University of Stavanger

DATE: 19th of December, 2014

FACULTY OF SCIENCE AND TECHNOLOGY

SUBJECT: PET-500 - PVT of Reservoirs and Fluids

TIME: 4 hours

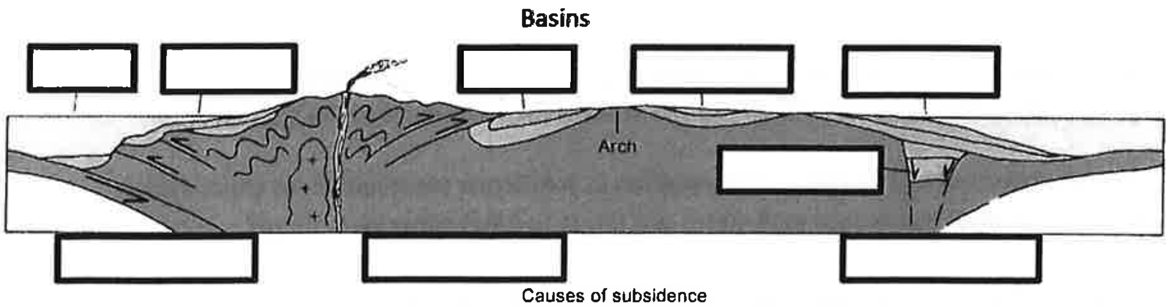
AID: No printed or written means allowed. Definite basic calculator allowed.
THE EXAM CONSISTS OF 2 PARTS ON 6 PAGES AND 1 ADDITIVE.
Part 1 is given equal weight as Part 2.
REMARKS: All answers in English. Answers on carbon paper.

Part 1a (25% of exam):
Reservoir Geology, 12 Questions

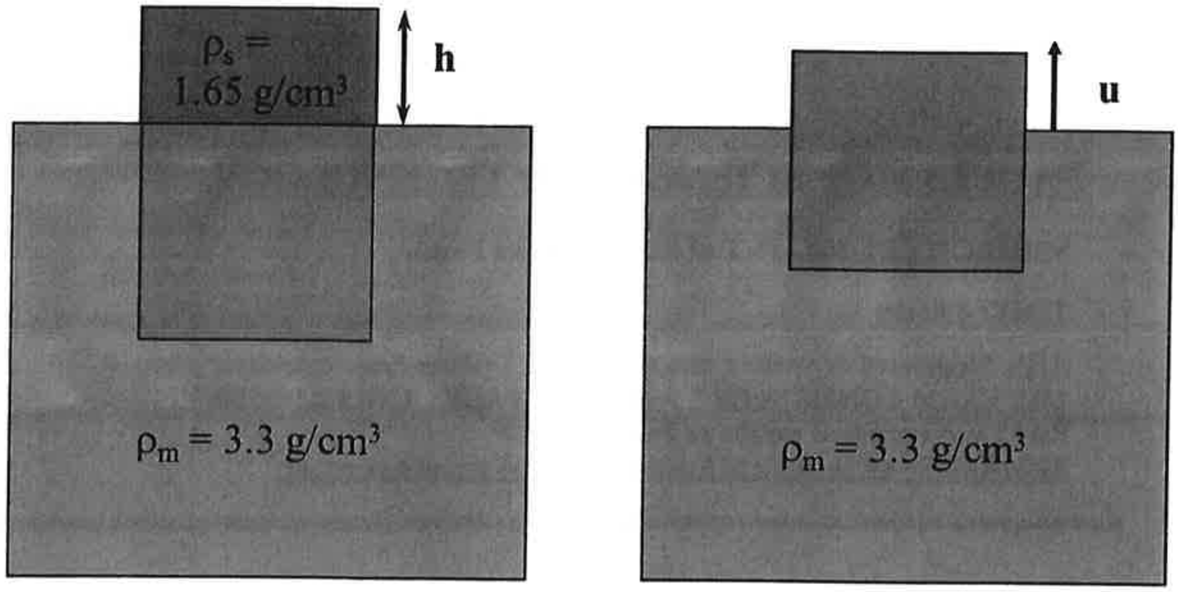
1. **What are the elements and processes of the Petroleum system?**

2. **What is basin modelling?**

3. **On the tectonic setting illustration below, fill in the various basins types as well as the major causes of subsidence. Make a sketch of the figure below with your answers.**



4. Calculate the isostatic uplift caused by 1.5 km erosion (see illustration below); h is erosion, u is uplift.



5. For Depositional Systems, according to "Walther's Law", what generates vertical sequences of sediments?

6. North Sea Chalk reservoir quality differs from typical limestone and dolomite carbonate reservoirs in what ways?

7. According to the "Golden Zone" concept, at greater than what temperature is there a high risk for reservoir overpressure, > 1.4 times hydrostatic ?
(Hint: > 65% of the Gulf of Mexico sandstone reservoirs are over pressured greater than this temperature).

8. If the mean surface or sea bottom temperature is 0°C, and the geothermal gradient is 30°C/1000m, then what would be the sub-surface depth interval of the Golden Zone?

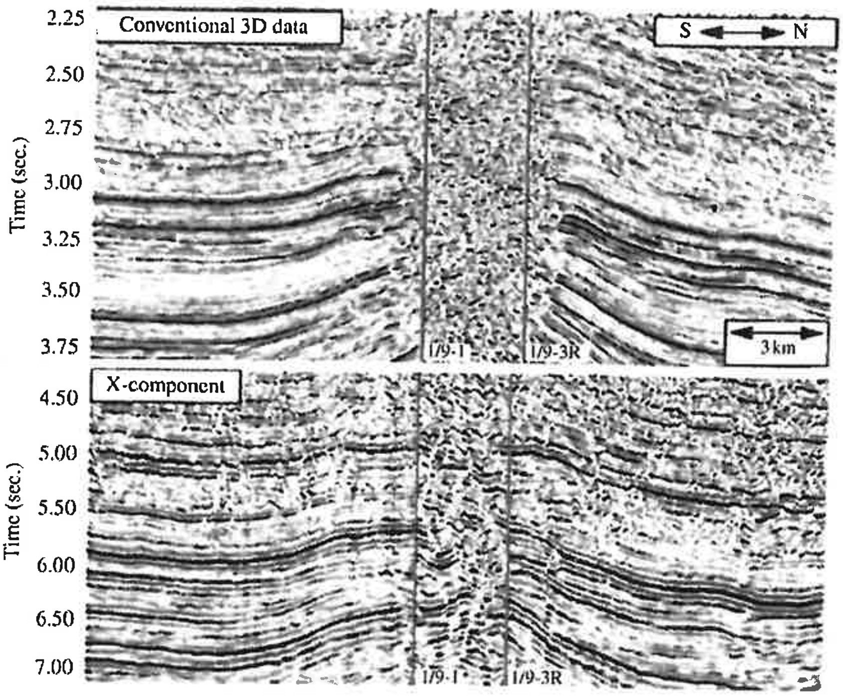
9. The precipitation rate of Quartz cementation in sandstone reservoirs is an exponential function of what subsurface parameter and linear to what other parameter?

10. Illustrate the three main types of faults and how do the fault blocks move in each fault type?

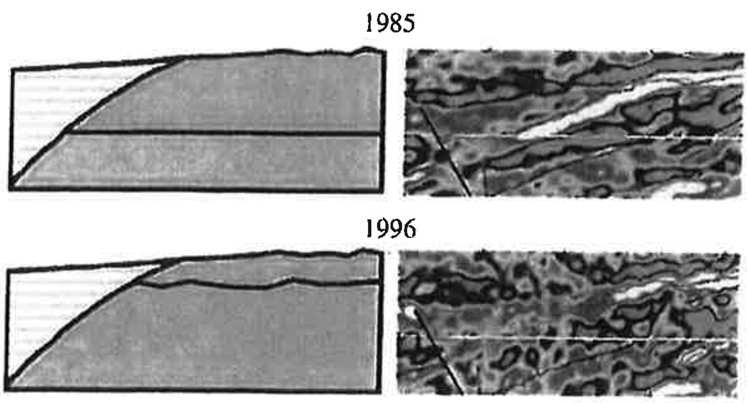
11. GEOPHYSICS/SEISMIC INTERPRETATION OF RESERVOIRS & FLUIDS:

The Figure below shows two seismic datasets acquired at approximately the same location, i.e. for the same part of the subsurface. How do the dataset differ and explain the time-scale values on the left.

What the zone in the middle (demarcated by vertical blue lines) represents and why it looks better on one section than on the other.



12. In a similar way, give your own account of what the figure below shows after 11 years of reservoir production history, and what type of seismic data would this be called?



Part 1b (25% of exam):
Reservoir Geology, 2 Questions

You have been tasked to estimate the volumes of oil/gas of 3 Norwegian Continental Shelf (NCS) prospects in terms of:

a. In-place resources of oil/gas in cubic meters **at reservoir conditions.**
b. Recoverable reserves of oil/gas in cubic meters (and barrels for oil) at surface conditions.

You must consider both the oil case and the gas case. Your employer is mostly interested in high value oil reserves, and also expects your recommendation of which prospect to prioritize for drilling.
Your subsurface team has provided you with the following information:

Prospect	Water Depth	Dimensions	Depth Crest	Depth Spill Point
1	165 m	7 x 10 km	1600 m	1650 m
2	130 m	10 x 20 km	2500 m	3000 m
3	800 m	20 x 40 km	2000 m	2300 m

Prospect	Reservoir T °C	Gross Thickness	Geol. Age	Depositional Environment
1	80	40 m	Jurassic	Shallow Marine
2	100	350 m	Triassic	Onshore Fluvial
3	70	300 m	Paleocene	Deep marine

Additional information:

Prospect 1 has a very weak flat seismic feature near the spill point.
Prospect 3 has a strong flat seismic feature near the mapped spill.

Show your calculations clearly organized, state your analogues for reservoir and fluid parameters for both the oil and gas cases, for a total of 12 answers (i.e. oil case 1.a , 1.b ; gas case 1.a , 1.b ; etc. , plus your recommendation on which prospect to prioritize for drilling.

63 microns sand grains
2 mm coarse grains sand

Part 2, *(50% of exam):*

PVT of Fluids, 8 Questions

The following data are given for a closed petroleum reservoir:

$P_i = 45000$ kPa
$P_d = 30500$ kPa
$T_{res} = 120$ °C
$S_{wi} = 0.18$
$\Phi = 0.23$
$Z_i = 1.15$
$Z_d = 0.95$
$(GOR)_i = 2000$ Sm^3/Sm^3

(Standard conditions: 15 °C and 101.32 kPa)

Composition (mole fraction) and molecular weight of components in the initial reservoir fluid:

Comp.	z_i	M_i
C_1	0.752	16.04
C_2	0.077	30.07
C_3	0.044	44.09
C_4	0.031	58.12
C_5	0.022	72.15
C6	0.022	86.17
C_{7+}	0.052	114

a.

Give a description of the fluid type by means of a PT-diagram.
What is the expected GOR-range?

b.

A representative reservoir fluid sample is needed for PVT and compositional analysis. What are the most optimum sampling techniques in this case? Give a short evaluation/explanation.

c.

Describe the principles of Constant Volume Depletion (CVD) analysis

d.

The initial well-stream volume at standard conditions, G_p, can be determined from production data (P_{res}, Z_g, V_g (sc), V_{sto}) in the one-phase area by transforming V_{sto} to GE_{sto}.

1. Derive an expression for $GE_{STO} = f(\rho_{STO}\ kg/m^3, M_{STO})$ as (Sm^3 gas/Sm^3 STO).
2. Explain, in details, using figure and formula how the initial gas volume (sc) of the well stream can be determined from production data.

e.

Based on 1000 m^3 bulk reservoir volume, calculate:

- HCPV (m^3)
- IGIP (Sm^3)
- IOIP (Sm^3)

In addition to the data given previously, the following data are used:

$M_{STO} = 110$

$\rho_{STO} = 800$ kg/m^3

GOR = $(GOR)_i$

f.

Calculate the density (kg/m^3) and B_g at P_i and T_{res}.

g.

Based on 1000 m^3 bulk reservoir volume, calculate the volume of well stream production (Sm^3), volume of STO (Sm^3), and volume of separator gas (Sm^3) in the pressure interval P_i to P_d.

h.

Suppose that all C1, C2, and C3 compounds are present as gas at sc.
Calculate the amount of gas (Sm^3) in the field based on 1000 m^3 bulk reservoir volume.

$PV = ZnRT$

Addition 1.

Important formula/correlations in PVT-Analysis.

Temperature:

°K = 273.15 + °C
°F = 1.8 x °C + 32
°R = °F + 459.69

Pressure:

1atm = 1013.250 mBar = 1.013250 bar = 101.3250 kPa = 0.1013250 MPa = 14.69595 psia
psia = 14.69595 + psig
1 atm = 760.002 mmHg at 0 °C

Density:

1 g/cm^3 = 62.43 lb/ft^3 = 350.54 lb/bbl
1 lb/ft^3 = 16.0185 kg/m^3
ρ_w = 0.999015 g/cm^3 (60 °F, 1 atm)
ρ_w = 0.9991 g/cm^3 (15 °C, 1 atm)

Specific density:

For liquids: Determined relative to water at sc.
For gases: Determined relative to air at sc.

$$\gamma_o = \frac{\rho_o}{\rho_w} = \frac{141.5}{131.5 + {}^oAPI}$$

$${}^oAPI = \frac{141.5}{\gamma_o} - 131.5$$

Cragoe`s formula (empirical formula giving molecular weight of hydrocarbons):

$$M_o = \frac{6084}{{}^oAPI - 5.9}$$

$$\gamma_g = \frac{M_g}{M_{air}} = \frac{M_g}{28.96}$$

Volume:

1 bbl = 5.615 ft^3 = 0.15898 m^3
1 ft^3 = 0.0283 m^3
1 US Gallon = 3.785 litre
1 Imp. Gallon = 4.546 litre
Molar volume of gas at standard conditions:
V_m = 379.51 SCF/lb mole (60 °F and 14.69595 psia)
V_m = 23644.7 cm^3/g mole = 23.6447 m^3/kg mole (15 °C and 101.3250 kPa)

Air:

Z_{air} = 0.9959 (60 °F, 14.69595 psia)
M_{air} = 28.96

Gas constant:

R = 10.732 (psia, ft^3, °R, lb mole)
R = 0.082054 (atm, litre, °K, g mole)
R = 8.3145 (kPa, m^3, °K, kg mole)