Coal Excercise
Mineral evaluation

Coal exercise: A lithological interpretation of coal and its related sedimentary environment with the aid of logging tools.

Objective: An evaluation of several coal seams and related sediments with the results of the GR, sonic, neutron, and density tool.

Case story: Due to the lack of "strong" foreign currencies in the Eastern European Countries, the amount of oil and gas, as a major part of the energy supply, is slowly declining. These countries are searching for alternative national energy sources and new ways of energy production.The Nazdrave-coal fields near Rila (Bulgaria) are situated at shallow depths. The area is well know of its relatively small coal fields and thin coal seams. The conventional mining methods are environmentally unacceptable and very expensive. Therefore the Board of the mines decided to investigate alternative coal/energy production methods such as Underground Coal Gasification (UCG) and Coalbed Methane Exploitation (CBM). On the basis of an available exploration well a target area is appraised; the thickness of the coal seams (at least 1.5 m) and the sealing quality of overlying strata (claystones or shales) are of major importance.
The following laboratory analysis are known from the exploratory well:
- Several coal seams have been identified.
- The main seam was cored and analyzed on densities:

$\rho_{carb.}$	=1.20 g/cc	Vt_{carb}	= 135 μs/ft
ρ_{ash}	=2.55 g/cc	Vt_{ash}	= 80 μs/ft
ρ_{mois}	=1.02 g/cc	Vt_{mois}	= 190 μs/ft

General questions:

- What are the horizontal and vertical resolutions of the available tools.
- Give an interpretation of the lithology between 160 m and 215 m, using the gamma ray, sonic and density tools. Square the gamma ray to define layer thicknesses.
  The following symbols can be used:

: : : : : :	Sandstone/siltstone	####	Claystone/shale
||||||||||	Carbonaceous claystones	■■■■	Coal

Questions regarding coal:

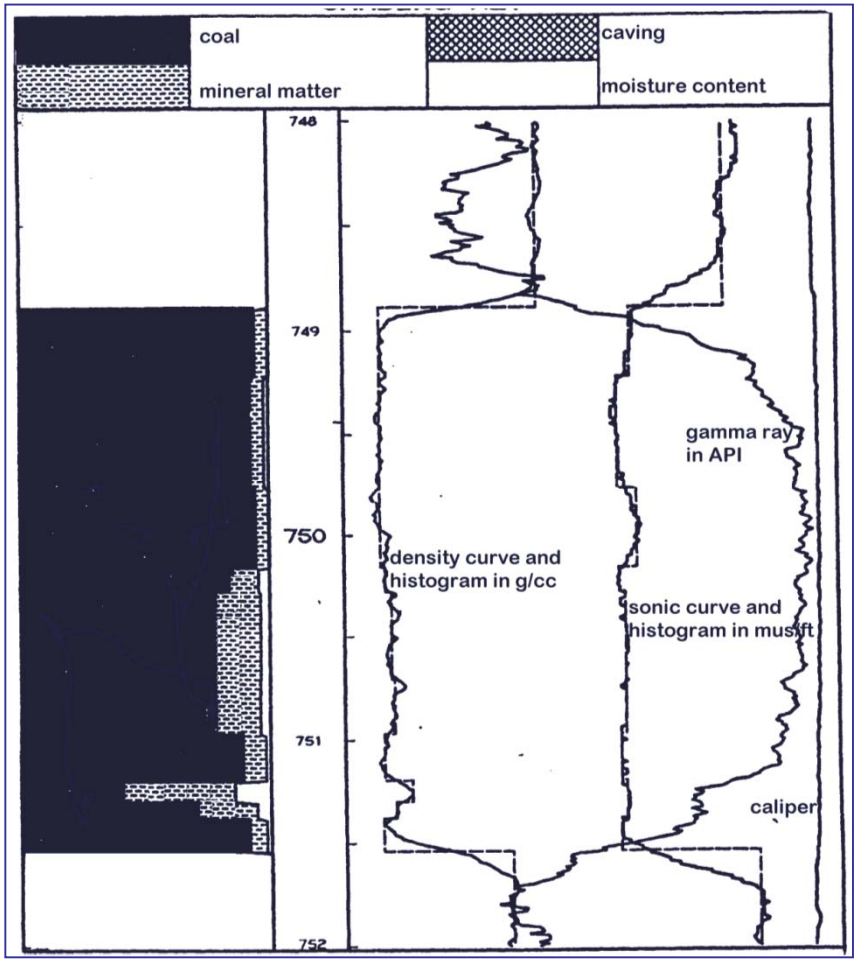
- Define the thicknesses of the different coal seams.
- Use figure 2 to define the coal type and ash content. Are the results relevant?
- Calculate the volumes for moisture, ash and coal, based on on the mentioned densities and transit times with the Lithology Assessment equations (syllabus)

Questions regarding overburden:

- Use the Gamma ray to define the shale line and sand line.
- Define the shale volumes for the layers in the zone between 160 and 180 m with the GR-shale equation.
- The clean sands in this section show an increasing transit time. What are the porosities when Sw=1? (use the bulk density, ρ_{mois}=1.02 g/cc and ρ_{matrix}= 2.68 g/cc).

Conclusive question: - Which coal seam can be used for UCG or CBM?

Lithology assessment: Coal moisture content



GR, sonic and density log, with the ash, moisture and coal fractions.

- sonic, and density log readings
- matrix response of the minerals for sonic, and density tools

$$\Delta T = \Delta T_{fl} \cdot V_{mois} + \Delta T_{ash} \cdot V_{ash} + \Delta T_{carb} \cdot V_{carb}$$

$$\rho_b = \rho_{fl} \cdot V_{mois} + \rho_{ash} \cdot V_{ash} + \rho_{carb} \cdot V_{carb}$$

$$1 = V_{mois} + V_{ash} + V_{carb}$$

DEPTH
(M)
Gamma Ray
(API)
0
200
Sonic Velocity
(µsec/ft)
150
100
50
Neutron-Neutron
(SNU)
0
200
400
Density
(g/cc)
1.00
3.00
Lithology
150
160
170
180
190
200
210

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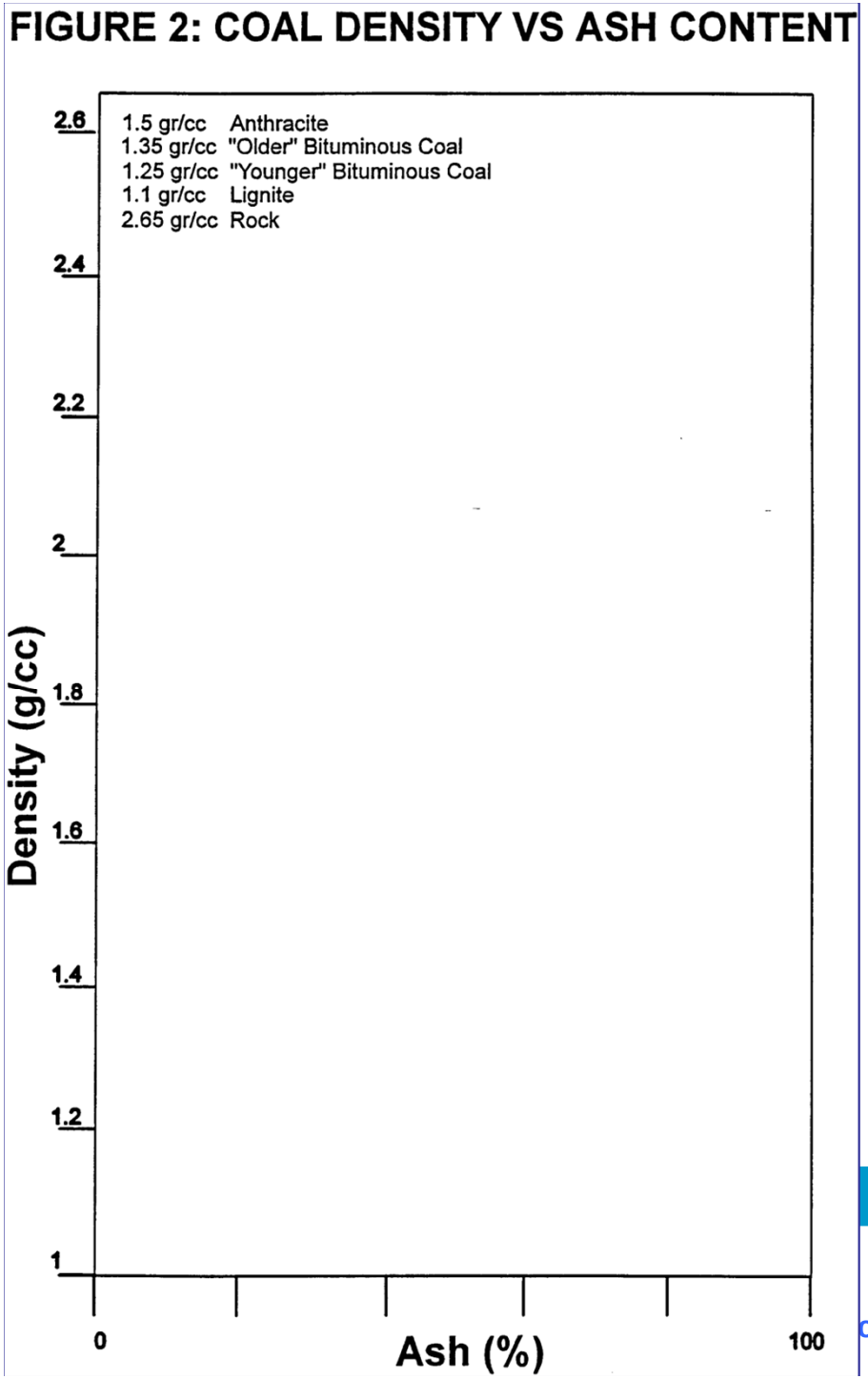
FIGURE 2: COAL DENSITY VS ASH CONTENT



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ANSWERS

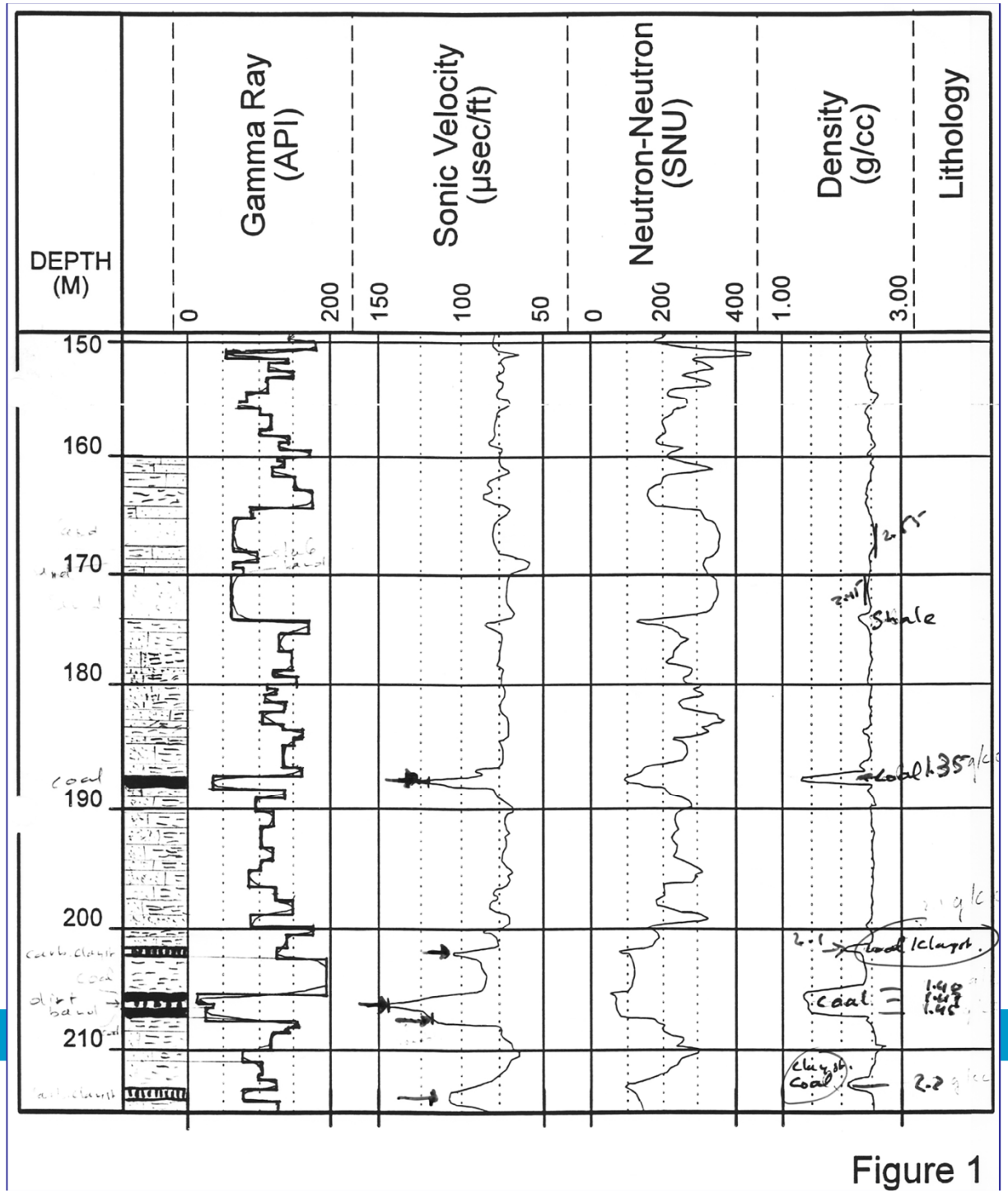

Figure 1

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Questions regarding coal:

- Define the thicknesses of the different coal seams.

Answ: See appendix/fig 1a, thickness according to squaring.

- Use figure 2 to define the coal type and ash content. Are the results relevant?

Answ: When no moisture is detected

- Read and plot density log and ash in wt%

Answ: in $\rho_{carb.}$ = 1.20 g/cc, ρ_{ash} = 2.55 g/cc

215 m:	carbonaceous claystone	78 wt%
205/207 m:	coal/carb.clayst./coal	19.5 wt%/22 wt%/16 wt%
202 m:	carbonaceous claystone	70 wt%
187 m:	coal	12 wt %

- Calculate the volumes for moisture, ash and coal, based on on the mentioned densities and transit times with the equations 15.2 a,b and c (syllabus)

Answ: three equations, three unknown.

$$V_{mois} + V_{ash} + V_{coal} = 1$$

$$\rho_{mois} V_{mois} + \rho_{ash} V_{ash} + \rho_{coal} V_{coal} = \rho_{bulk}$$

$$\Delta T_{mois} V_{mois} + \Delta T_{ash} V_{ash} + \Delta T_{coal} V_{coal} = \Delta T_{tot}$$

		ΔT_{tot}	ρ_{bulk}	V_{mois}	V_{ash}	V_{coal}
Upper coal		**135**	**1.35**	**0.12**	**0.13**	**0.75**
Lower coal top		**148**	**1.4**	**0.44**	**0.11**	**0.35**
lower coal bottom		**120**	**1.43**	**-0.06**	**0.11**	**94.7**

(Last coal probably no vapour, first method good)

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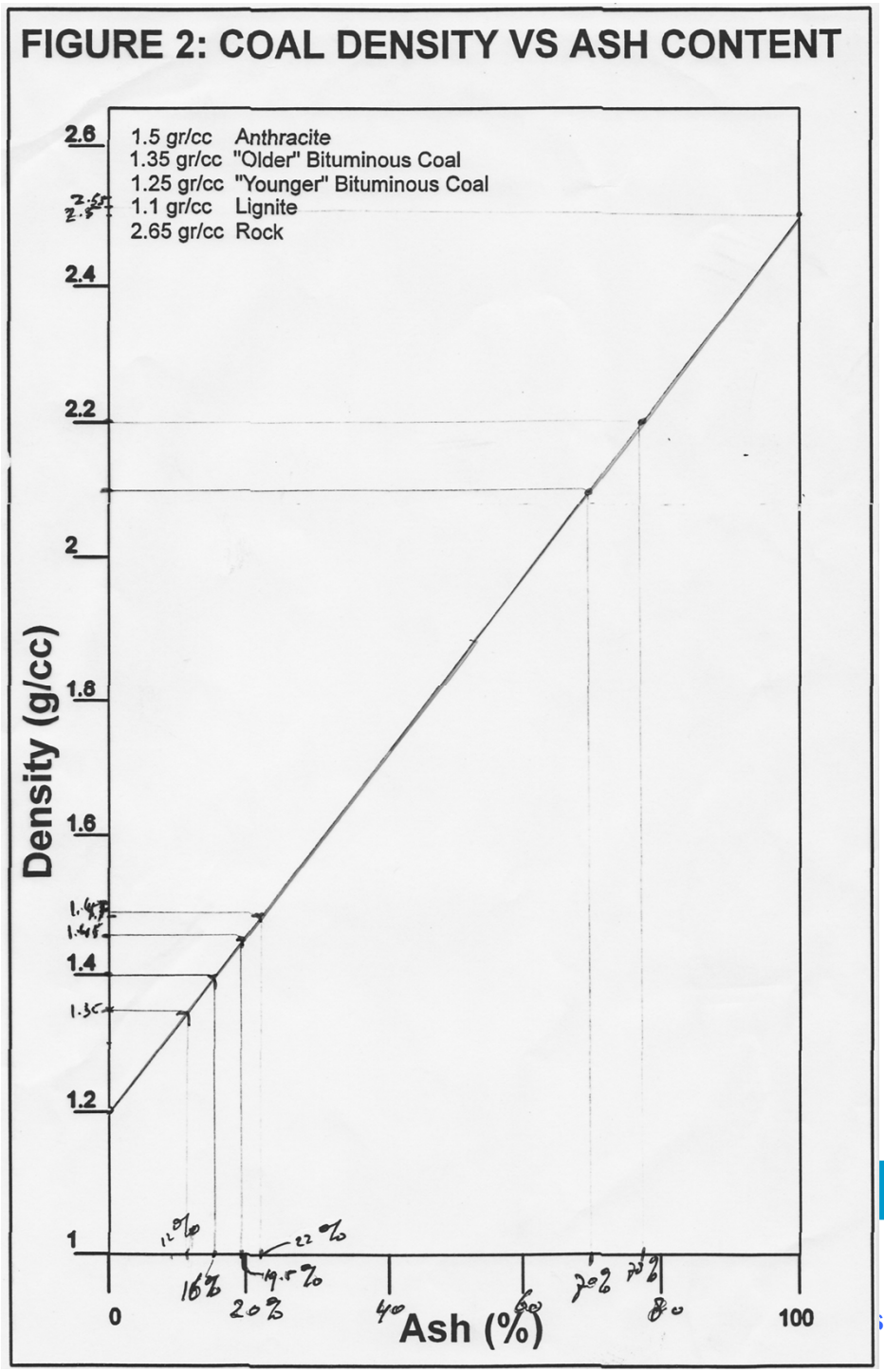
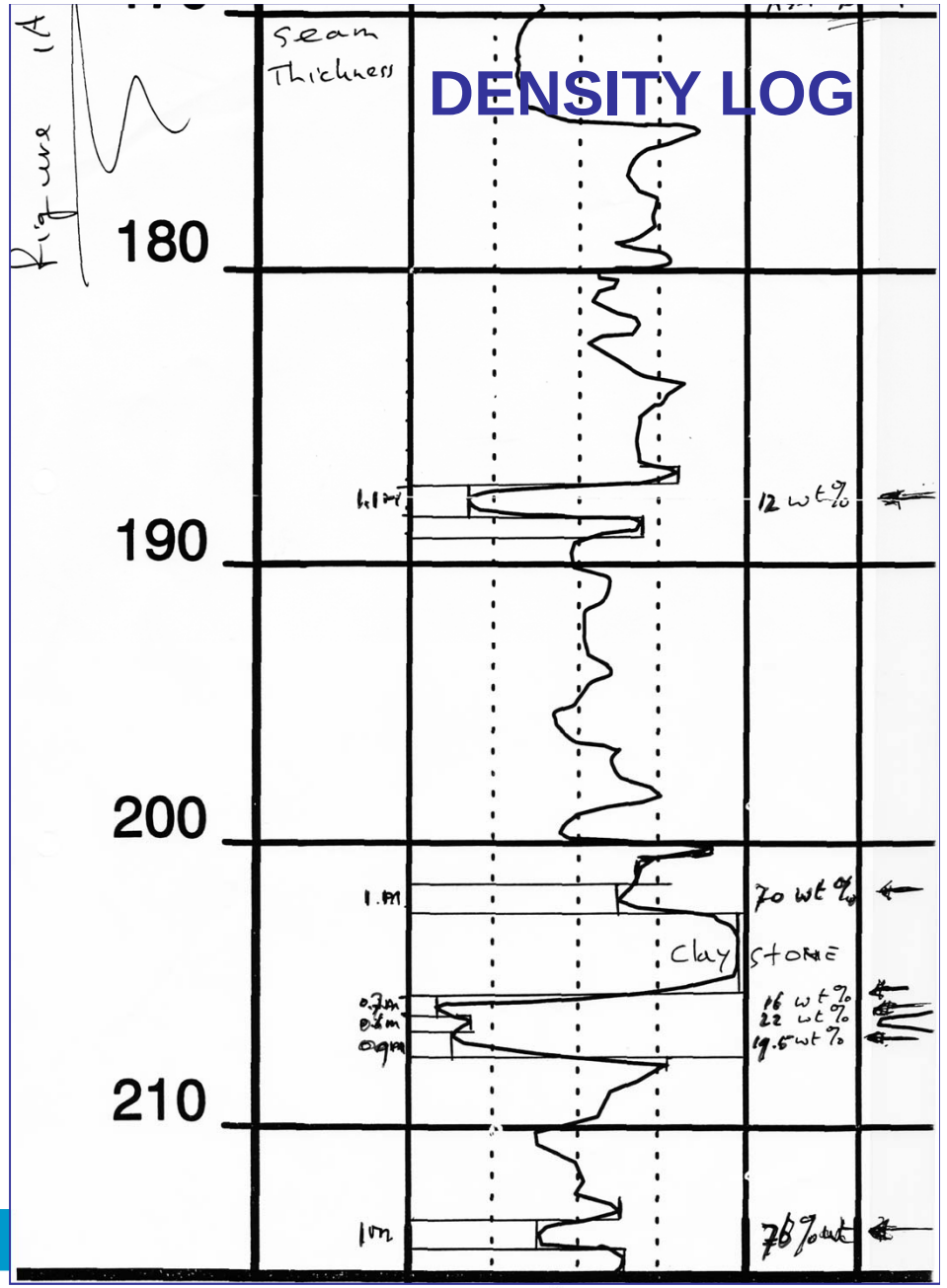


FIGURE 2: COAL DENSITY VS ASH CONTENT
1.5 gr/cc Anthracite
1.35 gr/cc "Older" Bituminous Coal
1.25 gr/cc "Younger" Bituminous Coal
1.1 gr/cc Lignite
2.65 gr/cc Rock
Density (g/cc)
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0
Ash (%)
100


DENSITY LOG
Seam Thickness
180
190
200
210
12 wt%
70 wt%
Clay stone
16 wt%
22 wt%
19.5 wt%

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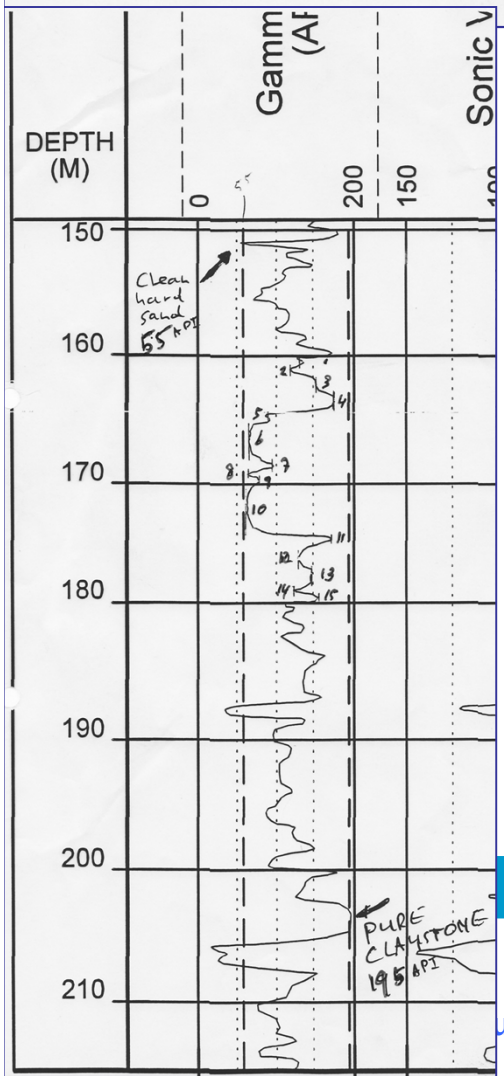
Questions regarding overburden:

- Use the Gamma ray to define the shale line and sand line.

Answ: Pure claystone at 204 m; 195 API, Pure sandstone at 151.5 m; 55 API.

- Define the shale volumes for the layers in the zone between 160 and 180 m with the GR-shale equation.

$$V_{shale} = \frac{GR - GR_{min}}{GR_{max} - GR_{min}}$$



GR_{max}-GR_{min}= 140		$GR_{at\ depth}$	V_{shale}
	Depth (m)	API	
1	161	130	0.54
2	162	120	0.46
3	163	155	0.71
4	164	180	0.89
5	165	90	0.25
6	167	60	0.04
7	168	95	0.29
8	169	60	0.04
9	170	75	0.14
10	172	57	0.01
11	175	170	0.82
12	176	130	0.54
13	177	148	0.66
14	178	125	0.5
15	179	157	0.73

- The clean sands in this section show an increasing transit time. What are the porosities when a Sw=1 is considered? (use the bulk density, ρ_{mois}=1.02 g/cc and ρ_{matrix}= 2.68 g/cc).

Answ: $\rho_{ma}V_{ma} + \rho_{fl}V_{fl} = \rho_{bulk}$

$V_{ma} + V_{fl} = 1$

	ρ_{ma}	ρ_{fl}	ρ_{bulk}	V_{ma}	ϕ
Upper sand (6)	2.68	1.02	2.55	0.92	0.08
Lower sand (10)	2.68	1.02	2.45	0.85	0.15

Conclusive question:

- Which coal seam can be used for UCG or CBM?

Answ:

UCG: Initially none; Upper coal thin.Upper part of the lower coal is very wet. Lower part however dry. Maybe after pumping for CBM, in a second phase usable.

CBM: When gas available, lower coal. Claistone functions as a seal.