LOG ANALYSIS

FOR EARTH SCIENTISTS

Exercises

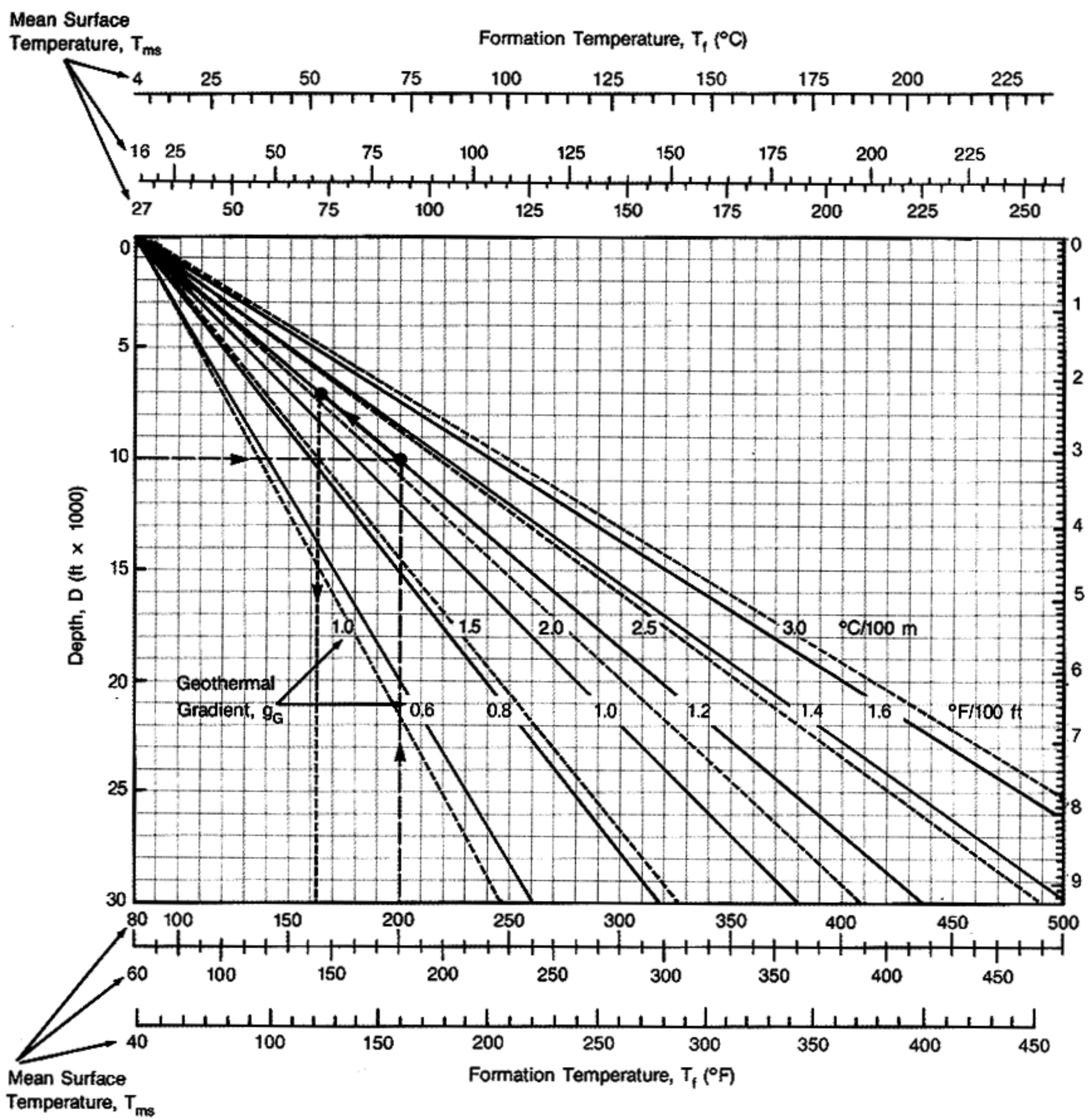
Course, version 2015

Thilo Bechstädt

GeoResources STC, Heidelberg

GEORESOURCES
www.georesources.de

Exercise 1-1



TEMPERATURE

Given: Surface temp. = 4°C; BHT = 120° C; TD = 4400 m; Formation depth = 3410 m.

Questions:

1. What is the geothermal gradient in °C /1000 m?
2. What is the temperature (T_f) of the Fm. at 3410 m?
3. The BHT temperature readings were taken during the first logging run, immediately after drilling.
   What effect, if any, on BHT would you expect after a few weeks?

Exercise 2-2

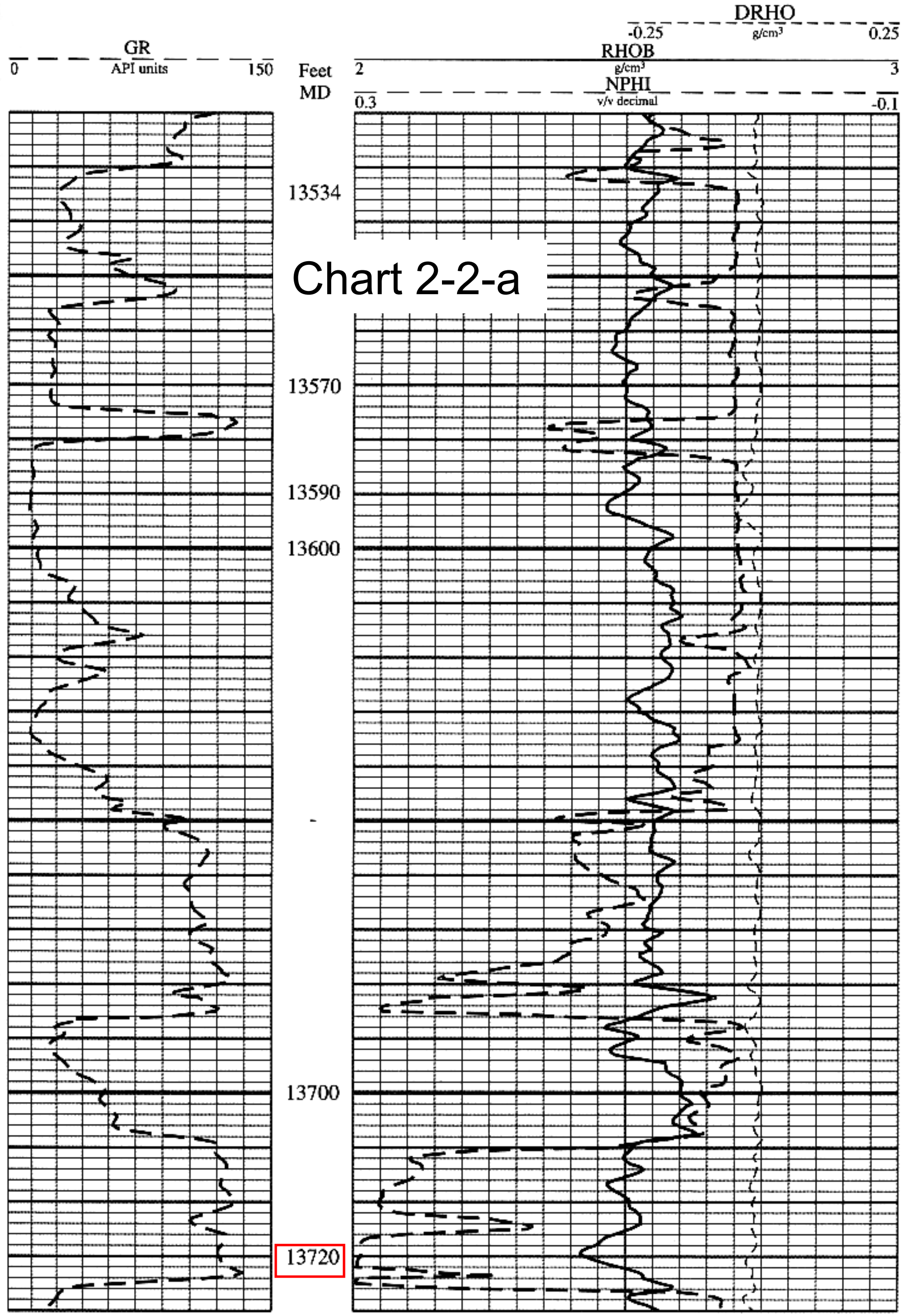


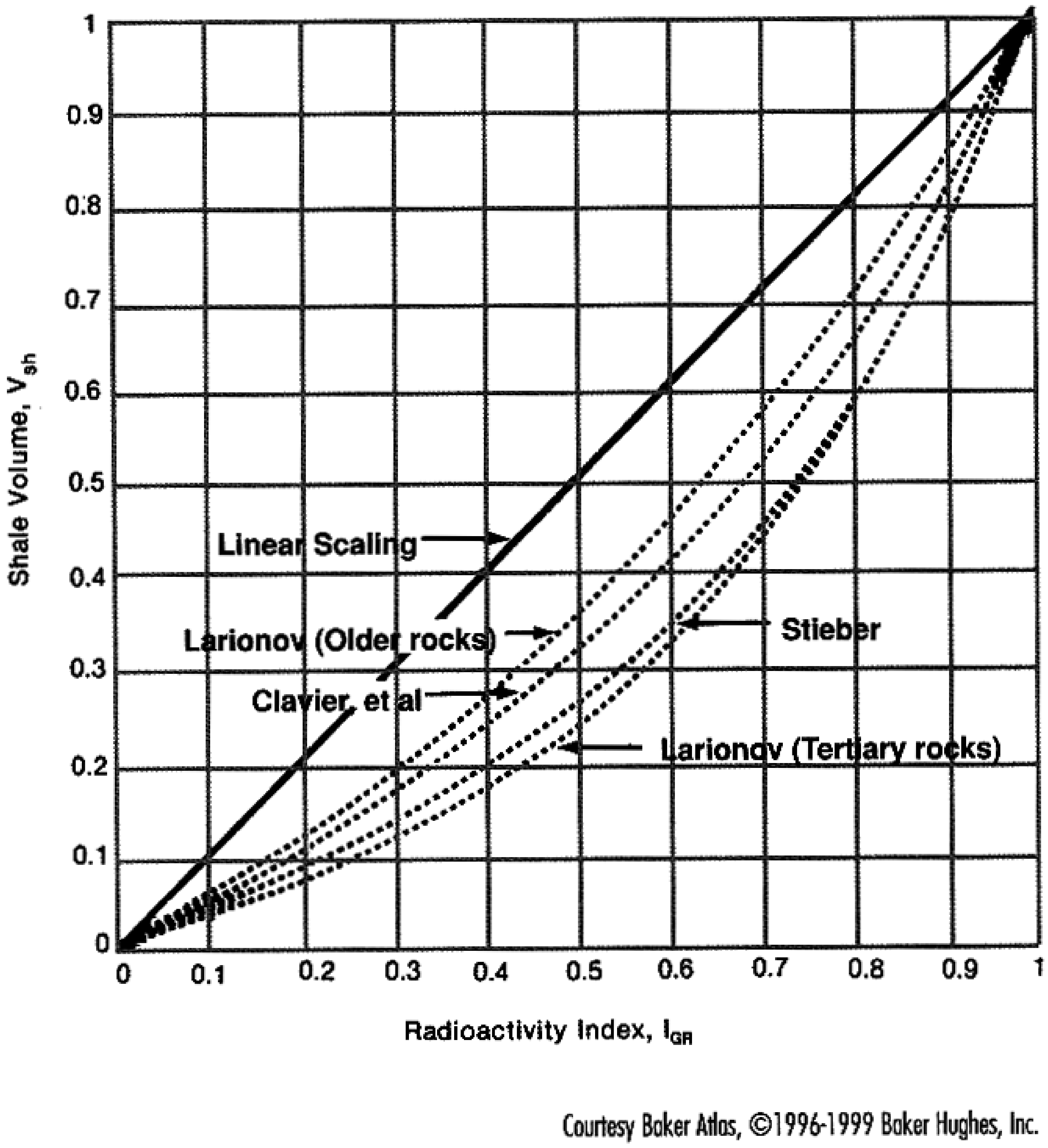
Chart 2-2-a

SHALE VOLUME

Calculate shale volume at 13,534, 13,570 and 13,701 ft from the *GR*. Use the formula given below and the chart for correcting gamma ray index to shale volume (chart 2-2-b).

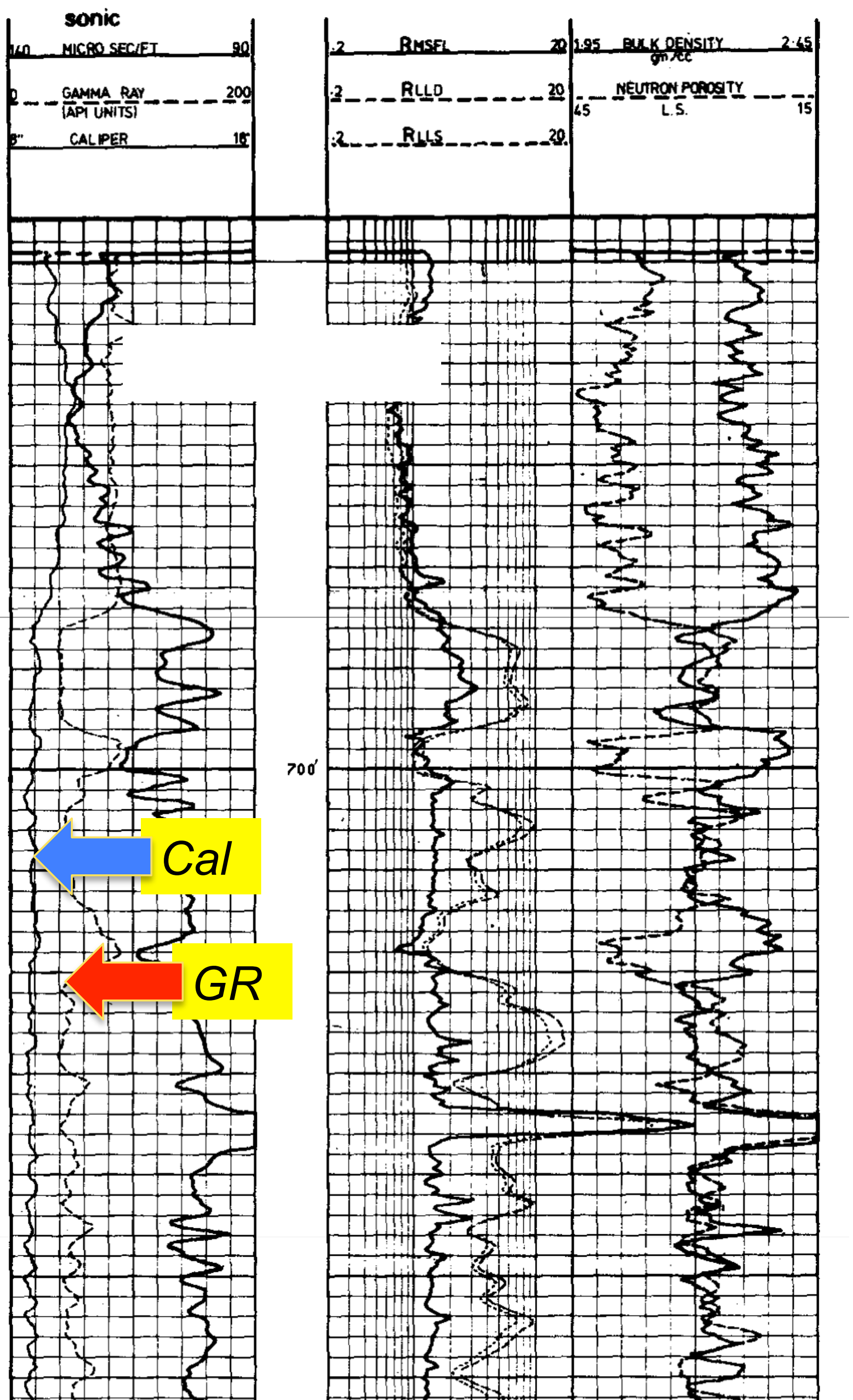
Give your results in a table, comprising the depths, GR_{log} reading, *IGR*, *Vshale* according to linear scaling and Larionov (for older rocks) and Steiber.

$$I_{GR} = \frac{GR_{log} - GR_{min}}{GR_{max} - GR_{min}}$$



Exercise 2-2

Chart 2-2-b

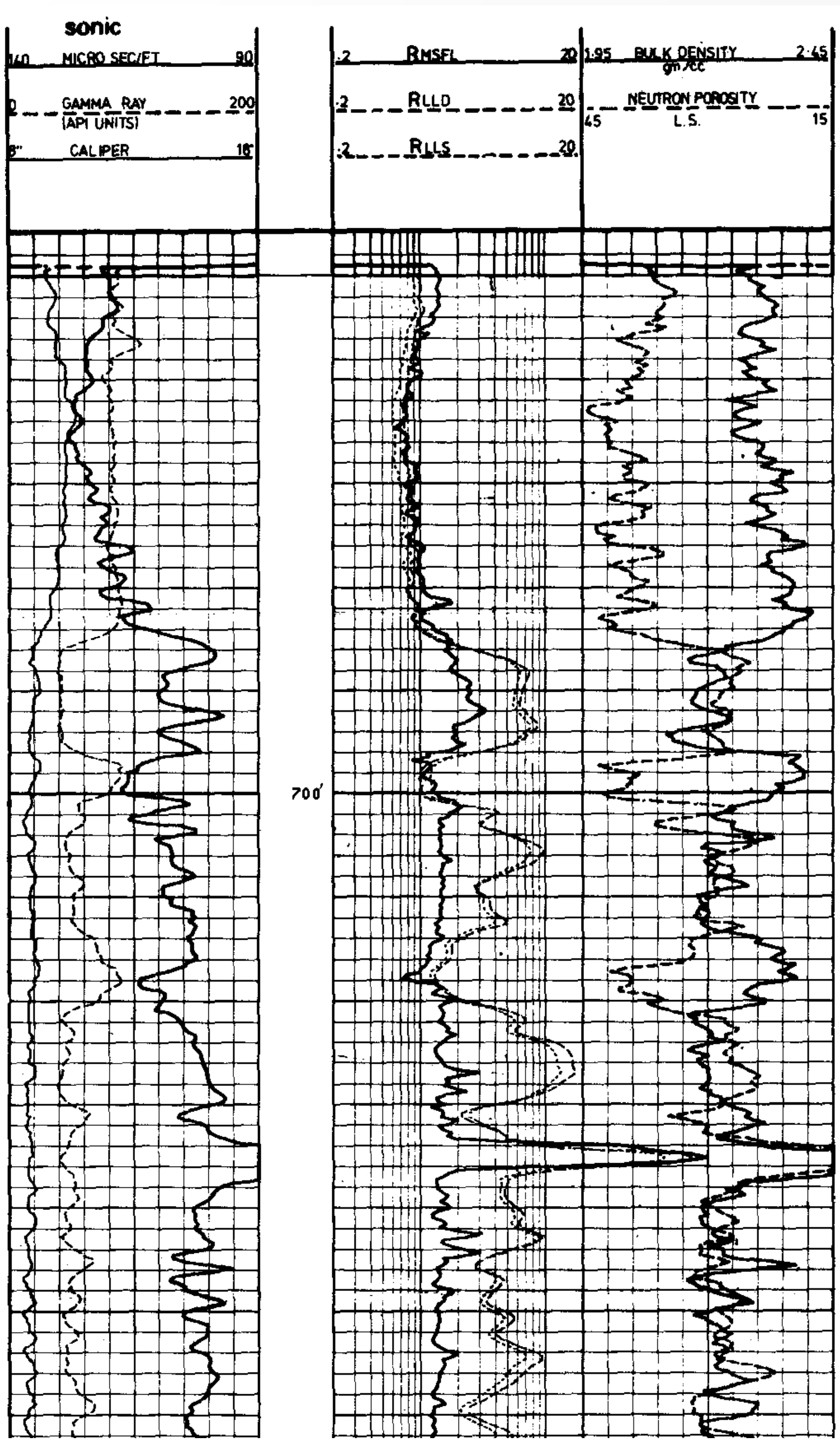


EXERCISE 2-3

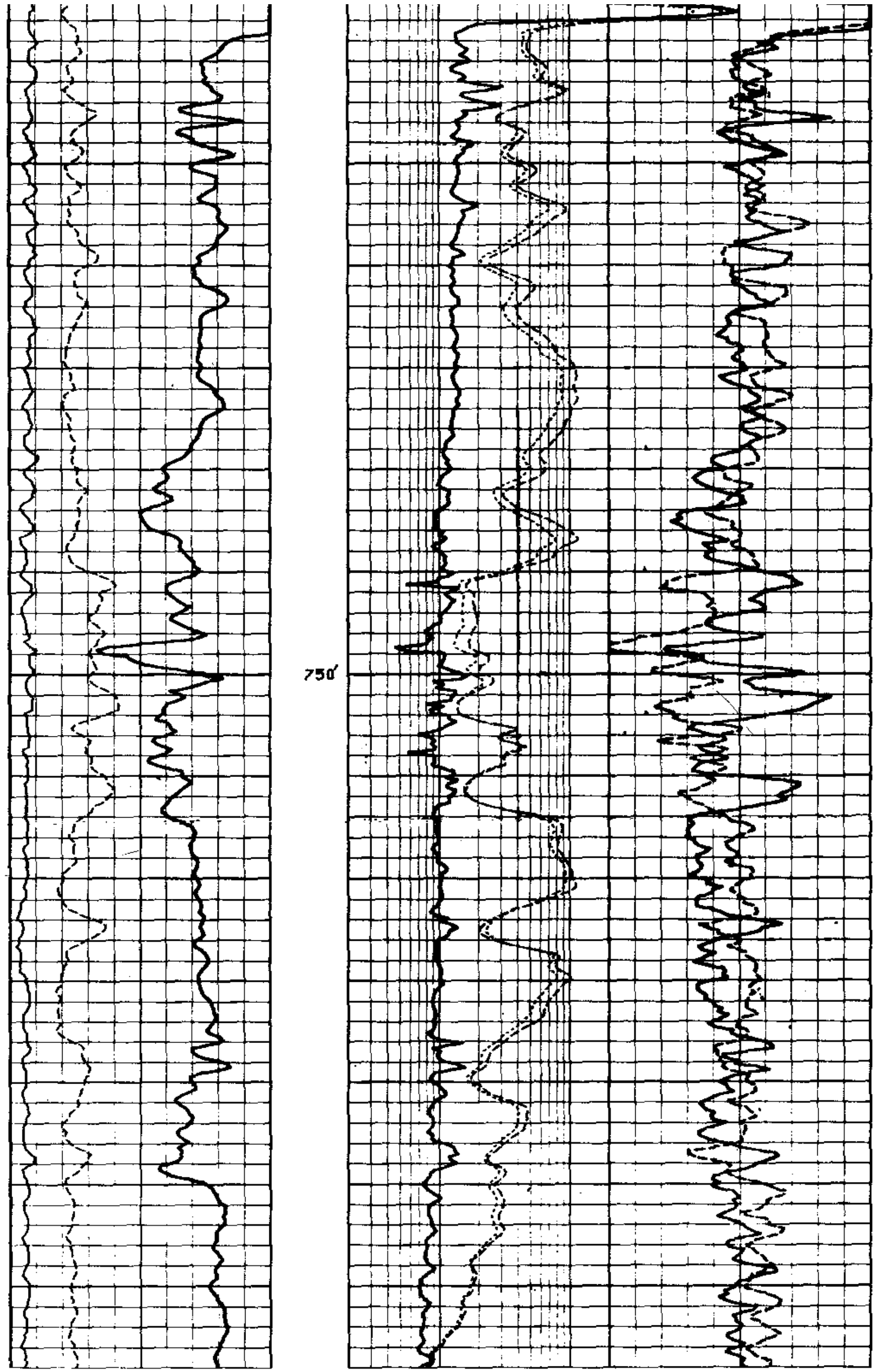
INTERPRET CLEAN/SHALY INTERVALS

1. Mark on the logs (exc. 2.2 und 2.3) the "clean lithologies" and the siltstone/shale intervals using *GR* and Caliper.
2. Draw the *GR* shale and clean lithology base lines on the logs.
3. Number the *GR* log patterns on the logs of exercises 2-2 and 2-3 according to the number code of the next slide. Mark the base and top of the individual patterns by horizontal lines.

4. If these are sandstones/shales, what environment would make sense?



Exercise 2-3; Chart 2-3-A



Exercise 2-2 and 2-3

irregular (1)

coarsening upward (2)

cylindric (3)

fining upward (4)

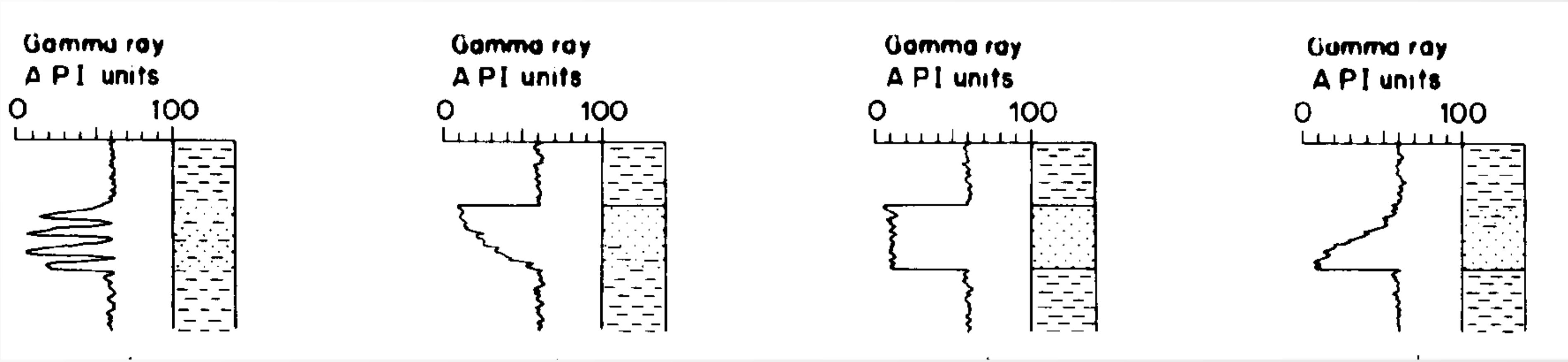
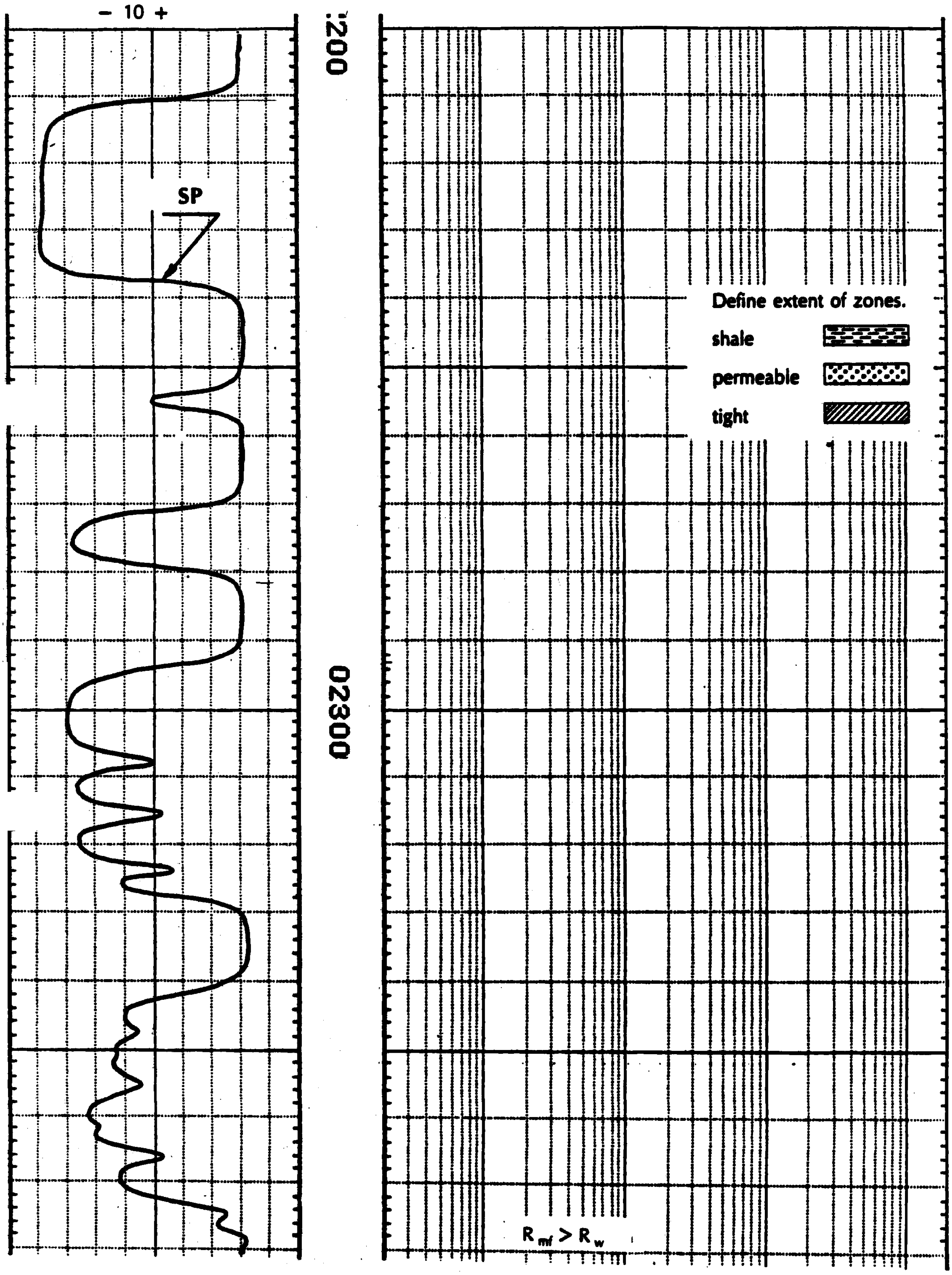


Chart 2-2-B

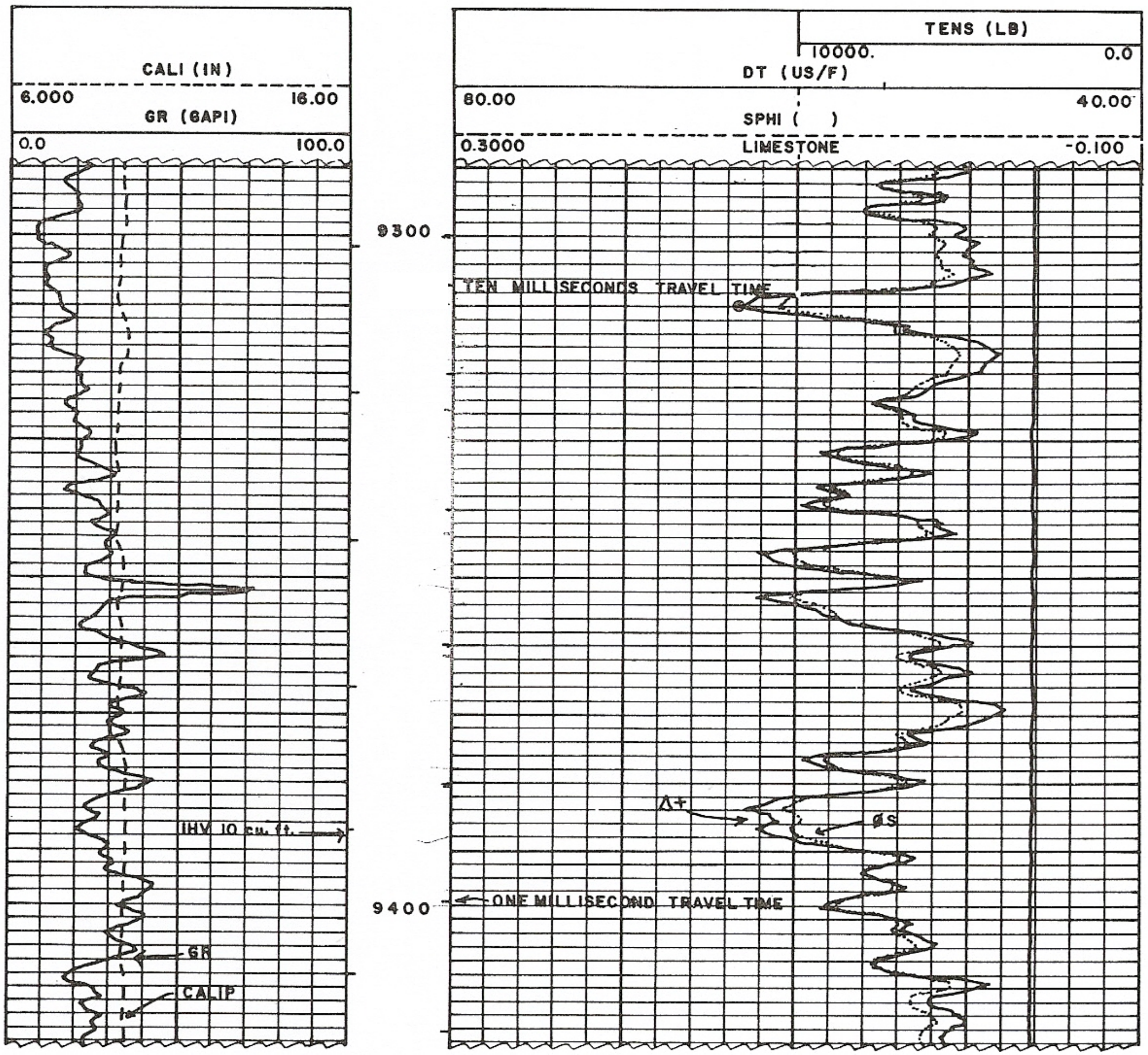
Gamma-Ray-Log (GR): facies interpretation

EXERCISE 2-4

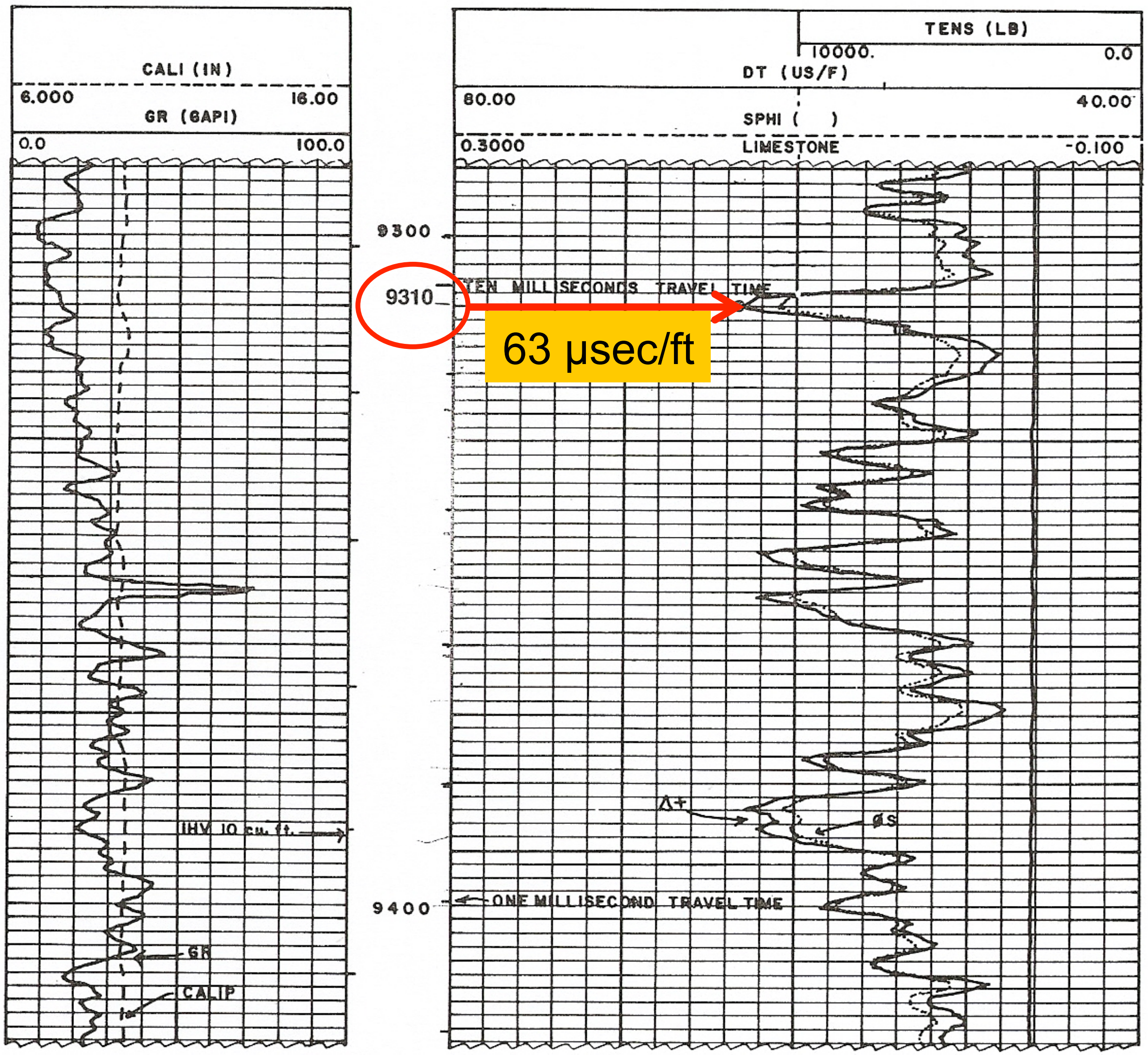
Define the extent of claystone (shale), permeable and inpermeable non-clayey successions.



Exercise 3-1: Porosity evaluation from Sonic (log)



Exercise 3-1a: Porosity evaluation from Sonic (log)



Exercise 3-1a: Porosity evaluation from Sonic (chart)

POROSITY EVALUATION FROM SONIC

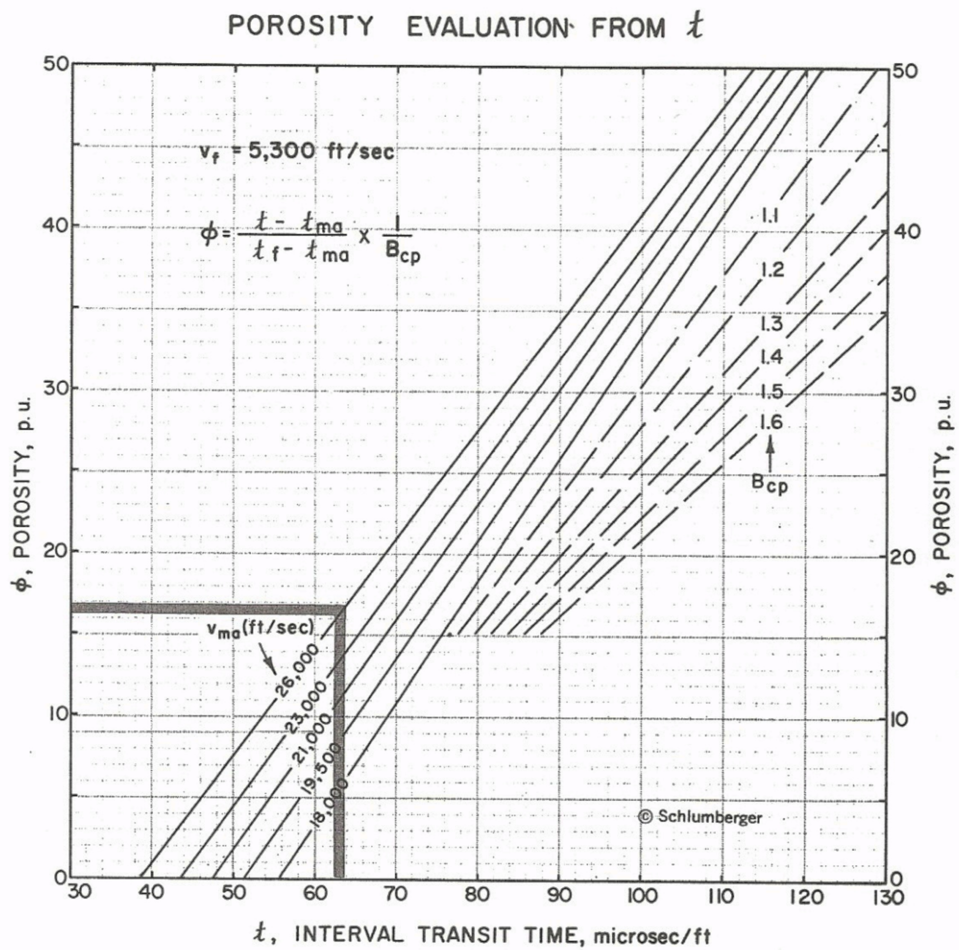


chart for fresh water mud

	v_{ma} (ft/sec)	t_{ma} (microsec/ft)
Sandstones	18,000-19,500	55.5 - 51.3
Limestones	21,000-23,000	47.6 - 43.5
Dolomites	23,000-26,000	43.5 - 38.5

Note:
The formation's matrix velocity and the type of mud must be known

Question:
Vma = 26000 ft/sec (Dolomite)
Fresh water mud
Δt = 63 μsec/ft @ 9310 ft
ϕ_s = xx %

Vma = 21000 ft/sec. (Limestone)

Exercise 3-1b: Porosity evaluation from Sonic (Wyllie formula)

$$\phi_s = \frac{\Delta t_{log} - \Delta t_{ma}}{\Delta t_f - \Delta t_{ma}}$$

Where :

ϕ_s = sonic derived porosity

Δt_{ma} = interval transit time of the matrix

Δt_{log} = interval transit time of formation

Δt_f = interval transit time of the fluid in the well (fresh mud = 189 ; salt mud = 185)

Depth = 9310 ft
Lithology [=] Dolomite
Mud [=] fresh mud
Sonic porosity = ?

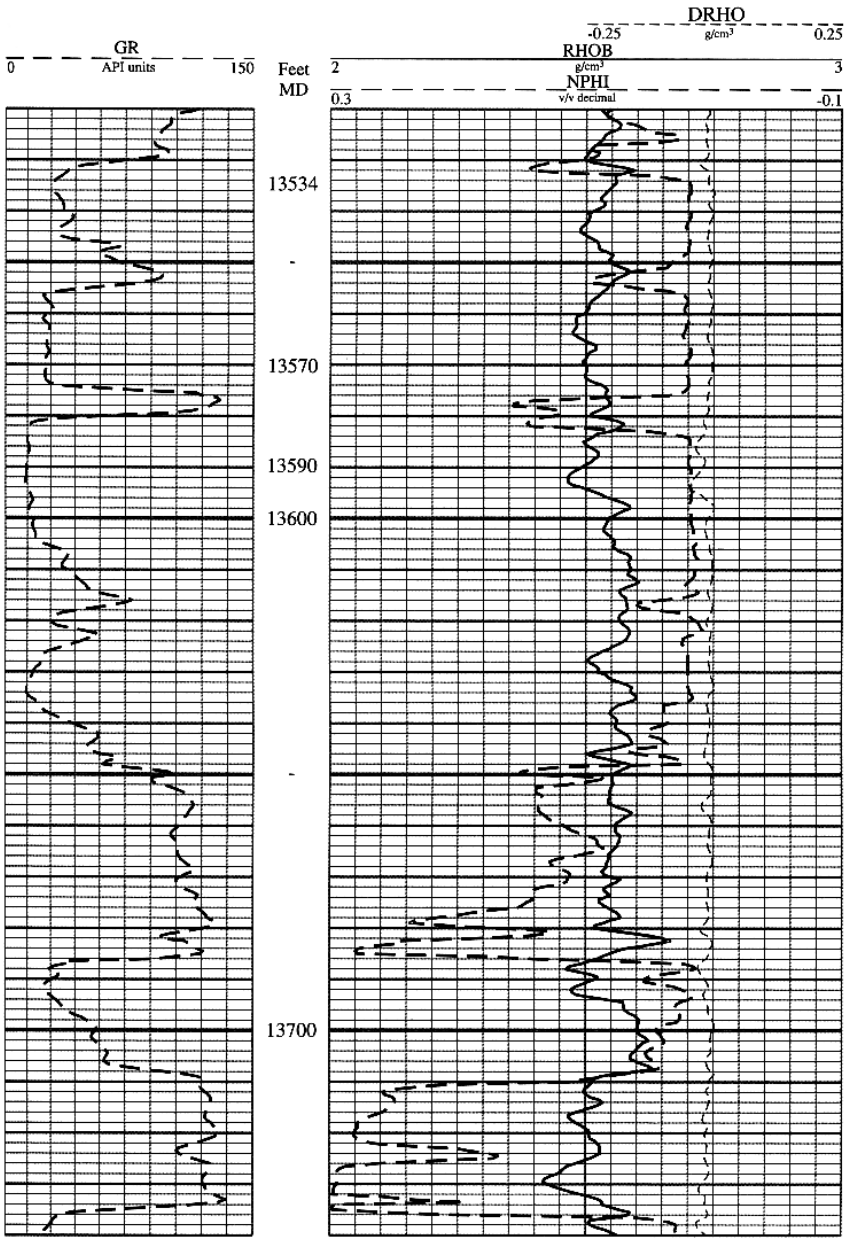
Lithology/Fluid	Δt_{ma} or Δt_{fl} (Wyllie) µsec/ft	Δt_{ma} (RHG) µsec/ft
Sandstone	51.0 - 55.5	56
Sandstones (5-20% ϕ)	62.5 - 86.9	
Limestone	47.6	49
Limestone (5-20% ϕ)	54.0 - 76.9	
Dolomite	43.5	44
Dolomites (5-20% ϕ)	50.0-66.6	
Anhydrite	50.0	
Rocksalt	66.7	
Shale	58.8 - 143.0	
Freshwater mud Saltwater mud	189 185	

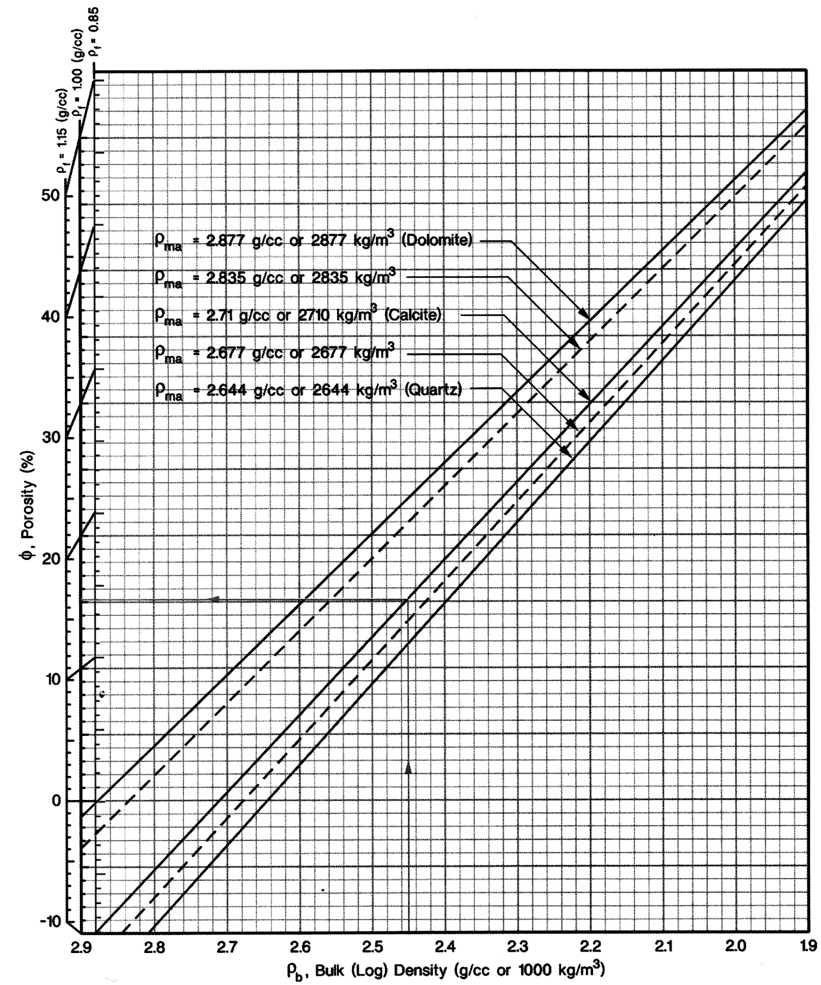
Exercise 3-2

POROSITY EVALUATION

1. Well 3-2 (a) was drilled through quartz sandstones and shales with fresh water mud.
2. Read the density (RHOB, ρ_b) and the neutron porosity values from log 3-2(a) at the following depths: 13,570 ft., 13,577 ft., 13,593 ft., 13,634 ft., 13,725 ft., and fill the data into a table.
3. Calculate the density porosity of the "clean intervals" from the ρ_b log values using the chart 3-2 (a).
4. Calculate the neutron porosity of the "clean intervals" from the NPHI (ϕ_N) log values using chart 3-2 (b). The log scale gives values from -0.1 (= -10% porosity) to 0.3 (= +30% porosity).
5. If porosity discrepancies exist between neutron and density porosity values, give your interpretation of the likely reasons.

Exercise 3-2 (a)





Courtesy Halliburton Energy Services, ©1994 Halliburton Energy Services

Figure 4.4. Chart for converting bulk density (ρ_b, RHOB) to density porosity (ϕ_D, DPHI).

Procedure:

1. Find the bulk density (RHOB) taken from the density log in Figure 4.3 on the scale at the bottom of the chart. Note that the scale is displayed from *high* values on the left to *low* values on the right.
2. Follow the RHOB value vertically until it intersects the proper matrix line [calcite (limestone) or dolomite] then move horizontally to intersect the y-axis representing the proper fluid density, in this case 1.00 g/cm³ (fresh water, the middle scale) to read the porosity (DPHI).

NOTE: The values in Table 4.8 are decimal fractions, the porosity values on the chart are in percent.

Exercise 3-2 (b)

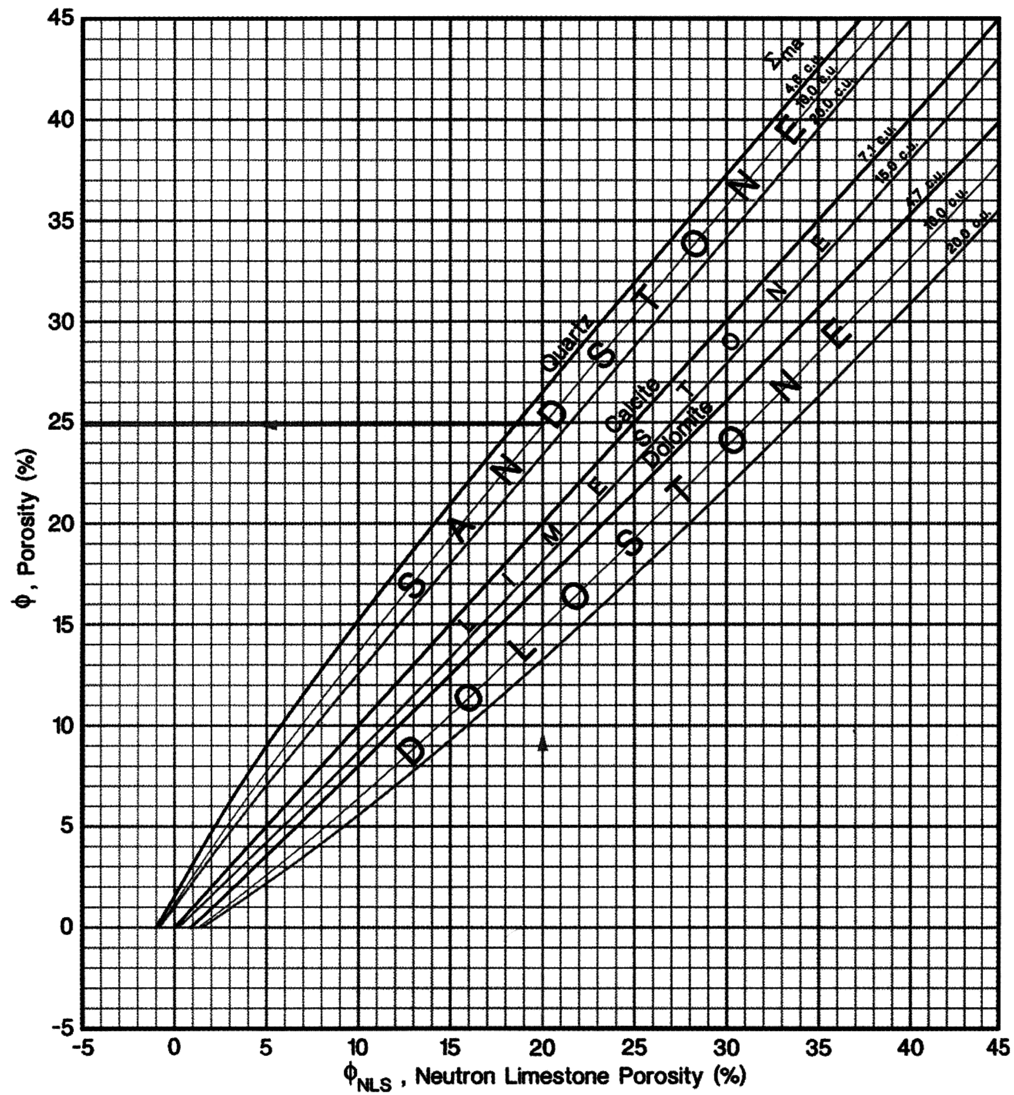
Figure 4.6. Chart for correcting Halliburton DSN-II neutron-porosity curve for lithology.

NOTE: For neutron logs, the chart used to correct the logged porosity for lithology MUST correspond to the type of neutron log run, and the company used to acquire the log data. A mismatch between the actual log used and the chart used for the conversion can lead to significant errors in the determination of lithology.

Procedure:

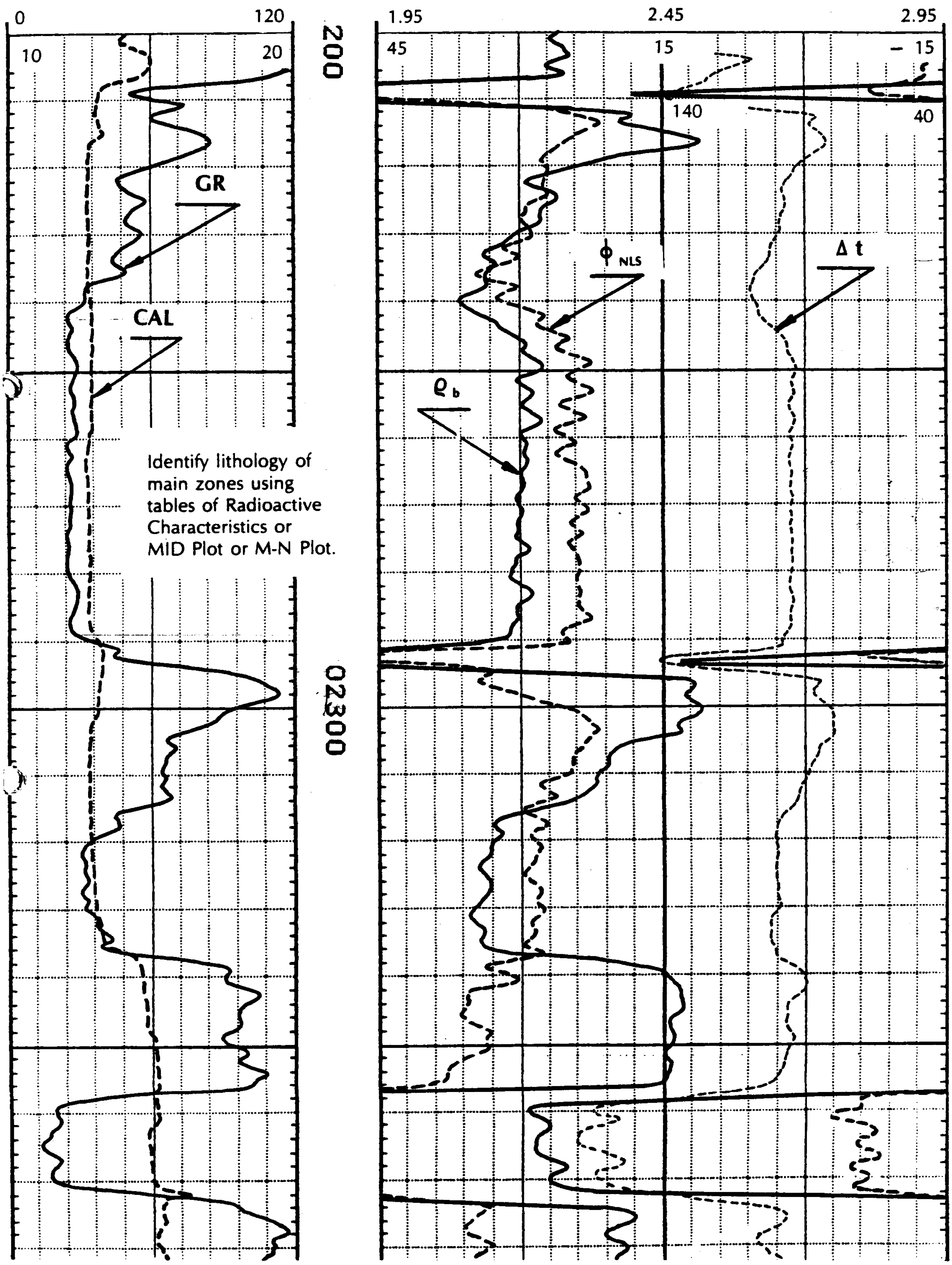
1. Find the neutron porosity (NPHI) taken from the neutron density log in Figure 4.2 on the scale at the bottom of the chart. The original neutron log data is referenced to limestone lithology.
2. Follow the NPHI value vertically until it intersects the proper matrix line (Dolomite or Sandstone) then move horizontally to intersect the y-axis the porosity, NPHI. Use the smallest value Σ_{ma} for each lithology to do the calculations.

NOTE: The values in the table are decimal fractions, but the porosity values on the chart are in percent.



EXERCISE 3.5

Define the different lithologies drilled in this well.



Exercise 3-6

Lithology determination: give lithologies of the well

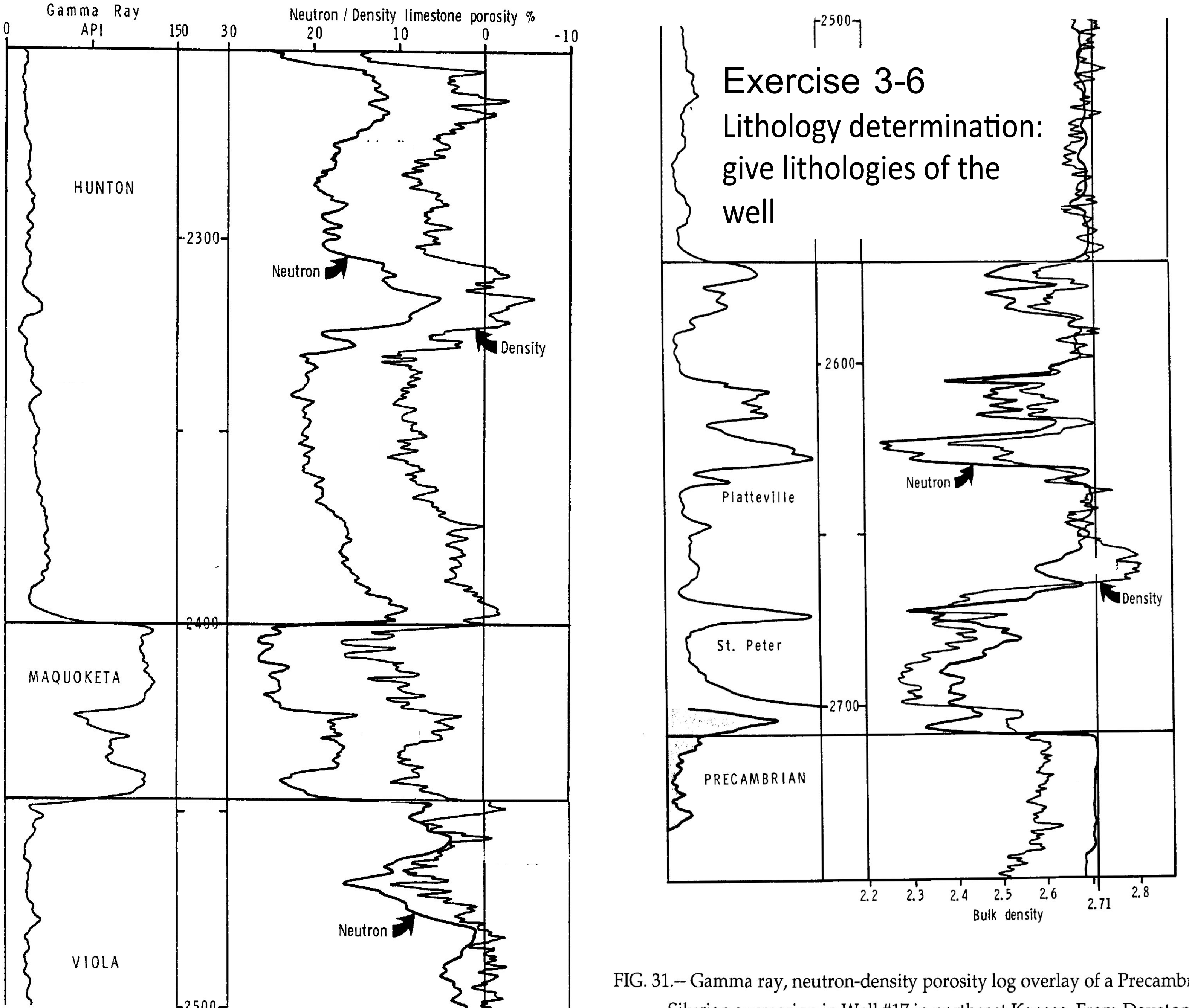


FIG. 31.-- Gamma ray, neutron-density porosity log overlay of a Precambrian to Silurian succession in Well #17 in northeast Kansas. From Doveton (1986).