Resit exam 13.04.2022

Exam Hall 2 E19 – G10, 16.00-18:00

Name: Student ID:

Q1 Geothermal heat flow & salt dome (35P)

In Figure 1 you find a geological cross section through a salt dome in the Northern Netherlands.

a) Sketch at the top of figure 1 the gravity profile which we would measure at the surface along this section. *Please note:* you do not need to calculate this, a qualitative sketch is sufficient. 10P

At constant heatflow q (Wm^{-2}), the temperature at depth z in the subsurface is governed by the equation:
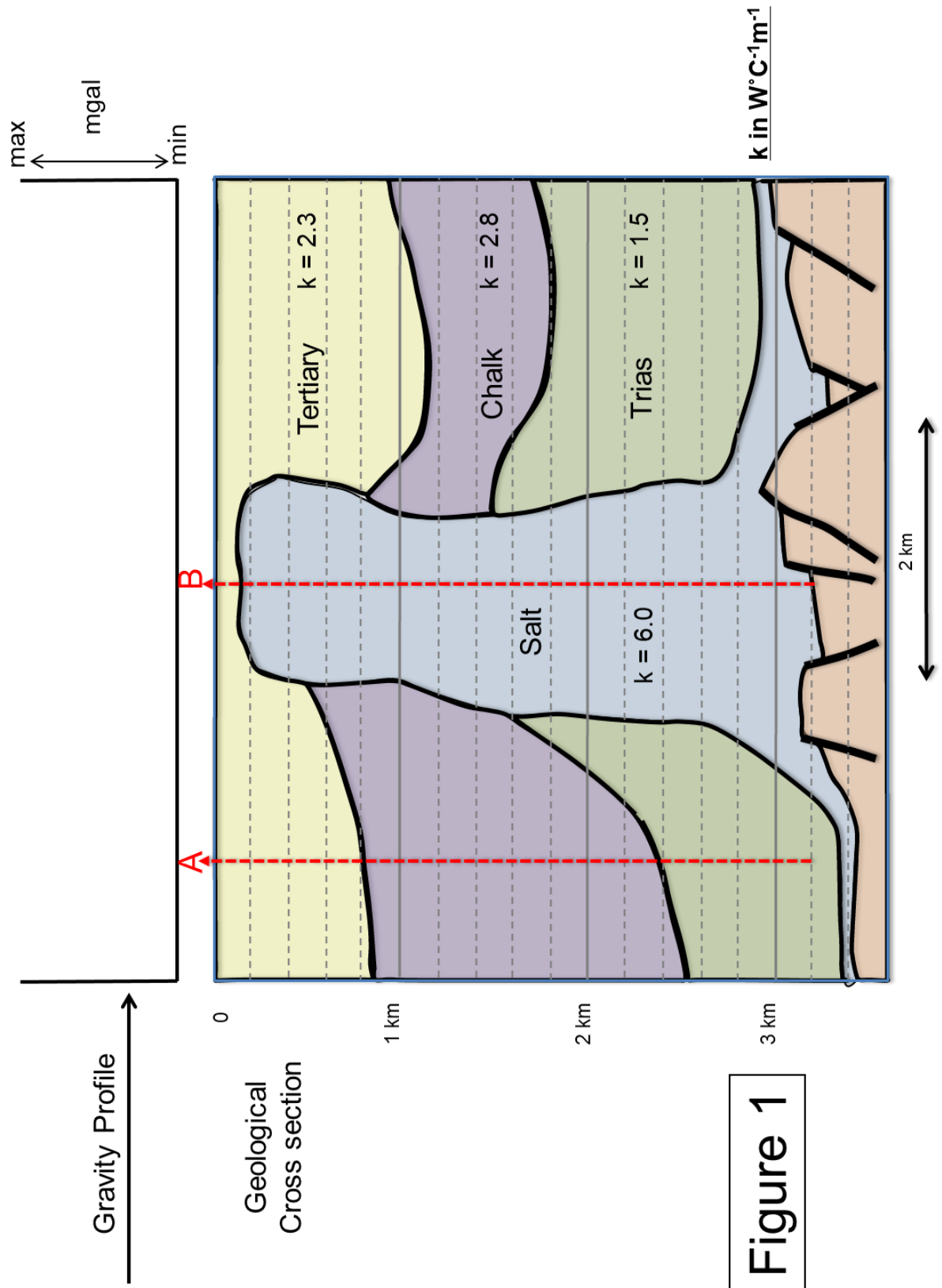
$$T(z) = T(0) + q \int_0^z \frac{dz}{k(z)}$$

Where k(z) is the thermal conductivity in $W°C^{-1}m^{-1}$ and T(0) is the temperature at the surface in °C.

b) Calculate the temperature at 3200m depth in the points A and B in the cross-section, assuming the temperature at the surface is 15°C and the heatflow is 65 mWm^{-2}.

Solution:

T_A (3200) = 15˚ + 65 10^{-3} [800/2.3 + 1600/2.8 + 800 / 1.5] = 15˚ + (65 10^{-3} x 1453) = 109.4°C

T_B (3200) = 15˚ + 65 10^{-3} [175/2.3 + 3025/6] = 15˚ + (65 10^{-3} x 580) = 52.7 ˚C

Figure 1

Gravity Profile

max
mgal
min

Geological
Cross section

Tertiary   k = 2.3

Chalk   k = 2.8

Trias   k = 1.5

Salt

k = 6.0

2 km

k in W°C⁻¹m⁻¹

0

1 km

2 km

3 km

A

B

2

Q2 Pressures in the subsurface (35P)

A well has been drilled in the shallowest prospect in a pressure cell (prospect A, Figure 2). The well found the reservoir overpressured and water-bearing, but with good gas shows. We strongly suspect that the seal was breached because of seal failure due to the overpressure. There are 2 deeper prospects (B and C) in the same pressure cell.

By drawing on the pressure-depth plot, solve the following two questions:

  a) What can we say about the chances of finding as in prospects B and C?
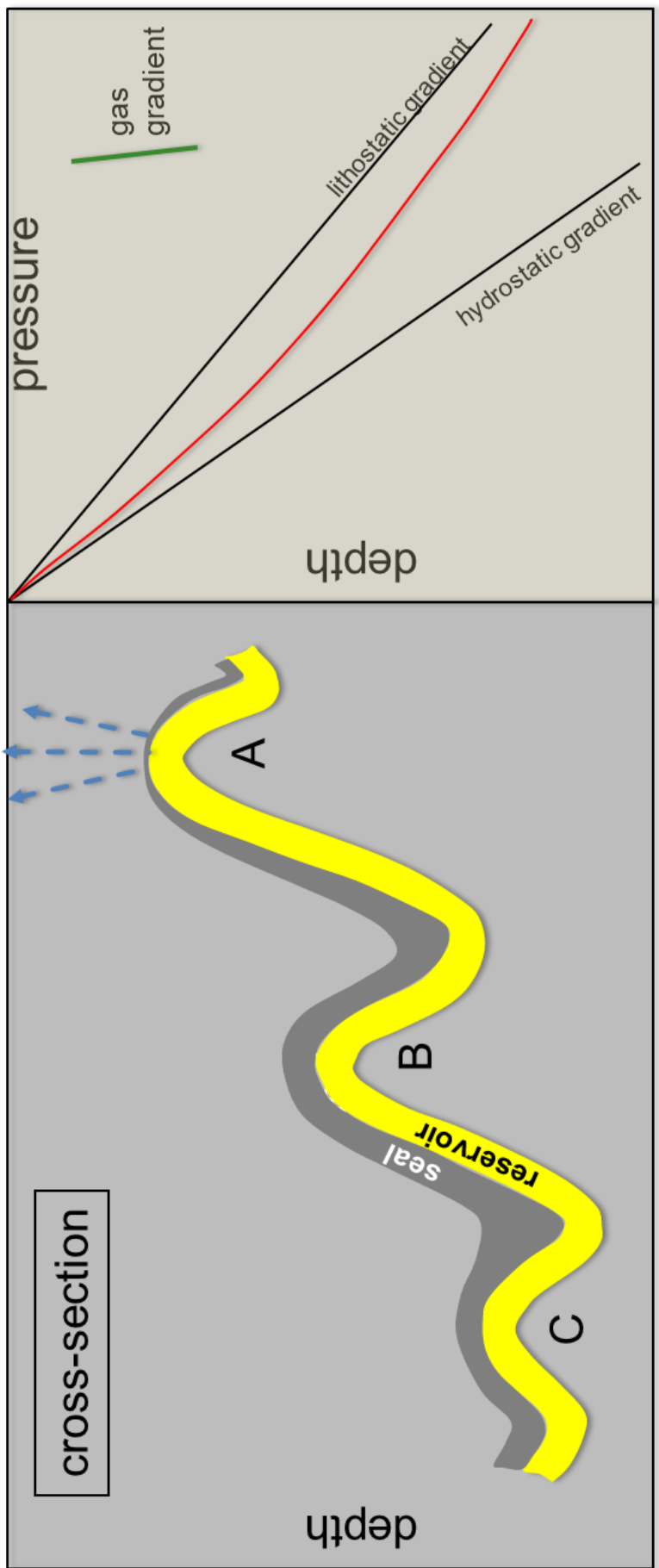 b) What are the heights of the potential gas columns we may expect to find in prospects B and C?

Figure 2: Cross section and pressure-depth plot of the prospect.

Q3 True or False (15P)

True or False? Circle the correct statement. One point per correct answer.

1. The inclination of the paleo-magnetic field is related to the paleo-longitude. TRUE/**FALSE**

2. The velocity of elastic waves, caused by an induced earthquake at reservoir level, decreases significantly when they reach the shallow soil interval at around 50m below the surface. **TRUE**/FALSE

3. Salt structures are better determined on gravity profiles than on magnetic profiles. **TRUE**/FALSE

4. The seismic response of a series of lithological contrasts in the subsurface is determined by the convolution of the source wavelet with the acoustic impedance time-series. **TRUE**/FALSE

5. The so-called "lower bound" pressure is determined by the fracture initiation pressure derived from leak off tests in wells. **TRUE**/FALSE

6. The density logging tool contains a radio-active source. **TRUE**/FALSE

7. Under isothermal conditions the viscosity of CO_2 is decreasing with increasing pressure. TRUE/**FALSE**

8. The thermal conductivity in limestones is lower than in salt. **TRUE**/FALSE

9. The heatflow of geothermal energy is predominantly caused by the cooling of the planet earth. TRUE/**FALSE**

10. The velocity of compressional (longitudinal) elastic waves is higher than the velocity of shear (transversal) elastic waves. **TRUE**/FALSE

11. Salt caverns offer larger storage volumes than depleted gas reservoirs. TRUE/**FALSE**

12. Fluid extraction from a reservoir cannot lead to surface subsidence. TRUE/**FALSE**

13. Aeolian sandstones generally have better reservoir quality than alluvial sandstones. **TRUE**/FALSE

14. Onshore subsurface storage of CO_2 is generally seen as the preferred option over offshore storage. TRUE/**FALSE**

15. One of the risks associated with deep geothermal energy production is induced seismicity. **TRUE**/FALSE

Q4 (15P)

Name five different ways the subsurface can be utilized? What are associated risks? Please elaborate.

-Hydrocarbon extraction

- CO$_2$ Storage

-Hydrogen storage/energy storage

- geothermal energy extraction

- nuclear waste storage