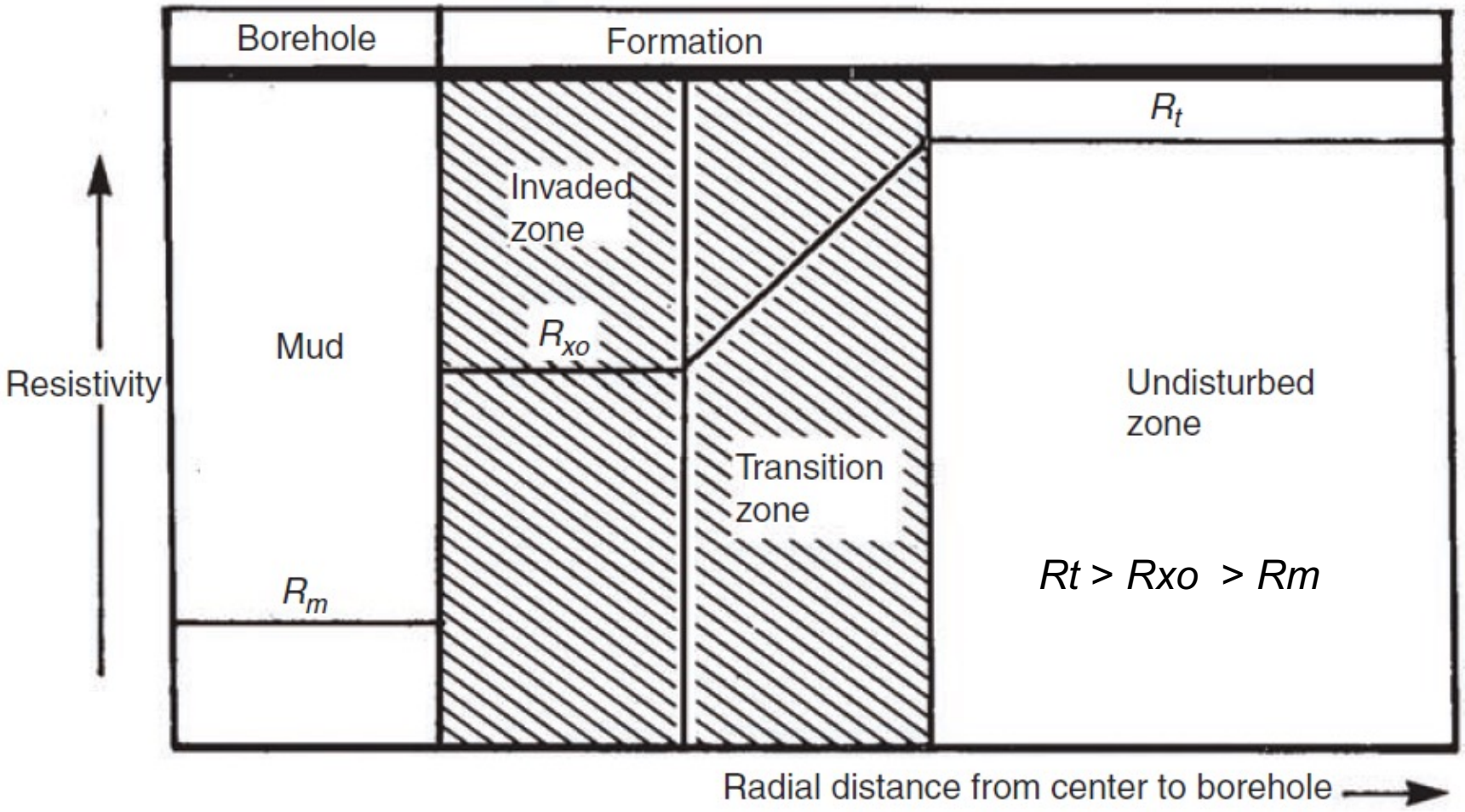
DUAL LATEROLOG

- LLD system uses remote (surface) return for the main and bucking currents
- LLs uses A2-A2’ electrode-pair as the return for the bucking current from A1-A1’, which reduces the effectiveness of focusing of I_0



	LLD		LLS
A_0	Measure Current Electrode	A_0	Measure Current Electrode
M_1 M_2	Monitoring Electrode	M_1 M_2	Monitoring Electrode
A_1	Bucking Current Electrode	A_1	Bucking Current Emitting Electrode
A_2	Bucking Current Electrode	A_2	Bucking Current Return Electrode

RESISTIVITY PROFILES



RADIAL CURRENT PATH

- Plan view of horizontal slice through the tool and surrounding formation
- For a constant current flow, it develops a series of voltage drop across each zone which can be simplified as

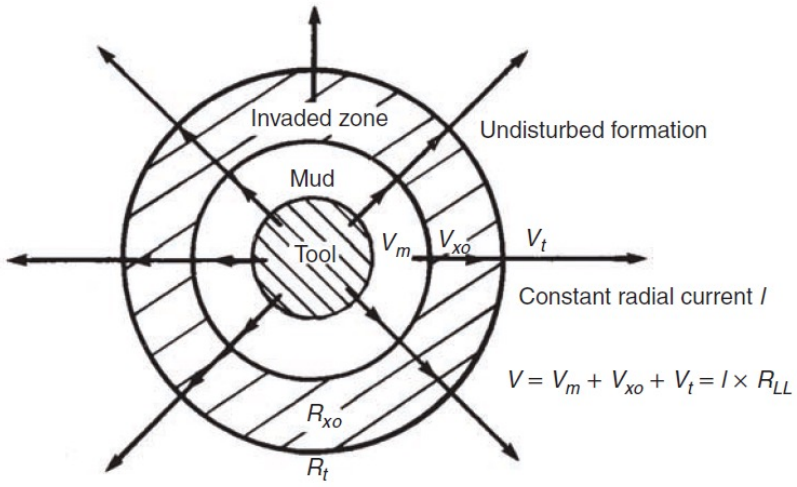
$$V_{total} = V_{mud} + V_{invaded} + V_{uninvaded}$$

Each voltage drop is propositional to the product of the current , the resistivity of the zone and geometrical constant (depending upon size)

$$V_{mud} = I * R_m * \alpha$$

$$V_{invaded} = I * R_{xo} * \beta$$

$$V_{uninvaded} = I * R_t * \gamma$$



RADIAL CURRENT PATH

- Total voltage V_{total} is related to the current I and measured resistivity (R_{LL}) by the tool

$$V_{total} = I * R_{LL}$$

When comparing

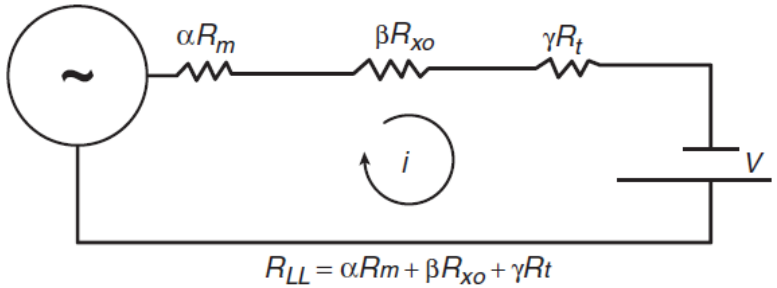
$$R_{LL} = \alpha R_m + \beta R_{xo} + \gamma R_t$$

α depends upon hole size while β and γ depend on invasion diameter d_i and difference between Rxo and Rt.

The response of the tool in an invaded formation can best described by pseudo-geometrical factor J (corresponding to the depth of investigation)

$$R_{LL} = R_{xo}J + R_t(1 - J)$$

J varies between 0 to 1. When d_i =0, J=0 while for d_i= infinite, J=1

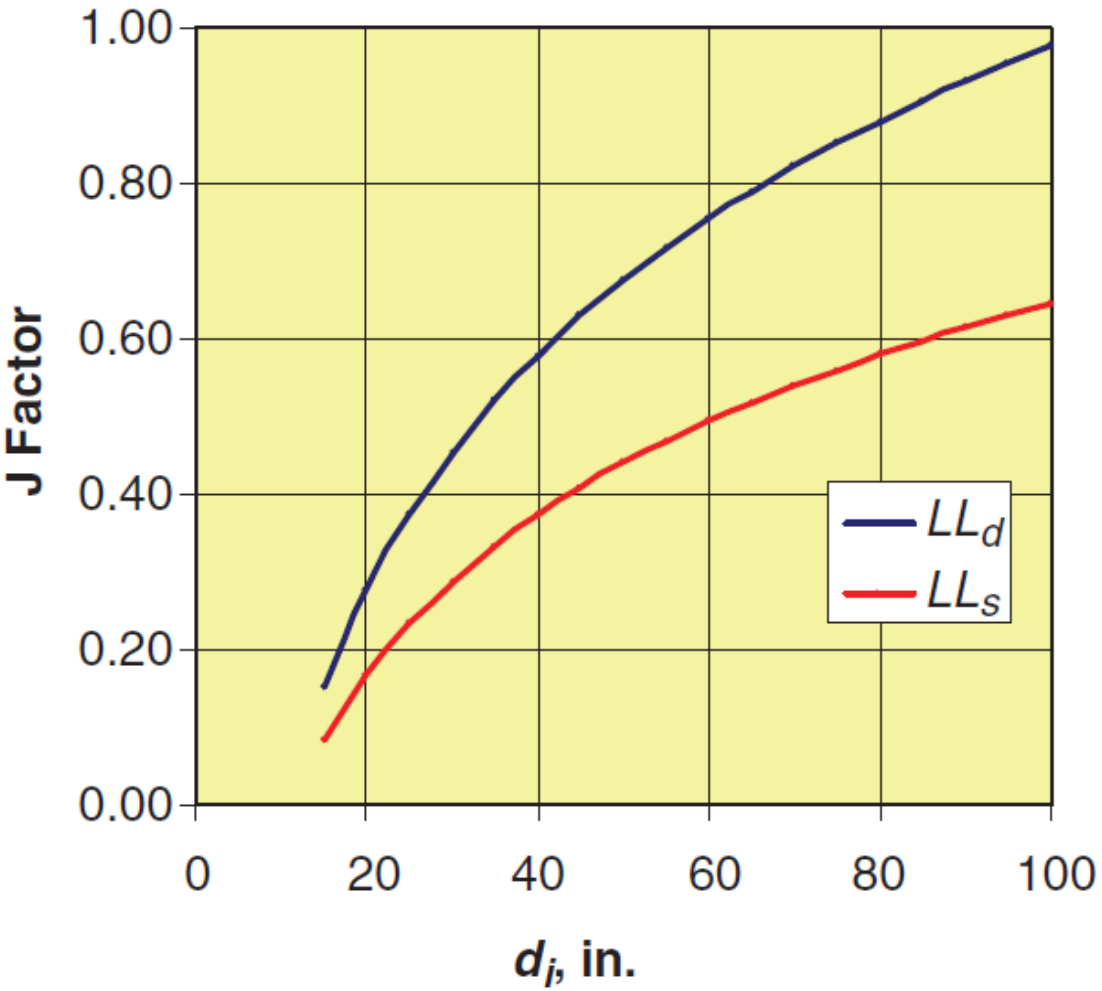


PSEUDO-GEOMETRICAL FACTOR J

- The pseudo-geometrical factor (also known as the apparent formation factor) is a correction factor used in resistivity logging to account for the effect of the borehole on the measured resistivity of the surrounding formation
- It is calculated by comparing the resistivity measured in a fully invaded formation (where the borehole is completely filled with drilling mud) to the resistivity measured in an uninvaded formation (where the drilling mud has not yet invaded the formation). The ratio of these two resistivities gives the pseudo-geometrical factor
- The pseudo-geometrical factor is used to correct the measured resistivity for the effect of the borehole, and to obtain an accurate estimate of the resistivity of the surrounding formation

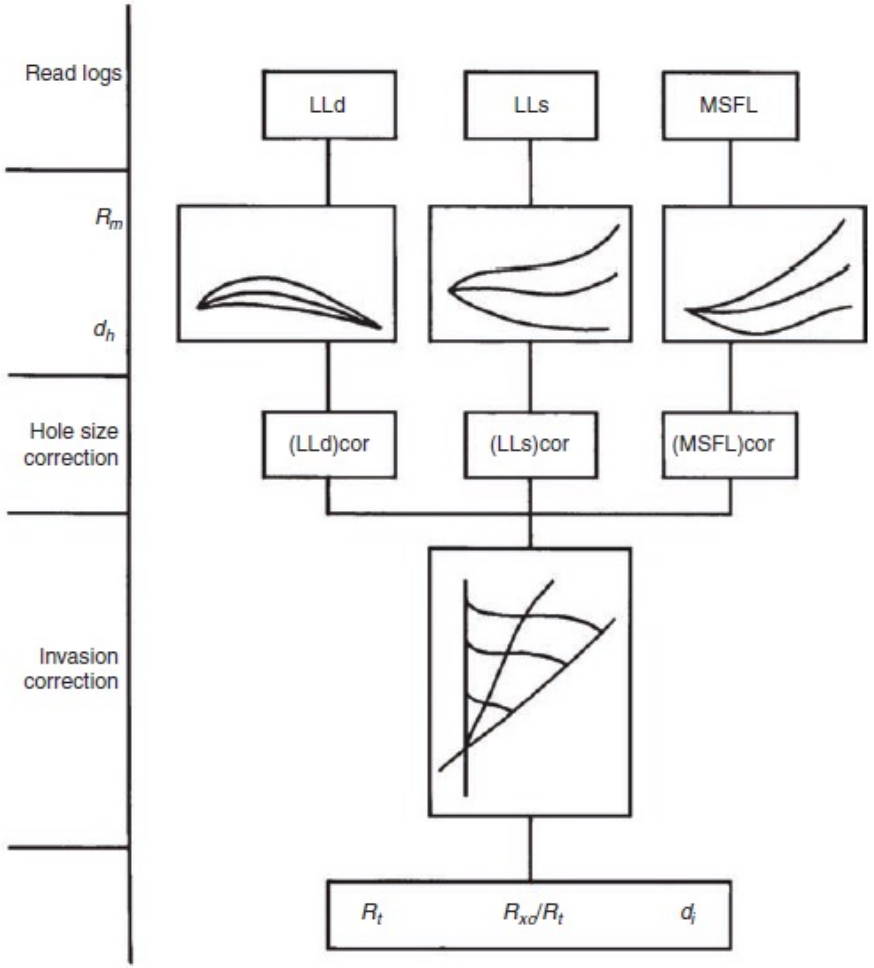
LATEROLOG PSEUDO-GEOMETRICAL FACTOR

- Both shallow and deep log have their corresponding J-d_i factors
- For example: R_{xo} = 3 Ohm-m, R_t = 8 Ohm-m and di = 40 inch, calculate R_{LLd} response
- How do you get accurate estimates of Rt from R_{LLd} response. Three unknowns (R_t, R_{xo}, d_i)



DUAL LATEROLOG CORRECTION

- In case of DLL, make borehole corrections first (borehole diameter, mud effect), then shoulder-bed corrections (if required) and finally invasion correction



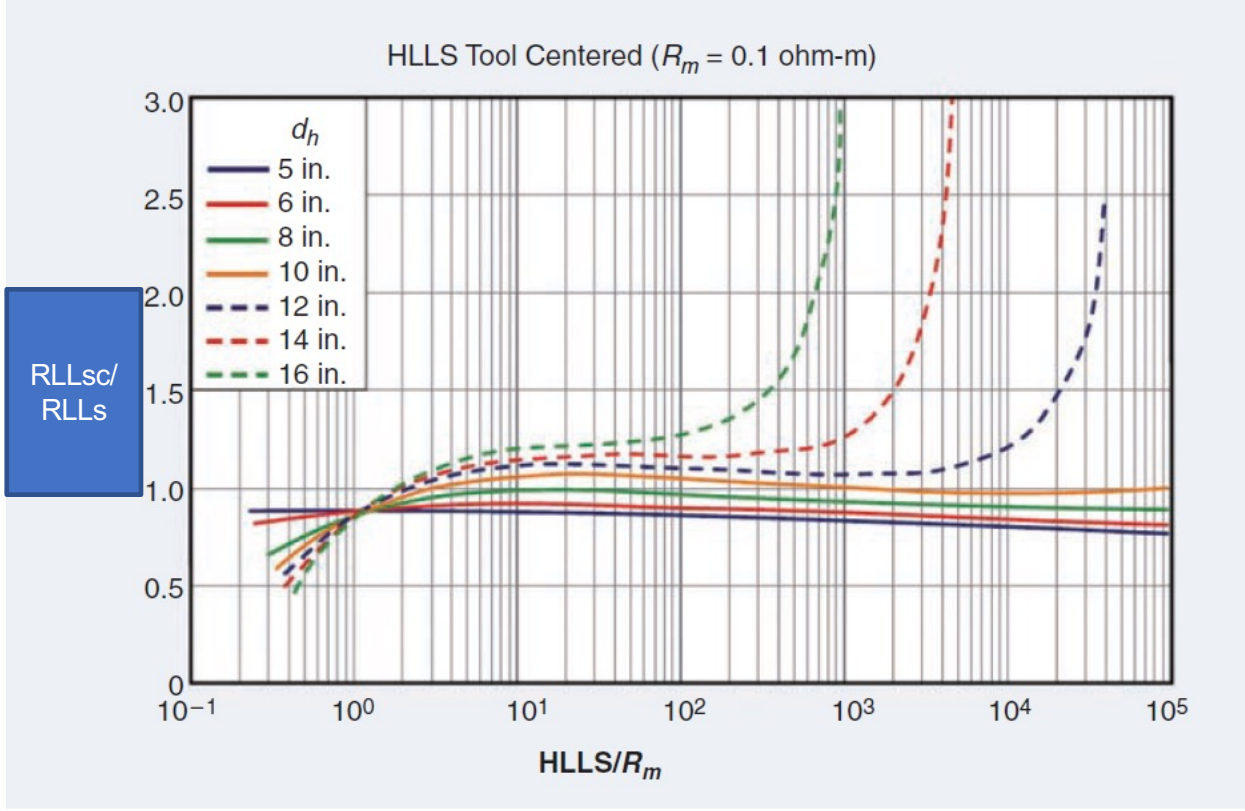
BOREHOLE SIZE CORRECTION CHARTS - LLS

Apply correction?

RLLs = 25.0 Ohm·m.

Rm = 0.25 Ohm·m.

Caliper = 14.0 in.



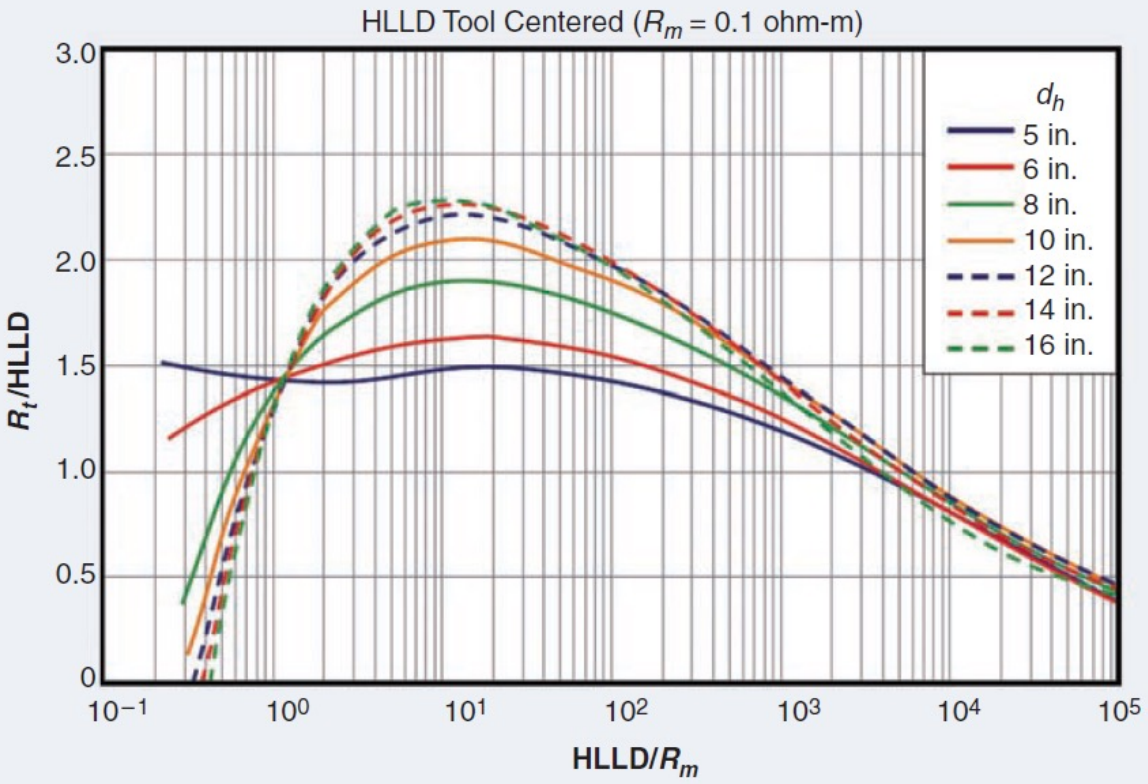
BOREHOLE SIZE CORRECTION CHARTS - LLD

Apply correction?

RLLd = 50.0 Ohm·m

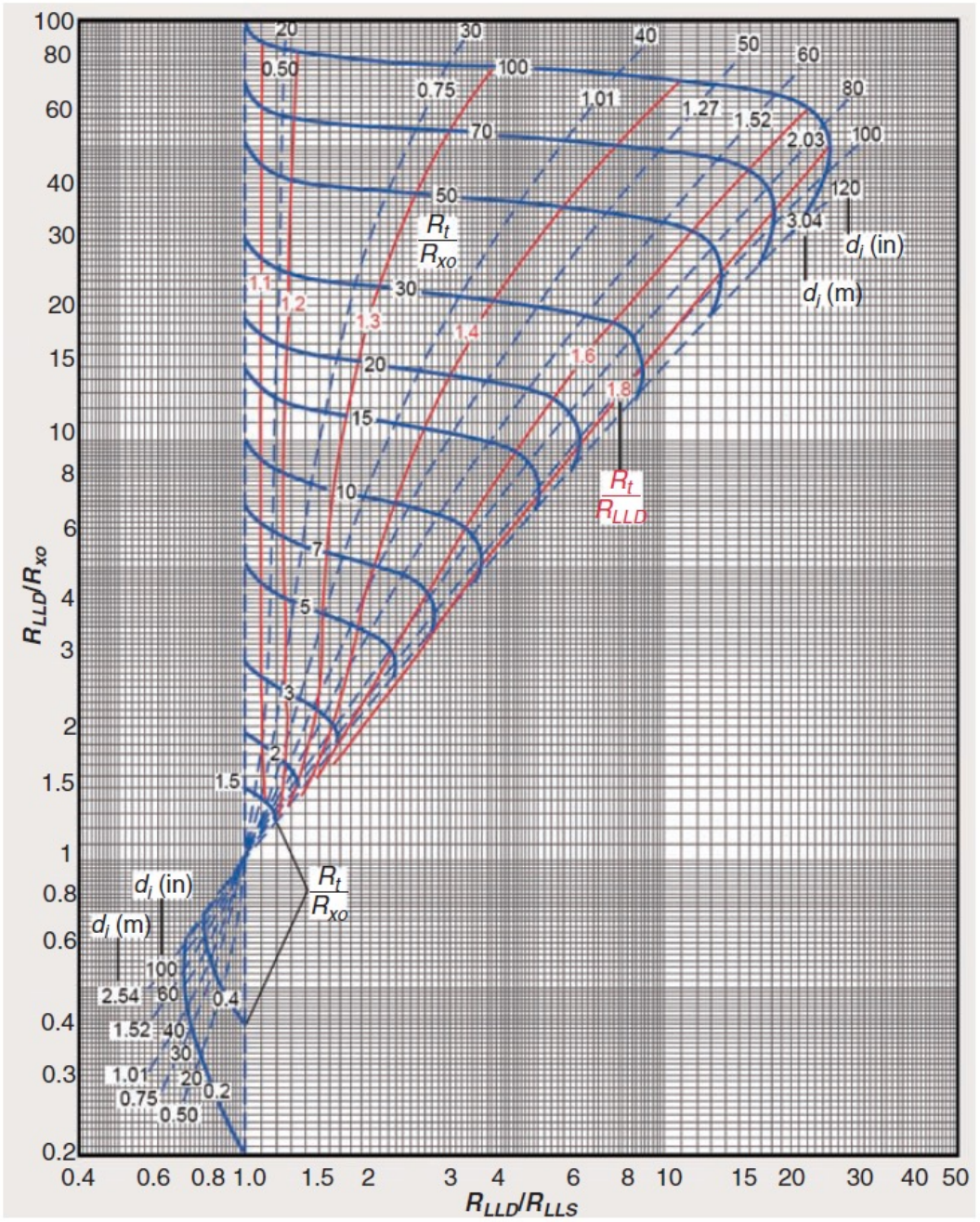
Rm = 0.25 Ohm·m

Caliper = 12.0 in.



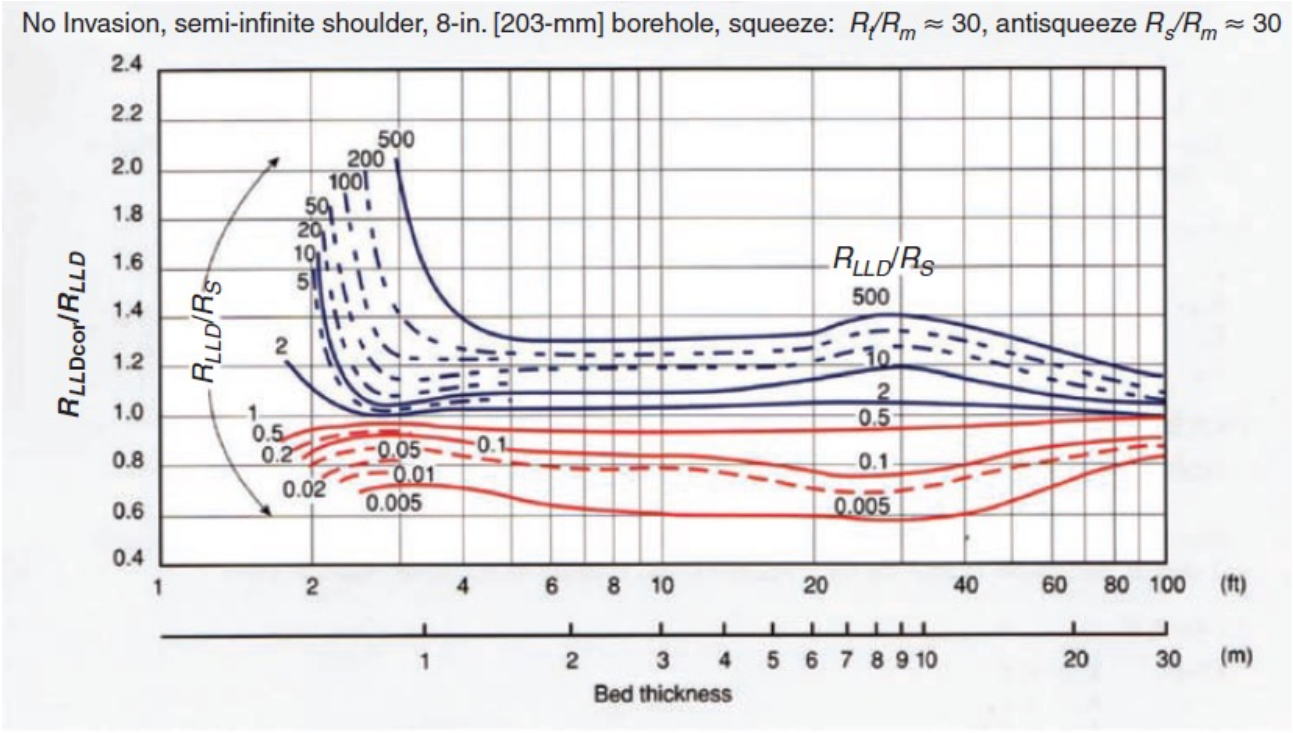
BUTTERFLY CHART

- After raw data is corrected for borehole effects, they also required to be corrected for invasion effects
- Lower part describes invasion pattern in case of (mostly in water saturated zones) $R_{MSFL} > R_{LLs} > R_{LLd}$



SHOULDERS-BED CORRECTION

- When the sonde is in front of a bed, on either side of which there is a resistive shoulder, current tends to concentrate in the least resistive path; in other words, the current is “squeezed” between the resistive shoulders into the formation of interest.



END OF LECTURE