Properties of common lithologies

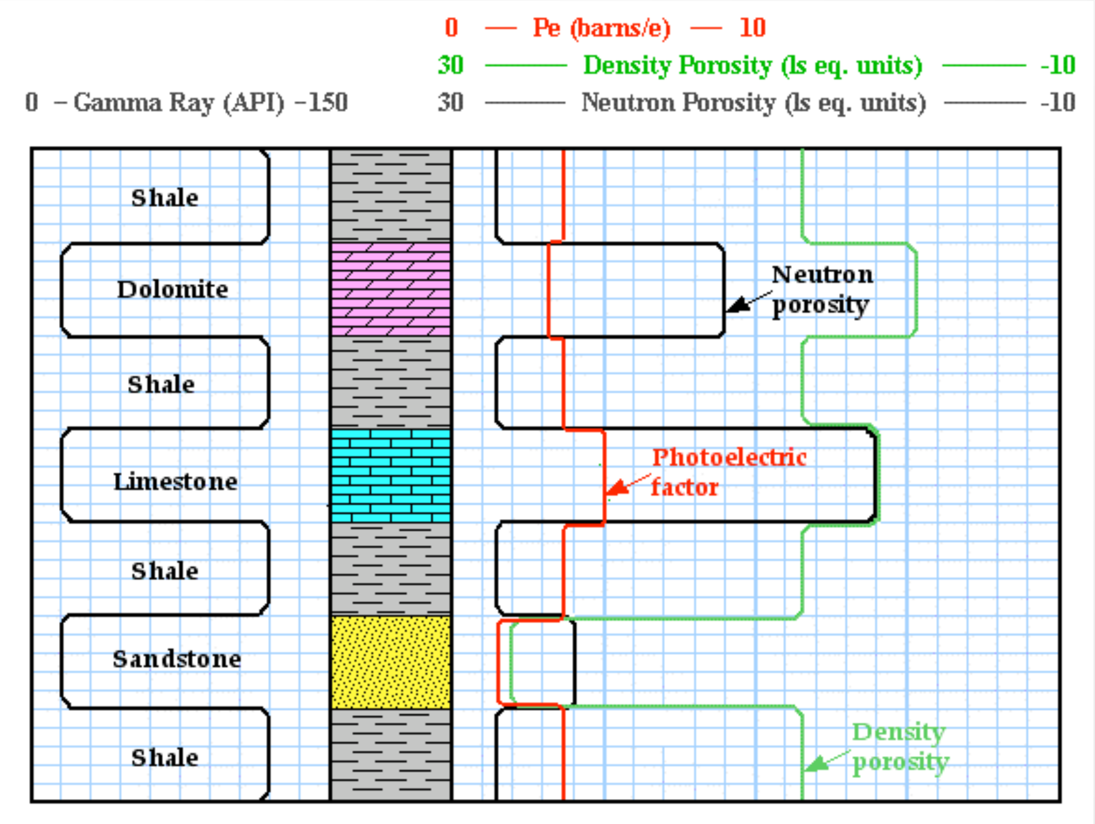
If the density log is of the newer litho- or spectral type and a photo–electric curve (P_e) is available, the ambiguity is distinctly reduced.

Many mixed lithologies can be resolved with this method: the P_e value falls between the single lithology value of each component. Problem for complex mixtures.

Lithology	ϕ_N and ϕ_D	P_e
Limestone	$\phi_N \sim \phi_D$	about 5
Dolomite	$\phi_D < \phi_N$ of 12-14 ϕ units	about 3
Sandstone	$\phi_D > \phi_N$ of 6-8 ϕ units	less than 2
Anhydrite	$\phi_D << \phi_N$ of 14 or more ϕ units	about 5
Salt	ϕ_D is 40% or more; ϕ_N slightly less than zero. But hole in salt succession ?? washed out.	4.7

Table is for limestone matrix; formation is water or oil filled.

Gamma ray and density/neutron/ P_e log overlays (1)



Density /neutron overlay indicates ϕ + lithology, P_e values better constrain lithology.

Matching of Neutron and Density log indicates:

- either limestone (if referenced to lst ϕ), or a
- cherty dolomite, or a
- cherty dolomitic limestone.

Photoelectric index helps to choose correct alternative.

In contrast, a dolomite reading on the photoelectric index curve alone could also be caused by a cherty or sandy limestone.

The simultaneous consideration of the neutron-density log overlay with the P_e log resolves what is more likely.

Properties of evaporites

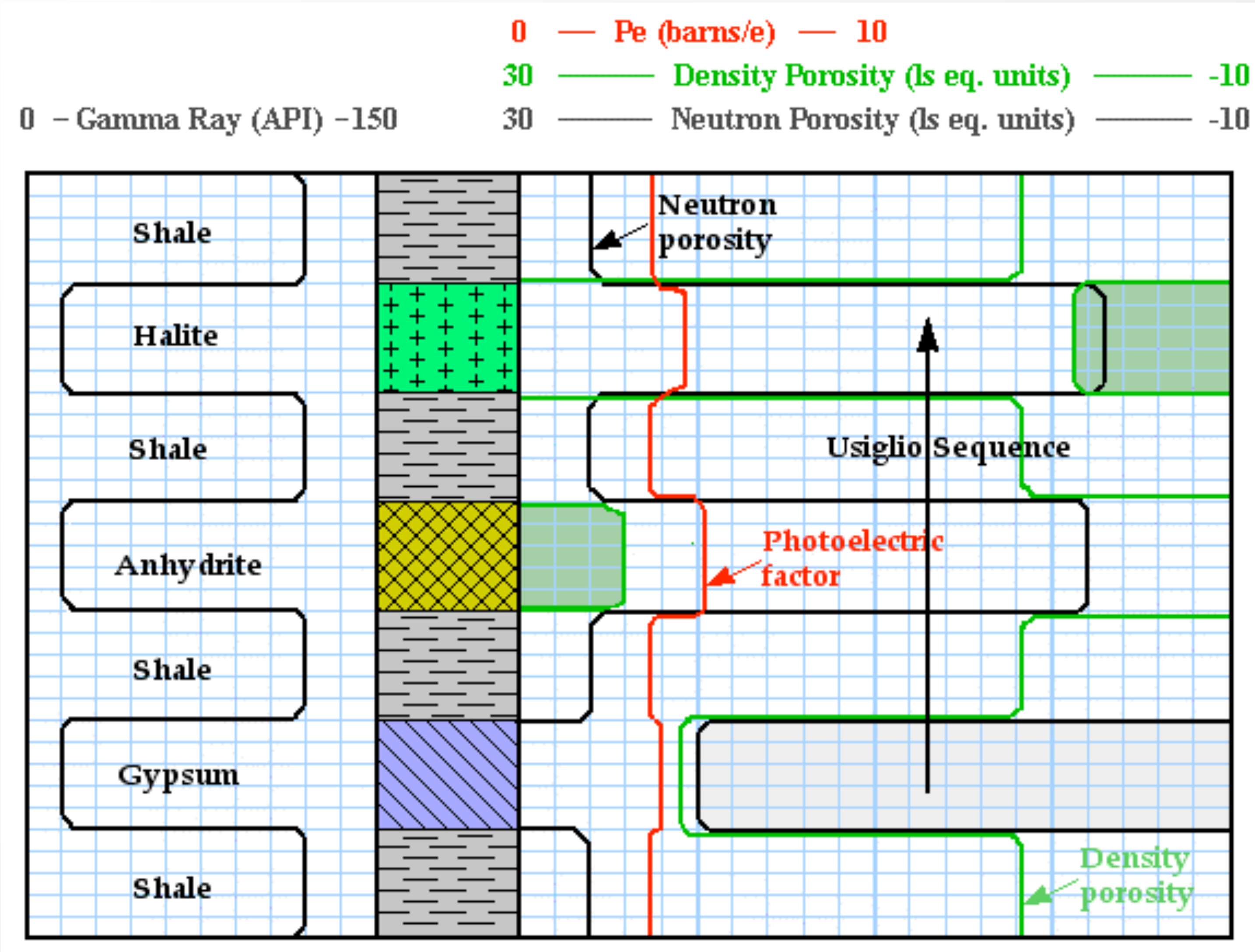
Gypsum, anhydrite, and rock salt (halite): highly distinctive logging properties (see Table below and Figure next slide).

Halite and anhydrite have markedly low and high bulk densities, respectively, while the very high neutron porosity of gypsum is caused by hydrogen in its crystal water.

Lithology	P_e	ϕ_N	ϕ_D (bulk density)
Gypsum	4.0	60	21 (2.35)
Anhydrite	5.1	-2	-16 (2.98)
Halite	4.7	-3	39 (2.04)

On the logs partly backup scale!

Multiple log overlay: evaporites



Succession of minerals, precipitated with increased evaporation: Usiglio (1849) sequence:

- carbonate,
- gypsum/ anhydrite,
- rock salt, etc.

Scales partly backup (hashed), normal scale is from -10 to 30% porosity.

Properties of coals

Coals: typically for deltaic environments with shales, siltstones, and sandstones, as well as occasional ironstones (typically siderite).

Clay mineralogy is quite variable, often elevated contents in kaolinite, particularly in paleosols.

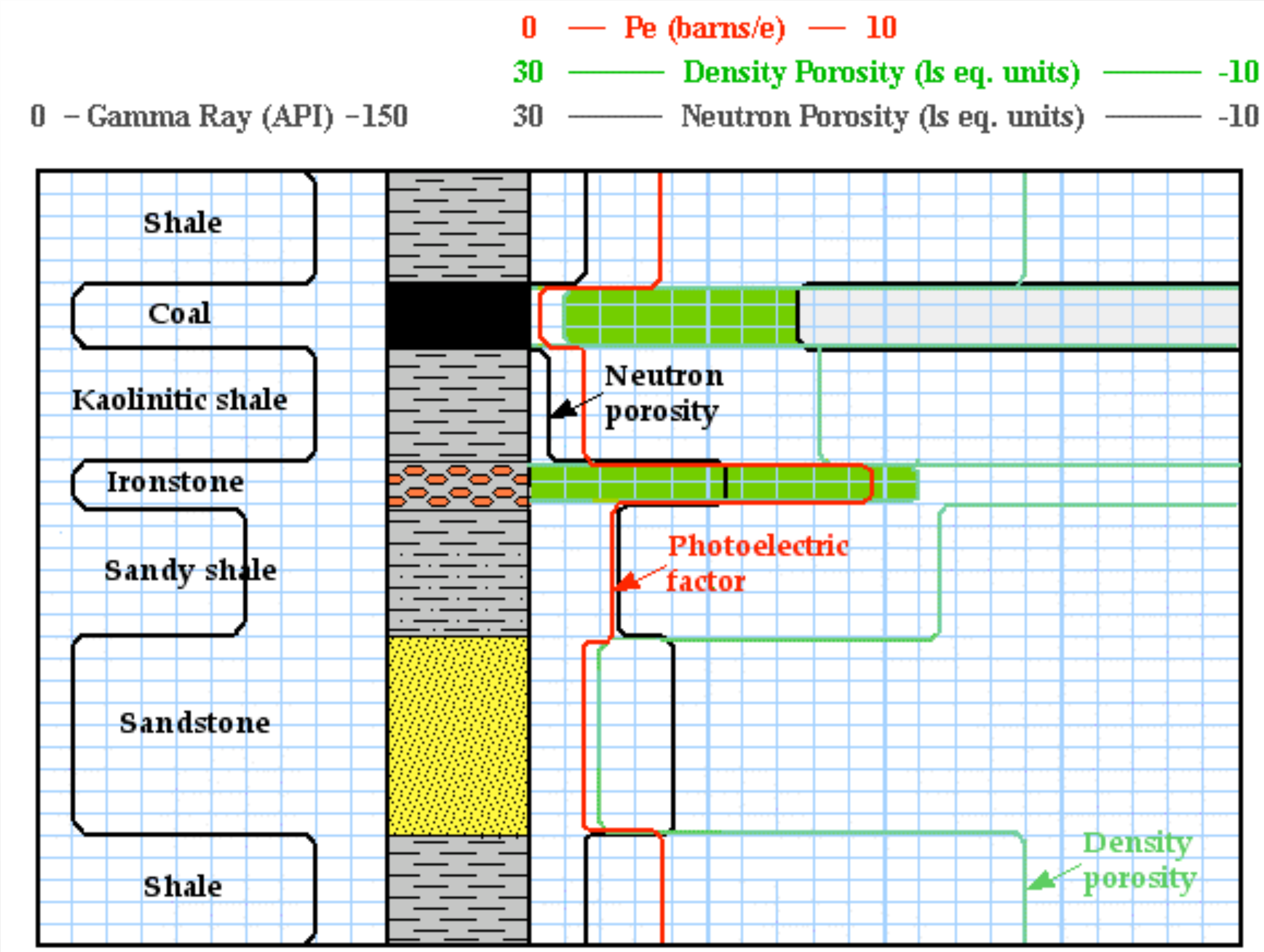
Also glauconite may develop in the marine part, especially during transgressions.

Logging properties of coals vary according to rank:

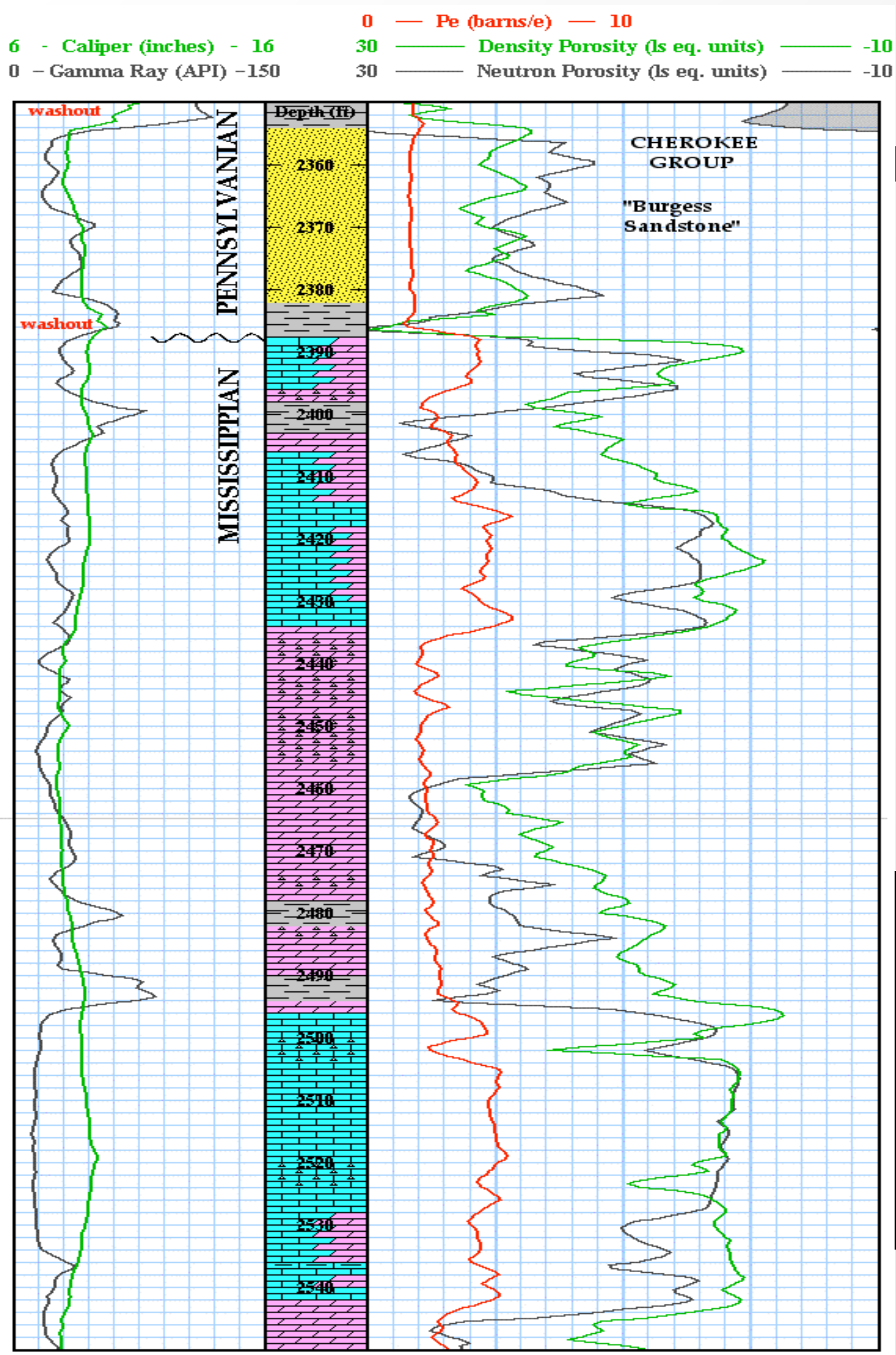
Lithology	P_e	ϕ_N	ϕ_D (bulk density)
Lignite	0.20	52	89 (1.19)
Bituminous coal	0.17	60	86 (1.24)
Anthracite	0.16	38	72 (1.47)

On the logs partly backup scale!

Multiple log overlay: coal



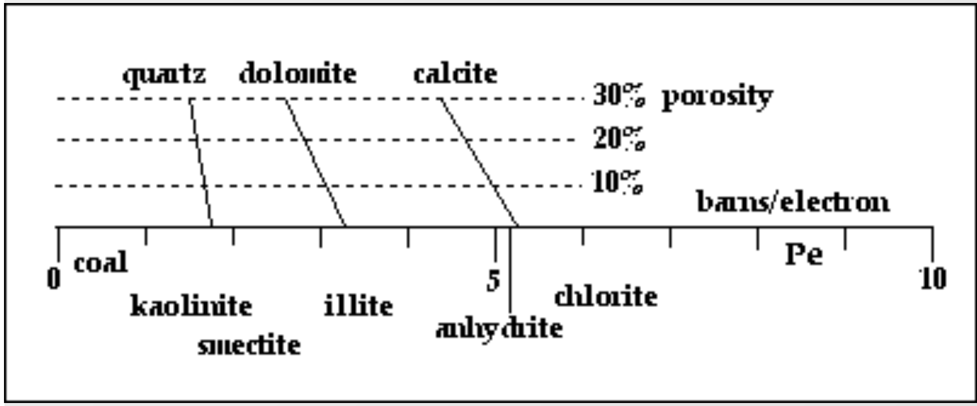
Scales again partly backup, because porosity readings of normal, non-logarithmic scale is from -10 to 30%.



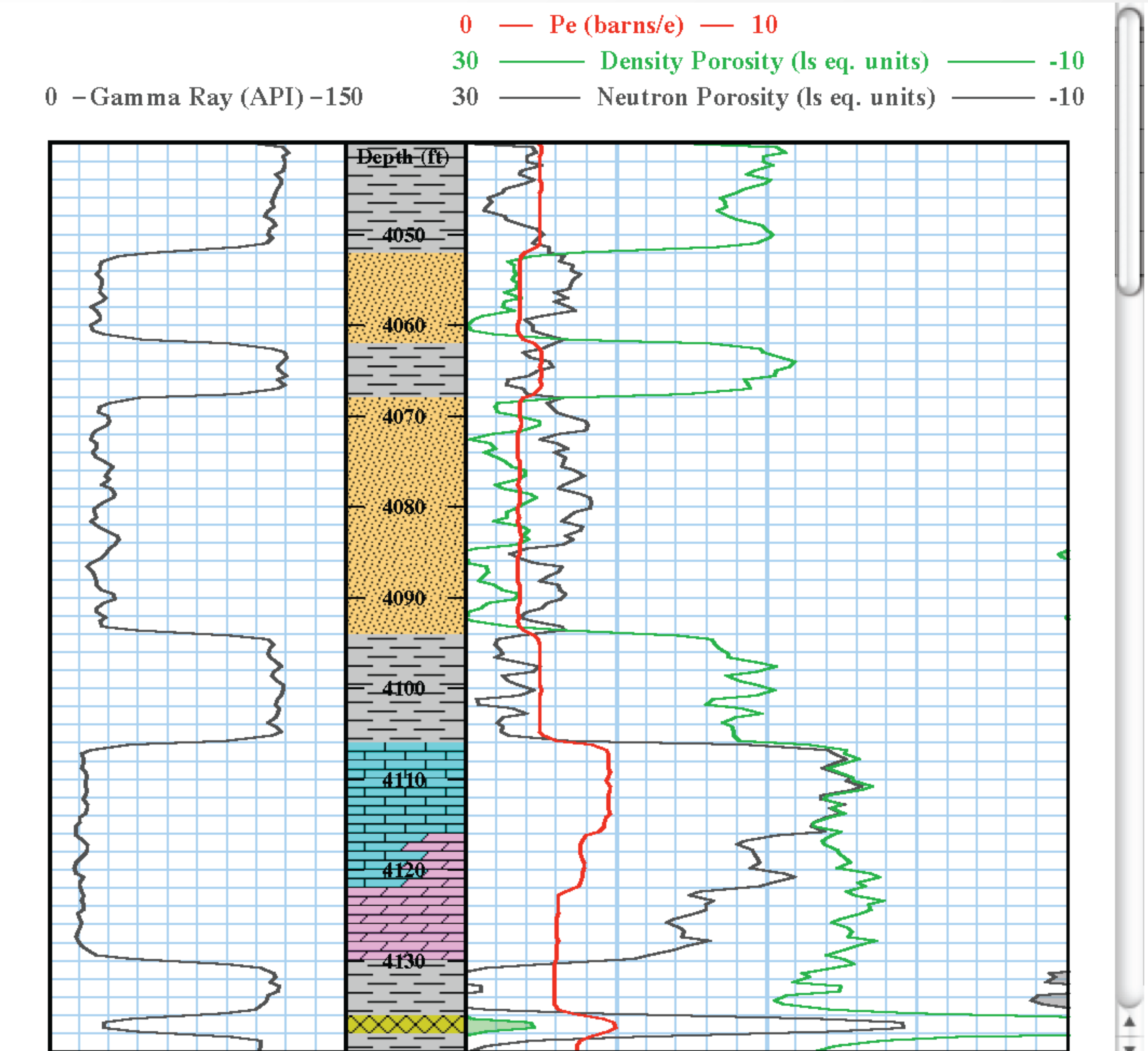
Exercise 3-3

Succession is a mixture of sst., lst., dol., and chert.

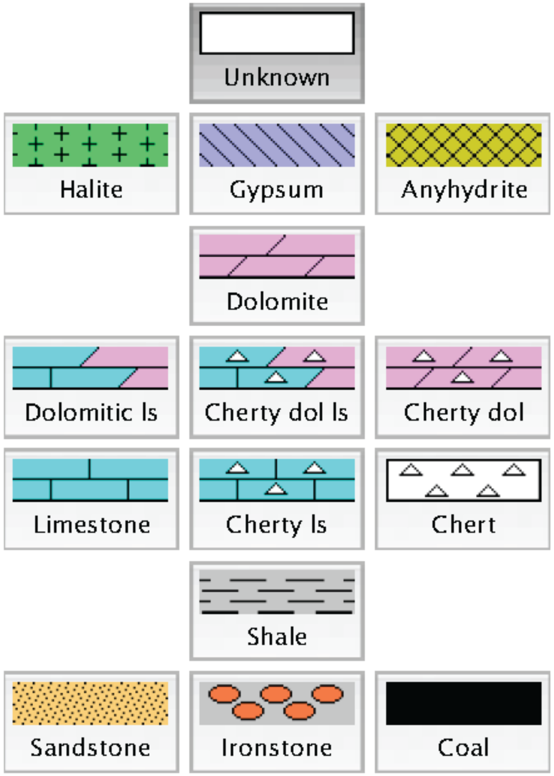
Give reasons for lithology plotted.



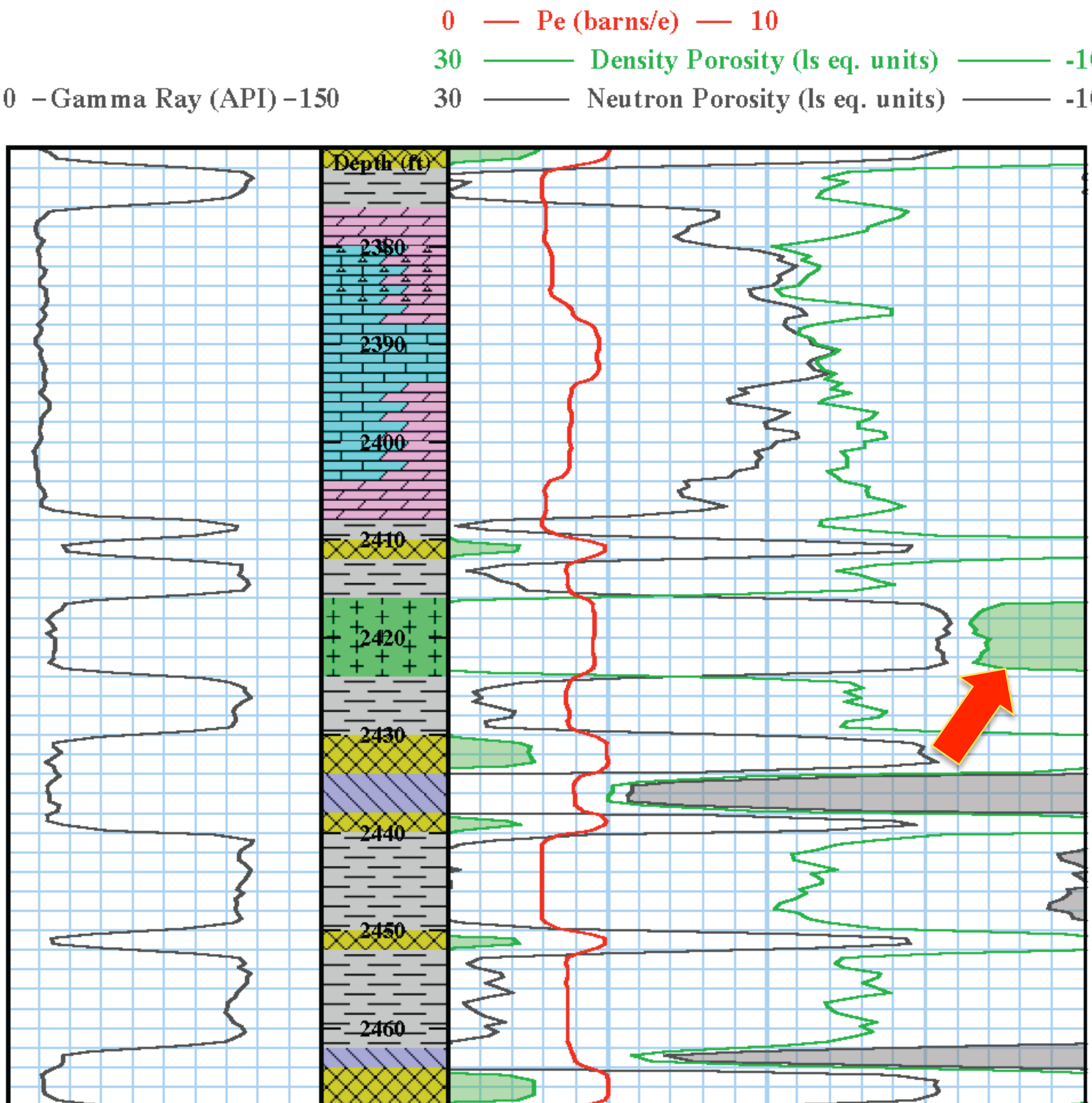
Exercise 3-4a: Oz machine



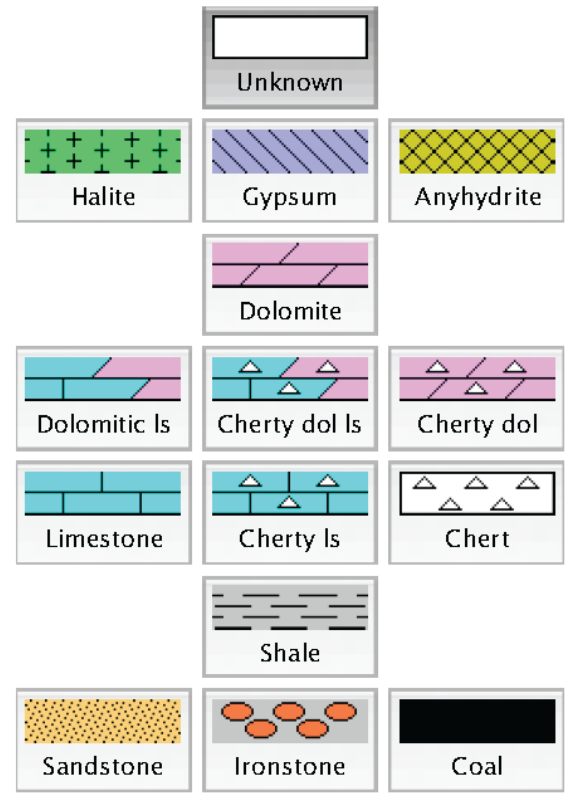
Reasons for lithology given



Exercise 3-4b: Oz machine

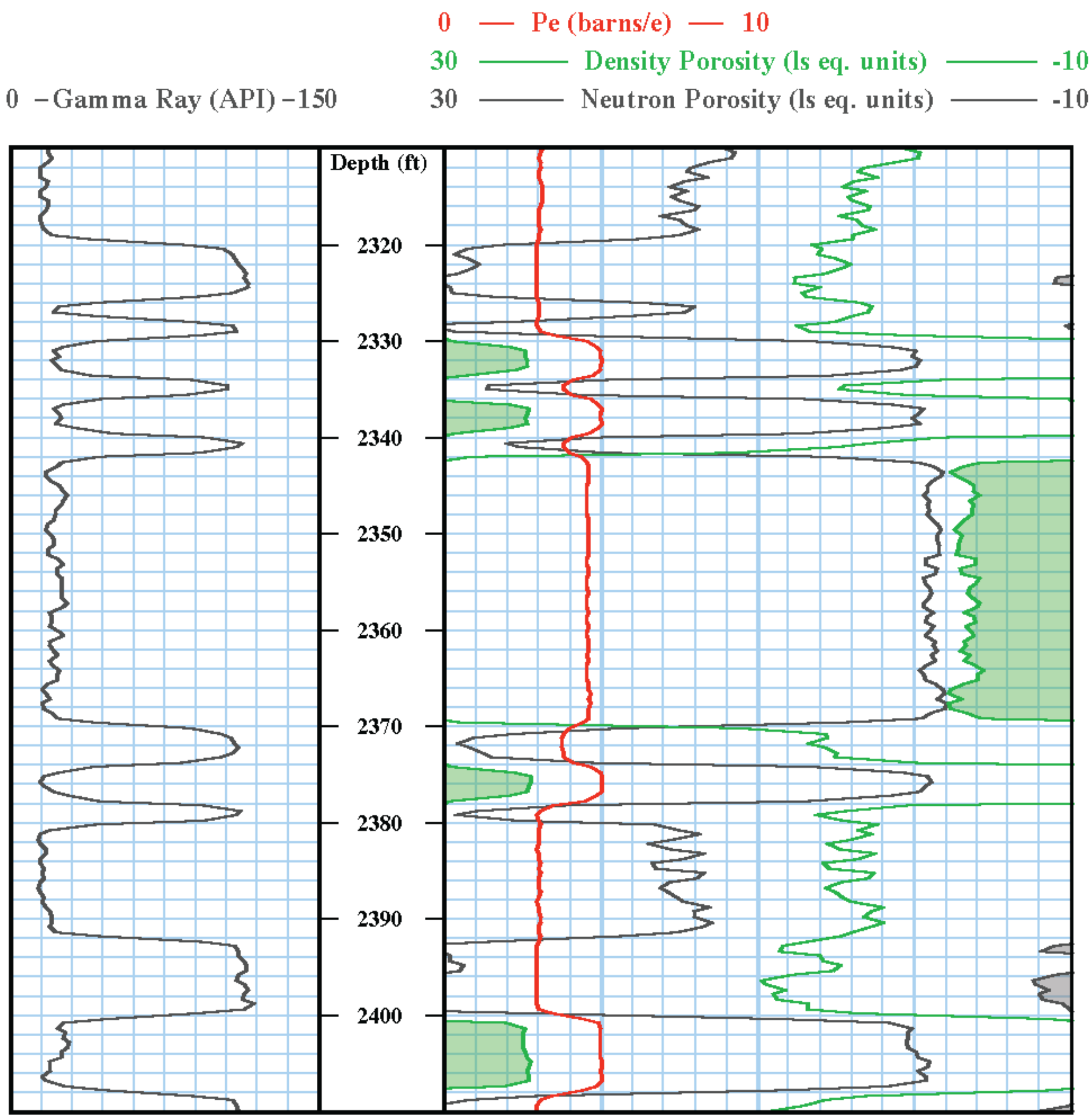


Reasons for lithology given

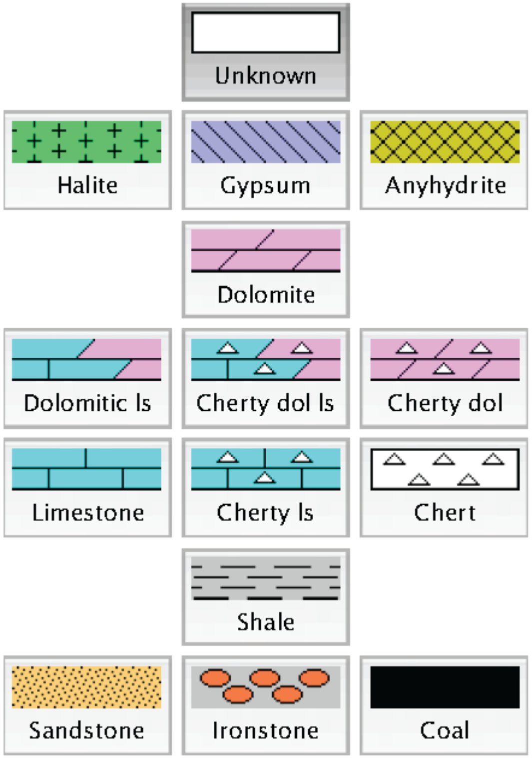


green: backup scale!
Not limestone!

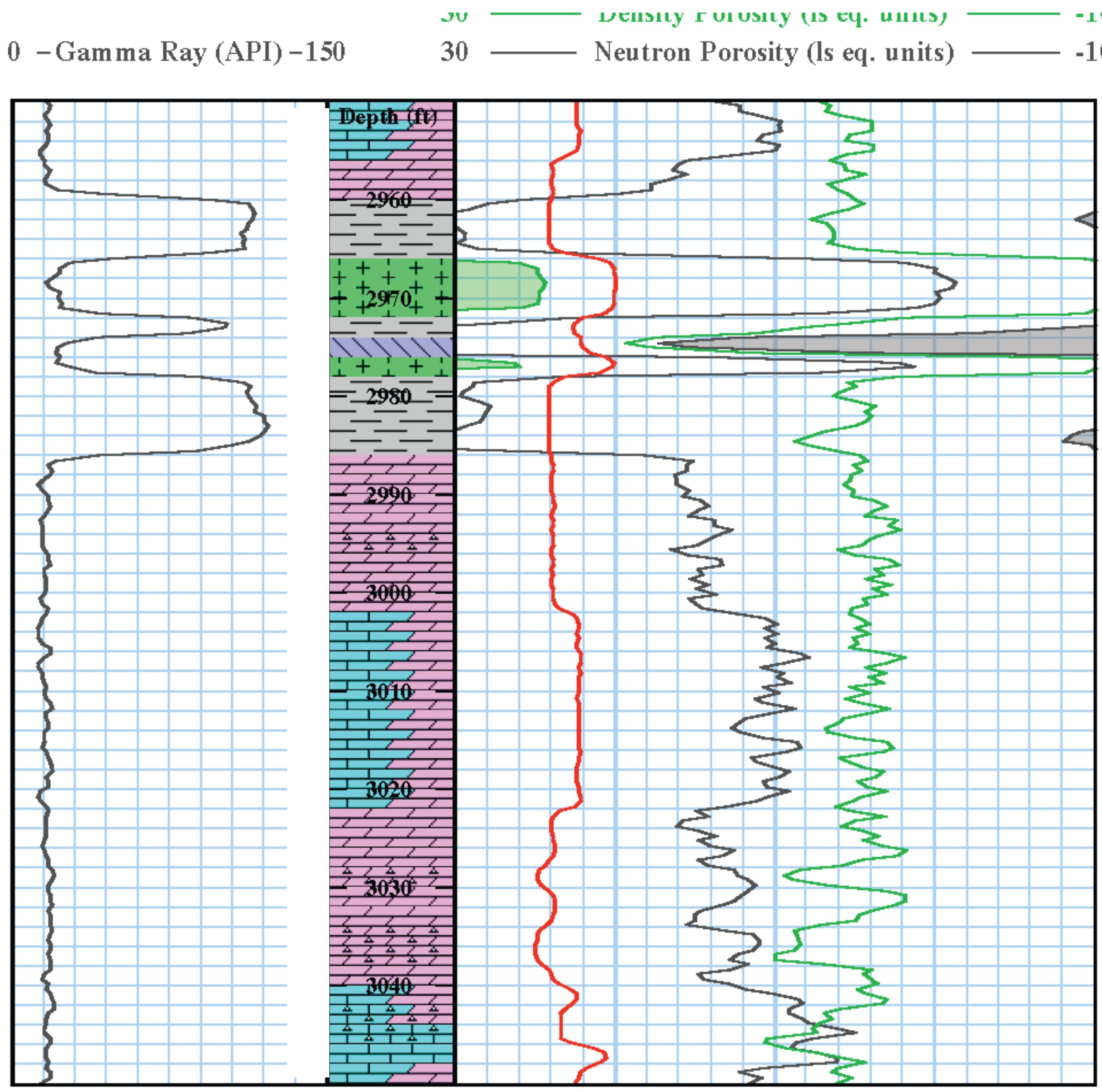
Exercise 3-4c: Oz machine



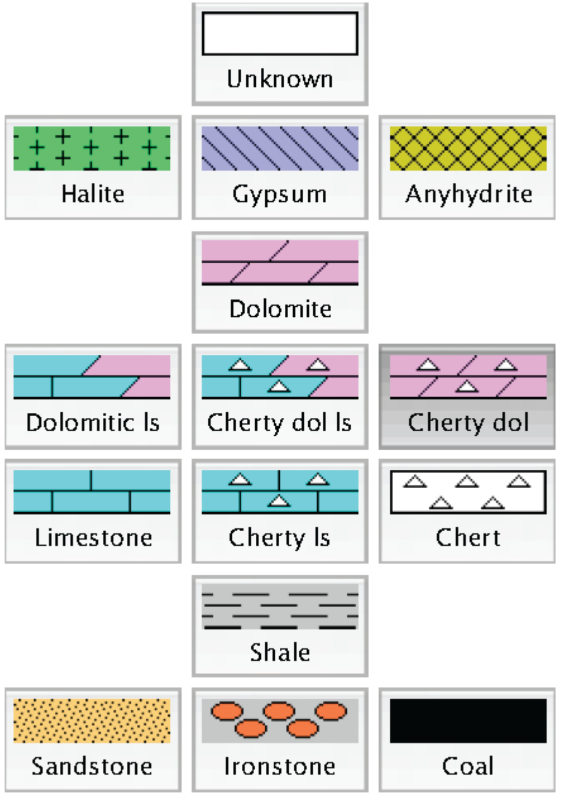
Plot lithology in depth scale



Exercise 3-4d: Oz machine



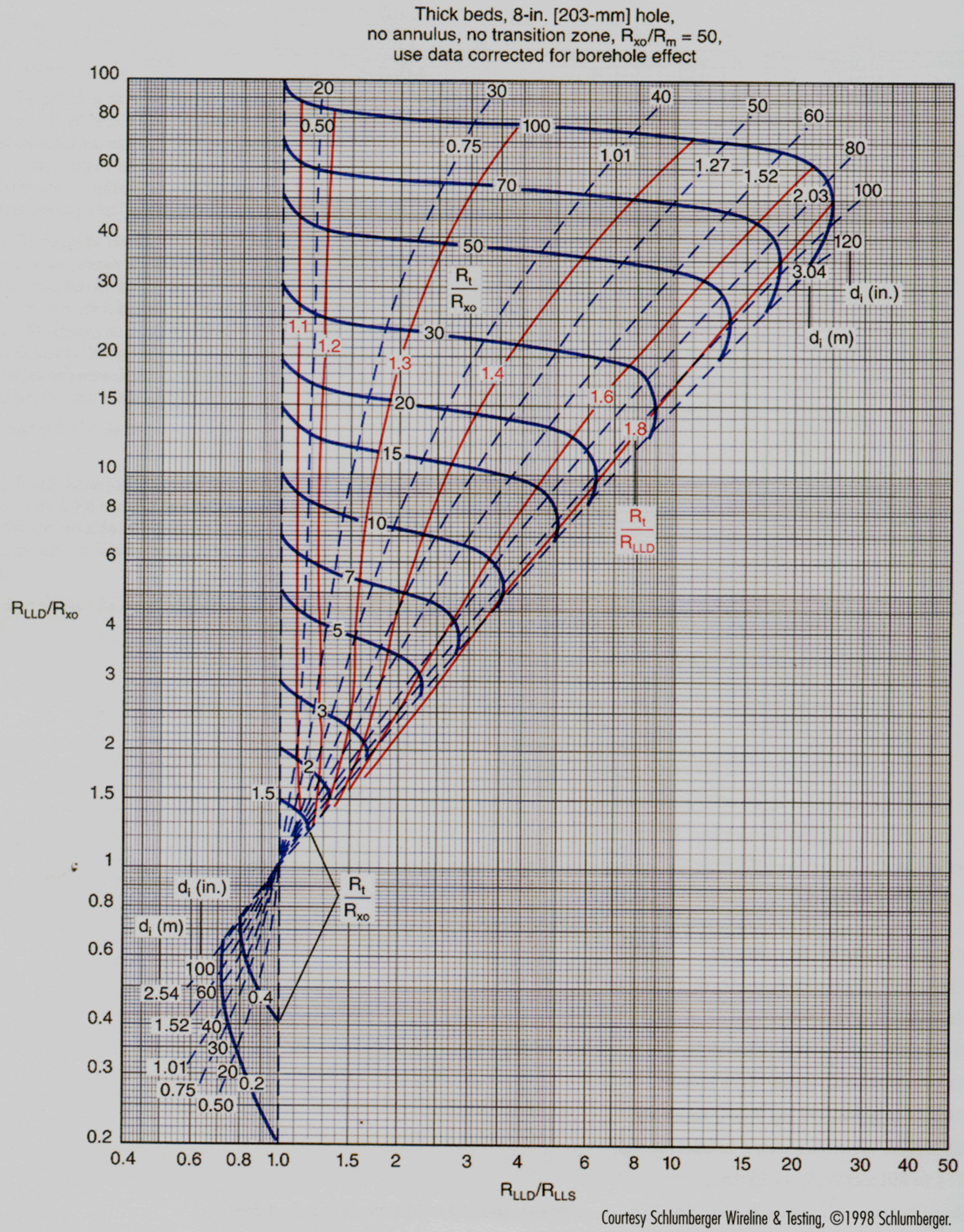
Where are mistakes in lithology interpretation?



Exercise 5-6: Dual Laterolog + MSFL

Dual laterolog - R_{xo} tornado chart for correcting logged resistivities to R_t.

- Blue dashed lines, upper part of diagram: scale from 20 to 120 gives d_i (diameter of invasion) in inches; scale from 0.5 to 3.04 gives d_i in meters.
- Blue solid lines: R_t / R_{xo}; scale values increase from bottom to top and range from 0.2 to 100.
- Red lines: R_t / R_{LLD}, ranging from 1.1 to 1.8.



Exercise 5-6: Dual Laterolog + MSFL

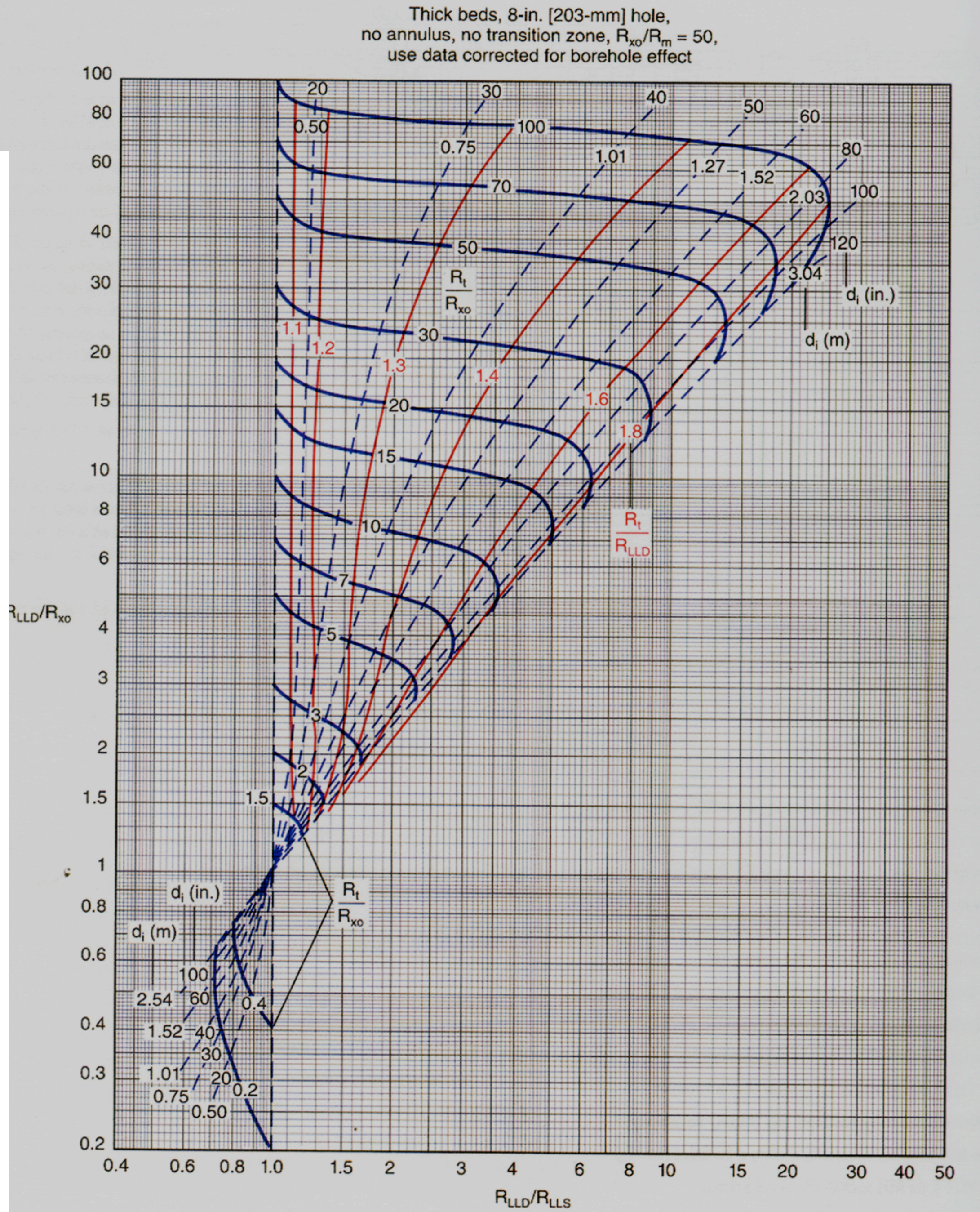
Procedure

To use the tornado chart different ratios have to be calculated first:

1. R_{LLD} / R_{MSFL} ($R_{MSFL} \cong R_{xo}$)
2. R_{LLD} / R_{LLS}
3. *Find* R_{LLD} / R_{xo} (vertical axis).
4. Find R_{LLD} / R_{LLS} (horizontal axis).
5. Read values needed for the following equations from the tornado chart: R_t/R_{LLD} and R_t/R_{xo}

$$R_{t\ corr.} = \frac{R_t}{R_{LLD}} \times R_{LLD}$$

$$R_{xo\ corr.} = \frac{R_{t\ corr.}}{R_t / R_{xo}}$$



Courtesy Schlumberger Wireline & Testing, ©1998 Schlumberger.

Class exercise: Dual Induction Log

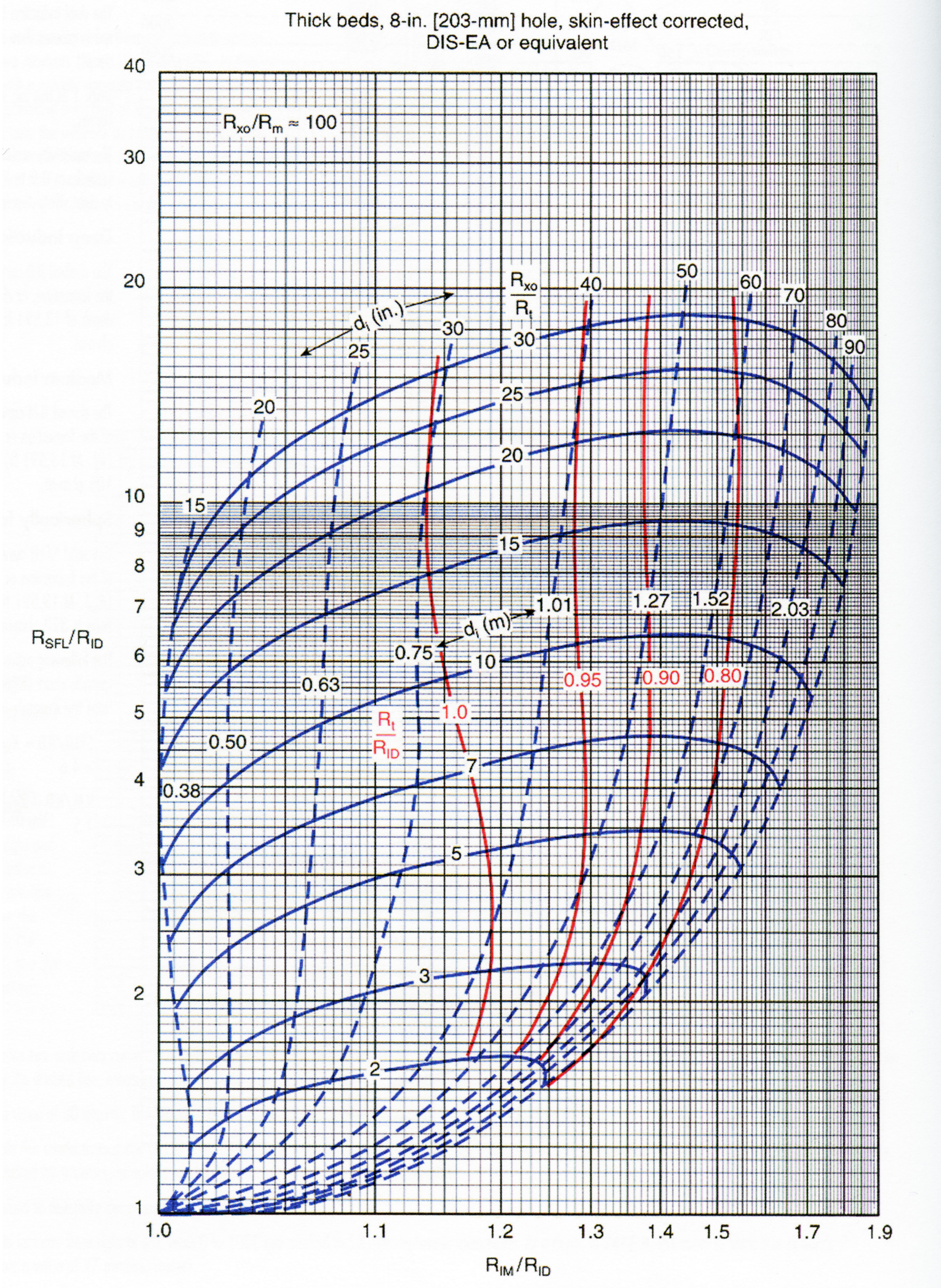
$$ILD = R_{ILD} = 70 \text{ ohm-m};$$
$$ILM = R_{ILM} = 105 \text{ ohm-m};$$
$$SFLU = R_{SFL} = 320 \text{ ohm-m}$$
$$R_{SFL} / R_{ILD} = 4.6$$
$$R_{ILM} / R_{ILD} = 1.5$$

$$R_t(\text{corrected}) = \frac{R_t}{R_{ILD}} \times R_{ILD}$$

equ. A

$$R_{xo}(\text{corrected}) = \frac{R_{xo}}{R_t} \times R_t(\text{corrected})$$

equ. B



Courtesy Schlumberger Wireline & Testing, ©1998 Schlumberger.