Name:
Student nr:

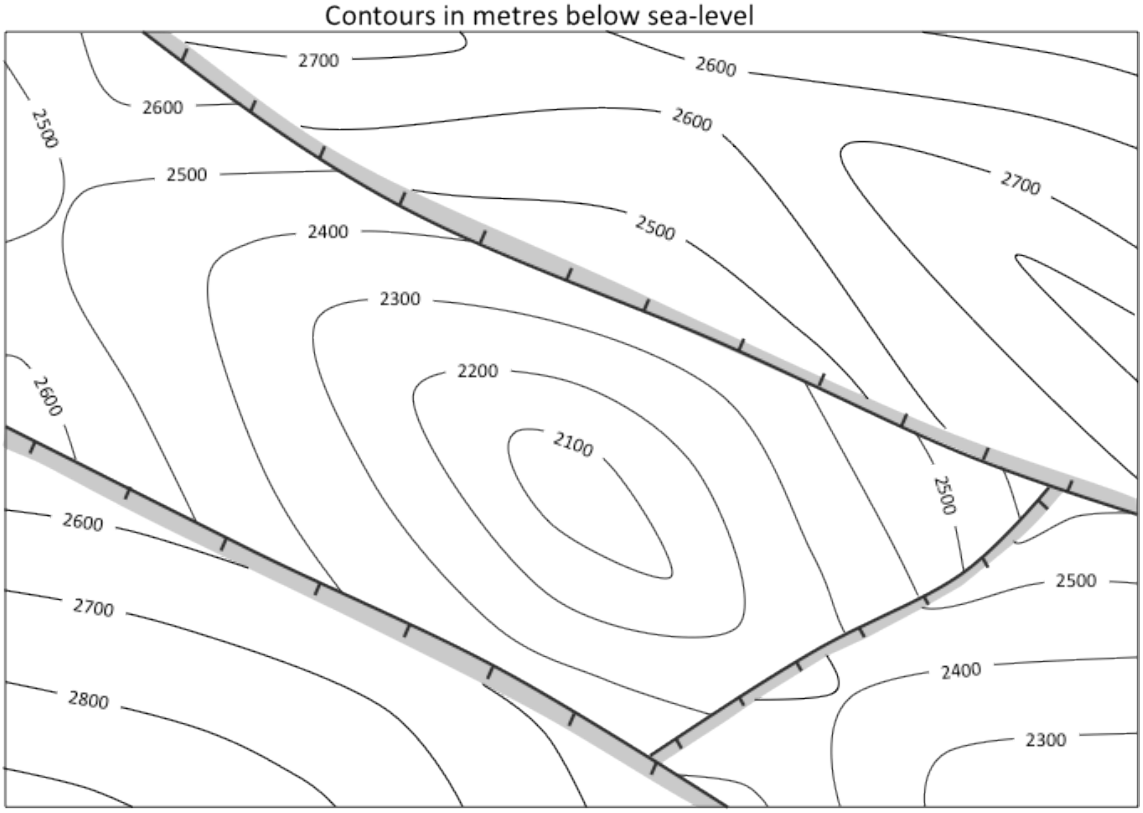
Petroleum Systems and Regional geology
Examination 2015

- Answers may be in English or Dutch (but please write clearly…)
- Indicate your name and student number on all pages
- Credits will be given for indications of understanding basic principles and for your reasoning
- Make as much use as you can of diagrams and illustrations

Question 1: *Spill and leak points* *(max 15 points)*

Depth map top reservoir

Contours in metres below sea-level



a. Describe the prospect(s) on the map above, and colour the total area of the trap(s):

Two separate traps:

1) An anticlinal structure with culmination at ca. 2050m, bounded by faults to N, S and SE, and with a spill point (saddle) to NW at 2500 m. Just beyond the NE-SW trending fault in the SE there is a spill point at 2400 m, with a tiny separate closure against the fault updip (NW) of this spill point.
2) There is a separate closure to the N of the northern fault with spill point at 2600(+)m and a culmination at circa 2450 m. This closure is bounded to the SW by the northern NW-SE trending fault.

Total 5 pts: If only the main anticlinal trap is mentioned: 3 pts
Both closures mentioned: 4 pts
Correct mentioning of depth of spill points/culminations: 1 pt

b. Draw one or two schematic cross-section(s) to illustrate the prospect, indicating the spill point(s), and the potential leak point(s). Also indicate the positions of the spill- and leak point(s) on the map.

Total 4 pts

c. Assuming that all faults are completely sealing (irrespective of juxtaposition), at what depth would you expect the hydrocarbon-water contact(s) to be as a most likely case, and why?

Total 3 points

- 2500 m for main trap (2 points)
- 2600 m for northern separate closure (1 point)

these are the deepest possible spill points.

d. Assuming that the reservoir is 100 m thick, and faults are leaking only when there is direct reservoir-reservoir juxtaposition: at what depth would you then expect the hydrocarbon-water contact(s) as a most likely case, and why?

Total 3 points

The throw of the fault separating the separate closure in the N is < 100 m, so should be leaking. In this case, the northern closure will have the same water contact as the main anticlinal closure

The NE-SW fault in the SE also has a throw < than 100 m, and should also be expected to leak. Hence, the spill point in the SE at 2400 m is then the control on the water contact: I expect the HC-W contact at 2400 m

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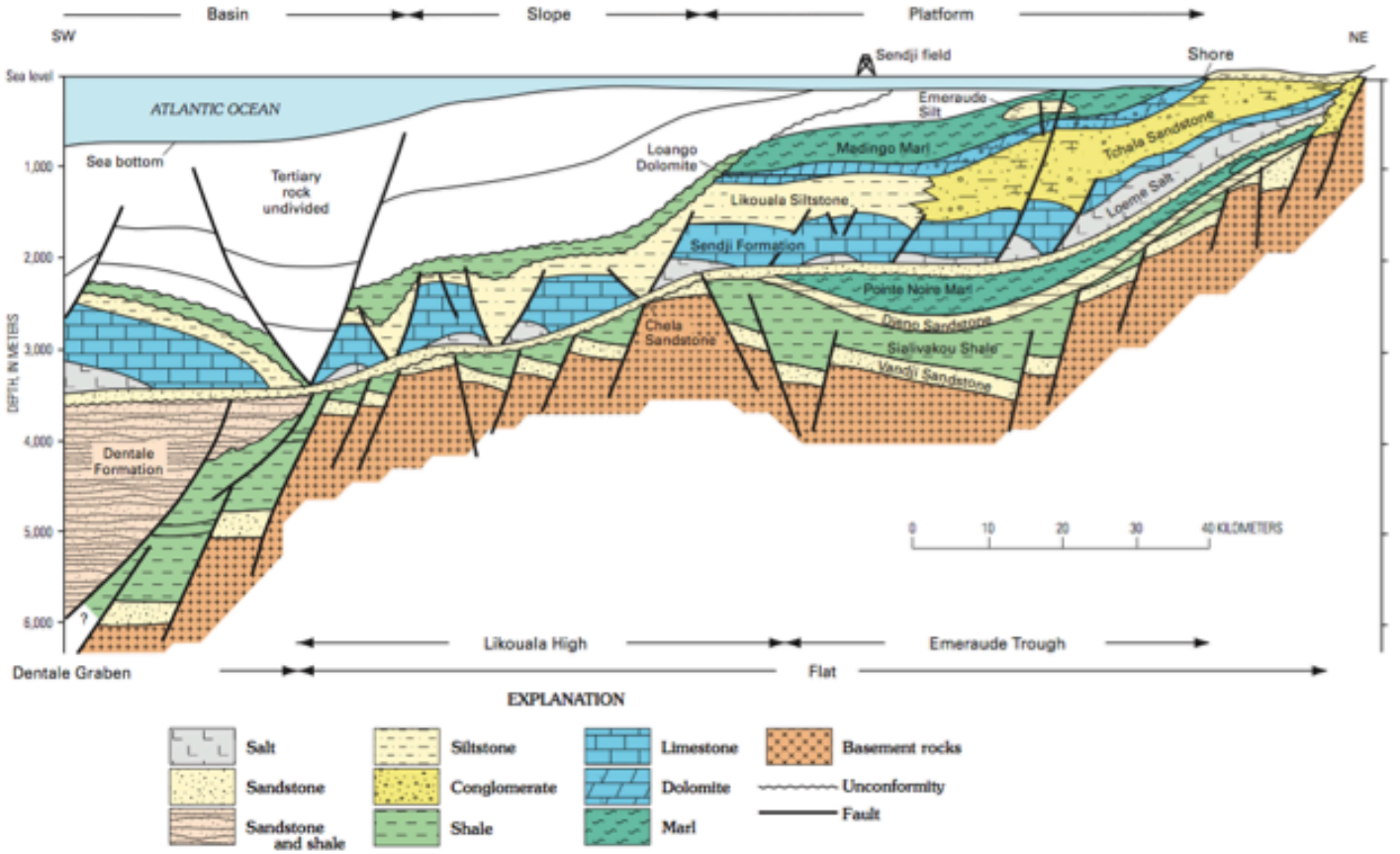
Question 2: *Basin type, cycles and prospectivity* (*max 15 points*)



a. What type of basin setting is this? *Total 4 pts*

Rift basin – successful rift, with post-rift or sag cycle above – (asymmetric) passive margin

- *Full score for rift + passive margin (or sag)*
- *Only 3 points if only rift basin or passive margin is mentioned*

b. Which basin cycles do you distinguish, and indicate some of the formation names that belong to the identified basin cycles? *Total 5 pts*

- Pre-rift: Basement and/or Chela Sandstones
- Syn-rift: Early rift: Vandji Sandstone
- Main rift: Sialvakou shale
- Waning rift: Djino Sandstone + Pointe Noir marl
- Late renewed rift pulse: Dentale Fm
- Post-rift: Everything above the main break-up unconformity

No inversion phase seems to be present

Full score of pre-, syn- and post-rift cycles have been mentioned, with reasonable indication of formation names
If only 2 of the cycles have been mentioned (+ fm names): 3 points
Only 1 of the cycles + fm names: 2 points
Add 1 point for mentioning waning rift stage (Point Noir)
Deduct 1 point if lithology/fm names have insufficiently been indicated

c. What kind of source rocks would you expect (type I, II, III), and in the identified basin cycles? *Total 3 pts*

Type I source rock in the main rift phase
Maybe Type III in the late syn-rift sequence
Type II marine source rocks in the distal post-rift sediments
1 point per correct indication of source rock type (type plus in which cycle)

d. What do you think of the hydrocarbon prospectivety of this basin? *Total 3 points*

In general, many rift basins and passive margins tend to have some hydrocarbons, so the prospectivity should be promising.
Rift basins tend to have good oil prone Type I source rocks, so there could be an oil play in the syn-rift sequences (or cycle). Reservoirs may be turbiditic or fluvio-deltaic sandstones in fault-bounded traps
In the post-rift sequence there may be marine Type II source rocks charging carbonate or clastic reservoirs in fault-bounded or salt-induced traps
3 points for positive view of prospectivity
1 extra points if also trap types and reservoir types in syn-rift have reasonably correctly been indicated
1 extra point if also traps types and reservoir types in post-rift have reasonably been indicated

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Question 3: *Rift basins* *(max 15 pts)*

a. Describe the typical basin development and characteristics of a rift basin (use sketches). *Total 6 points*

b. Which source rocks types do you expect in a syn-rift sequence ? *Total 3 points*

Type I in syn-rift (algal; oil-prone)
Type III in late syn-rift (land plant organic matter; gas prone)

2 points for Type I
1 extra point for Type III

c. What reservoir types do you expect in syn-rift sequence? *Total 3 points*

- Turbidites (lacustrine?) in underfilled rift basin *1 points*
- Fluvio-deltaic clastics (sandstones) in late (waning) rift stage *1 point*
- Alluvial fan sandstones close to main syn-rift fault *1 point*

d. Which trap types do you expect in a rift basin (use sketches)? *Total 3 points*

- Stratigraphic traps in turbidites
- Hanging wall fault controlled traps (up-thrown fault blocks)
- Footwall fault-controlled traps
- Dip-closures in roll-over anticlines
- Dip-closures (anticlanal treaps) in inversion structures
- Faulted dipclosures (faulted anticlinal traps) in flower structures

For < 2 types: 0 pts
2 trap types with reasonable sketches: 1 pt
3 trap types with reasonable sketches 2 pts
>3 trap types with reasonable sketches: 3 pts
Deduct 1 pt for no (or very poor) sketches

Question 4: ***Unconventional gas*** *(max 15 pts)*

a. What are the main differences between conventional gas and unconventional gas? *Total 5 points*

Conventional	**Unconventional**
Difficult to find – easy to produce	Easy to find – difficult to produce
Reservoir with reasonable por & perm	In reservoir with low por & perm
Can be produced without stimulation	Needs stimulation (fraccing)
Low density of production wells	High density of production wells
May be produced with normal wells	Generally requires horizontal wells

1 difference: 1 point
2 differences: 2 point
3 differences: 3 points
4 differences: 4 points
5 differences: 5 pts

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b. What are the main types of unconventional gas and briefly describe what it is?
Total 5 points

- Shale gas
  Gas from (oil-prone, Type II) source rocks in gas window
- Basin Centre Gas
  Gas from thick sequences of very tight (low permeable) clastic rocks, normally in fluvio-deltaic settings, with interbedded shales, sandstones and coalsCoalbed Methane
- Coal-bed methane
  Gas from coals; at relatively shallow depths (<1200 m)

(- Gas Hydrates
  Gas from hydrates below the sea-bed in cold waters)

4 points for SG, BCG and CBM + 1 point if all are correctly described
2 points for 2 of the 3, + 1 point if correctly described
1 points for 1 of the 3, + 1 point if correctly described

c. What are the problems of unconventional gas production, and how are these problems dealt with? *Total 5 points*

1. High well density: drilling multiple deviated wells from a single surface location
2. Tight reservoirs and low productivity: Fracking
3. High water usage required for fracking: no solution
4. Usage of chemicals for fracking: no solution
5. Back-production of polluted water: collecting and treating water before disposal
6. Societal resistance: information sessions
   - Danger of pollution of ground water / drinking water: Not a real issue where there is good regulation
   - Danger of induced earthquakes due to fracking: Very limited risk only for minor earthquakes
   - Danger of subsidence because of gas attraction: No risk in already tight shale reservoirs
   - Heavy traffic in rural areas: this is a real issue…

Full score of 5 points requires at least 1, 2, 3, 4 and 3 issues of 6
4 points for at least 3 out of 1-5 and 2 issues of 6
3 points for at least 2 out of 1-5 and 1 issue of 6
2 points for 2 out of 1-6
1 point for 1 issue correctly mentioned

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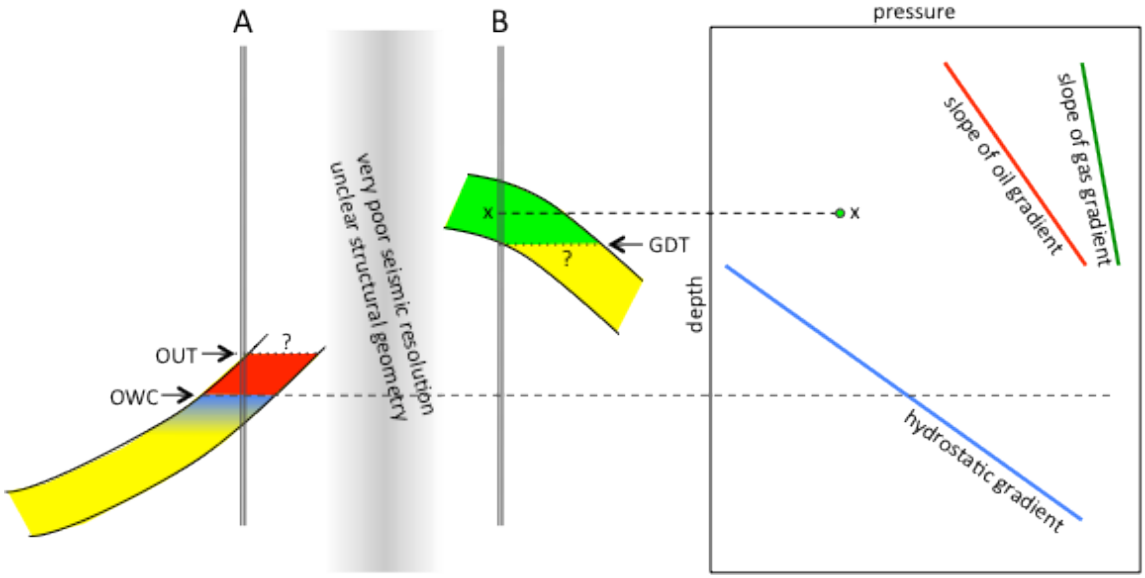
Question 5: ***Pressures*** *(max 10 points)*



Well A found a sandstone resevoir with an oil-water contact (OWC). Because of extremely poor seismic data quality, the area where the crest of the trap is assumed to be cannot be imaged. Consequentlty, there is an oil-up-to (OUT) at the level where the well intersects the top of the reservoir (i.e. it is not clear if oil or gas is present above the depth of the OUT).

Well B, found the same reservoir fully gas-bearing, wit a gas-down-to (GDT): i.e. it is not clear how far the gas column extends to deeper levels, and if oil is present or not. A pressure measurement "x" has been made in the centre of the reservoir in the well, and the pressure is plotted on the depth-aligned pressure-depth plot next to the cross section.

The structural geometry in the area between wells A and B is not clear because of the poor seismic, and it is not clear whether the hydrocarbons seen in wells A and B are pert of a single HC accumulation or not.

There are no overpressures, and the hydrostatic gradient for the area is indicated on the pressure-depth plot, togehther with the slopes of an oil gradient and of a gas gradient.

a. Is it possible that the reservoirs intersected with wells A and B are part of a single HC accumulation, and if yes, indicate on the pressure plot the depths of all HC contacts? (explain, make sketch on the pressure-depth plot)

Yes, then there will be an oil-water contact at intersection of the gas gradien through x and the oil gradient through the OWC of well A
5 points

b. Assuming that the reservoir found in wells A and B are not part of a single trap, what can you say about the HC fill and HC contacts of the trap that has been intersected with well B?

Then there may be a GWC at the intersection of the gas gradiwent through x and the hydrostatic gradient, or there may be an oil rim and a deeper OWC
5 points

Question 6: ***Carbonate reefs*** *(max 10 pts)*

a. Why are reefs generally attractive exploration targets?

b. hat determines generally the depth of the hydrocarbon-water contact in reefs (use sketches)?

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Question 7: ***Source rocks*** *(max 10 points)*

a. Describe the characteristics of source rock types I, II and III in terms of:
- Depositional environments in which they are typically deposited
- Main hydrocarbon products
- Expulsion characteristics (maturities at which they expel hydrocarbons)

Question 8: ***Definitions*** *(max 10 pts)*

a. What is a Petroleum System?

b. What is a hydrocarbon play?

c. What is a prospect in petroleum geology?