

The Svalex 2004 pre-course assignment

To participate on Svalex 2004 you have to pass this pre-course assignment. Your result from this pre-course assignment will count 20 % when you are evaluated after the field course on Svalbard.

First you have to select **one** of the three pre-course assignments you wish to work on; **Geophysics, Geology or Reservoir Engineering**. Each set of assignments are tough on the topic in the heading (i.e. Geology is tough on the geology questions), but have easy questions on the two other topics (i.e. Geology is easy on geophysics and reservoir engineering). We therefore recommend geology students to select the Geology assignment, reservoir engineering students to select the Reservoir Engineering assignment and so on.

Each student has to solve **one** of the pre-course assignments described above and submit it electronically by **May 15th 2004** to Finn Sverre Karlsen (NTNU) at: finnk@ipt.ntnu.no. Your submission should be no longer than 10 printed A4 pages (using Times New Roman 12 pt and 1.5 line spacing), any extra pages will not be considered when evaluating your submission. Write your full name, institution, e-mail address and the name of the pre-course assignment you have selected (Geophysics, Geology or Reservoir Engineering) on top of the first page. Use references in the text and include a list of references on the last page. The web quiz (exercise 4 in each assignment) must be solved online and is not counted as part of your ten pages.

Each student has to solve and submit the assignment they selected **individually**. If a student try to duplicate or copy all or part of another student's assignment, both students will fail the pre-course assignment.

We encourage you to use the internet and the program SvalSim (GEO2000) to solve your assignment. If you have any questions, please contact one of the resource personnel or Bjarne Rafaelsen (bjarne.rafaelsen@ig.uit.no).

Good luck.

Contents

Pre-course assignments:

Geology pre-course assignment	page 2-3
Geophysics pre-course assignment	page 4-5
Reservoir Engineering pre-course assignment	page 6

<u>2004 Svalex Sedimentology Quiz Login Info:</u>	page 7
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Resources:

Selected resources	page 8
Resource personnel	page 9

Geology pre-course assignment

1a. There are several reservoir units within the post-Devonian strata of Svalbard. Discuss briefly the depositional environments for each of the possible reservoir units. If possible, say something about lateral thickness variations.

1b. The post-Devonian rock of Svalbard has been subjected to several phases of tectonic activity. Describe briefly the age and structural style associated with the various tectonic events.

2a. Use the lithostratigraphic column of Svalbard to evaluate where you would expect to find good/strong reflectors if you did a reflection seismic survey in Isfjorden? Explain why!

2b. The ratio of reflected amplitude from an interface is determined by a formula for zero angle of incidence. What is the formula?

2c. Two multichannel reflection seismic surveys are to be performed in Isfjorden. The aim of acquisition I is structures at ca. 10 km depth, whereas mapping of the uppermost ca. 100 m below the seafloor is the main target in Acquisition II. Discuss possible choices of source and receiver in both cases.

3a. Calculate the height of the capillary transition zone between water and oil and between oil and gas.

3b. From the literature, try to evaluate the validity of the J-function concept.

Given:

Data: Density of water, 1 g cm^{-3}
Viscosity of water, 1 cp
gravitational constant, 980 cm s^{-2}

Units: 1 atm is $1.01325 \cdot 10^6 \text{ dyn cm}^{-2}$
1 dyn is 1 g cm s^{-2}
1 cp is $10^{-3} \text{ Pa}\cdot\text{s}$
1 md is $9.869 \cdot 10^{-16} \text{ m}^2$

Table 1: Values given to solve exercise 3.

Leverett's J-function is defined by

$$J(S) = \frac{P_c(S)}{\sigma \cos \theta} \sqrt{\frac{k}{\phi}}, \dots \dots \dots (1)$$

where S is saturation and P_c is capillary pressure. The parameters are: σ surface tension, θ contact angle, k permeability, ϕ porosity. The units are from a consistent set, e.g., SI-units, and J is a dimensionless a capillary pressure and is the same for a given facies even if the parameters vary.

For a reservoir that may be conceived as a single facies, the J-function in Table 2 was constructed by averaging the results from many core samples. Otherwise, the

S	$J(S)$
1.000	0.00
0.950	0.22
0.900	0.31
0.750	0.55
0.600	1.02
0.450	1.66
0.300	2.84
0.250	3.80
0.235	4.23
0.235	5.29

Table 2: J-funksjonen for et reservoar

reservoir has average properties as shown in Table 3.

porosity	$\bar{\phi}$	=	0.20
permeability	\bar{k}	=	200 md
surface tension oil-water	σ_{wo}	=	30 dyn/cm
contact angle oil-water	θ_{wo}	=	35°
surface tension gas-oil	σ_{go}	=	5°
contact angle gas-oil	θ_{wo}	=	10°
density of oil	ρ_o	=	850 kg/m ³
density of gas	ρ_g	=	120 kg/m ³
density of water	ρ_w	=	1050 kg/m ³

Table 3: Other average properties of the reservoir

4. This exercise must be solved via the internet and you only get **one** chance to answer the questions. Read the questions carefully and answer the quiz. Instructions on how to get started on is found on page 7 under "2004 Svalex Sedimentology Quiz Login Info".

Geophysics pre-course assignment

1a. There are several reservoir units within the post-Devonian strata of Svalbard. Discuss briefly the depositional environments for each of the possible reservoir units. If possible, say something about lateral thickness variations.

1b. The post-Devonian rock of Svalbard has been subjected to several phases of tectonic activity. Describe briefly the age and structural style associated with the various tectonic events.

2a. Use the lithostratigraphic column of Svalbard to evaluate where you would expect to find good/strong reflectors if you did a reflection seismic survey in Isfjorden? Explain why!

2b. What kind of seismic waves are generated for post critical reflections?

2c. You are to acquire seismic data over a structure located partly on land and partly in Isfjorden. There is an open borehole in the area. Discuss various options you have to optimize your task. Explain your choice of sources, receivers, geometries etc.

3a. Calculate the height of the capillary transition zone between water and oil and between oil and gas.

3b. From the literature, try to evaluate the validity of the J-function concept.

Given:

Data: Density of water, 1 g cm^{-3}
Viscosity of water, 1 cp
gravitational constant, 980 cm s^{-2}

Units: 1 atm is $1.01325 \cdot 10^6 \text{ dyn cm}^{-2}$
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Table 1: Values given to solve exercise 3.

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$$J(S) = \frac{P_c(S)}{\sigma \cos \theta} \sqrt{\frac{k}{\phi}}, \quad \dots \dots \dots (1)$$

where S is saturation and P_c is capillary pressure. The parameters are: σ surface tension, θ contact angle, k permeability, ϕ porosity. The units are from a consistent set, e.g., SI-units, and J is a dimensionless a capillary pressure and is the same for a given facies even if the parameters vary.

For a reservoir that may be conceived as a single facies, the J-function in Table 2 was constructed by averaging the results from many core samples. Otherwise, the

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Table 3: Other average properties of the reservoir

4. This exercise must be solved via the internet and you only get **one** chance to answer the questions. Read the questions carefully and answer the quiz. Instructions on how to get started on is found on page 7 under "2004 Svalex Sedimentology Quiz Login Info".

Reservoir Engineering pre-course assignment

1a. Geologists subdivide sedimentary rocks into formations, beds, groups and sub-groups, and supergroups. What is the relationship between these different terms?

1b. Explain briefly the terms *lithostratigraphy* and *biostratigraphy*.

1c. The post-Devonian rocks of Svalbard are subdivided into several groups. What is the name and age of the various groups on Svalbard?

1d. In which groups does one find reservoir rocks? List the names of the best reservoir rocks on Svalbard and adjacent Barents Sea. Use the literature to make a few statements about the thickness, lateral extent, and variations in thickness.

2a. Give examples of coherent and random noise found in seismic data

2b. At a certain angle of incidence the seismic wave will be totally reflected. At what angle will this first occur, and what is this angle called?

2c. Two multichannel reflection seismic surveys are to be performed in Isfjorden. The aim of acquisition I is structures at ca. 10 km depth, whereas mapping of the uppermost ca. 100 m below the seafloor is the main target in Acquisition II. Discuss possible choices of source and receiver in both cases.

3. The data in Table 1 is from a RFT-test (“Repeat Formation Tester”) of an uncompleted well. The depth is referred to the rotary table which is 610 m above mean sea level.

Depth (m)	Pressure (MPa)
2475	20.074
2500	20.133
2525	20.182
2550	20.339
2575	20.535
2600	20.721
2625	20.947
2650	21.202
2675	21.467

Table 1: RFT-data from an uncompleted well

3a. Determine the densities of the fluids in the formation.

3b. Determine the depth to the free gas-oil and water-oil contacts and the thickness of the oil zone.

3c. Determine if the water zone is normally geo-pressured.

3d. The following data are known for this reservoir from a PVT-analysis: Volume factor B_o for oil, densities ρ_{os} and ρ_{gs} for oil and gas at the surface and dissolved gas-oil ratio R_{so} . How could you then check the oil density value found under question a?

4. This exercise must be solved via the internet and you only get **one** chance to answer the questions. Read the questions carefully and answer the quiz. Instructions on how to get started on is found on page 7 under ”2004 Svalex Sedimentology Quiz Login Info”.

2004 Svalex Sedimentology Quiz Login Info

Follow the link below and the log in page should appear:

<http://129.241.27.50:8080/quiz/stud/login.jsp>

Log in: You must first be registered as a student. You do this by clicking the *Not registered yet?* link below the password box. Enter correct information in all the fields.

User name: Select a user name, and make a note of it.

Password: Select a password, and make a note of it.

Keep a record of your user name and password.

Have your password mailed to you: If you loose your password, you can have it mailed to you by clicking the link on the log in page. You then enter the user name in the box - in other words try not to loose your user name.

Using WeBQuiz:

- Before you can complete any quizzes, you must first sign on to the course you want to work on: Click on *Add course* and tick the box next to the course you want to attend.
- Then Click *View Waiting quiz* and then *Do Quiz* in the subject where you want to work. You will have to wait a while for the quiz to appear.
- The questions of the quizzes are normally of two kinds:
 - True/False - where you have to find whether the statement is true or false. Click the appropriate radio button.
 - Multiple choices: Select the answer you think is most correct. Only one alternative can be chosen.
- Deliver the answer: To complete you work and deliver the answer you push the *Deliver* button below the quiz.
- Check the results of your work by selecting *View status* from the main menu.

Time limit: Remember that quizzes are open for work in a limited time span. This means that if you are not working on the quizzes in the allocated time interval, you will be registered as NOT having completed the quizzes.

WeBQuiz wants to know what help is needed by the student user. Report back to

helge.langeland@ipt.ntnu.no

Help page:

www.ipt.ntnu.no/~helan/WEB-teaching_Basic_Petrophysics/WeBQuiz_Log_in.htm

Selected resources

Excercise 1:

- Johnsen, S.O., Mørk, A., Dypvik, H. & Nagy, J. 2002: Outline of the Geology og Svalbard. 11 pp. www.svalex.net/files/Outline%20of%20the%20Geology%20of%20Svalbard.pdf
- Nøttvedt, A., Livbjerg, F., Midbøe, P.S., & Rasmussen, E. 1992: Hydrocarbon potential of the Central Spitsbergen Basin. In: Vorren, T.O., Bergsager, E., Dahl-Stammes, Ø.A., Holter, E., Johansen, B., Lie, E., & Lund, T.B. (Eds.): *Arctic Geology and Petroleum Potential*. NPF Special Publication 2, p. 333 – 361.
- Haremo, P. & Andresen, A. 1992: Tertiary decollement thrusting and inversion structures along Billefjorden and Lomfjorden Fault Zones, East Central Spitsbergen. In: Larsen, R.M., Brekke, H., Larsen, B.T., & Tallrås, E. (Eds.): *Structural and Tectonic Modelling and its Application to Petroleum Geology*. NPF Special Publication 1, p. 481 – 494.
- Johannessen, E.P. & Steel, R.J. 1992: Mid-Carboniferous extension and rift-infill sequences in the Billefjorden Through, Svalbard. In: Dallmann, W.K., Andresen, A. & Krill, A (Eds.): *Post-Caledonian tectonic evolution of Svalbard*. Norsk Geologisk Tidsskrift 72, p. 35-48.

Excercise 2:

- Johansen, A.E., Kibsgaard, S., Andresen, A., Henningsen, T., & Granli, J.R., 1994: Seismic modelling of a strongly emergent thrust front, West Spitsbergen Foldbelt, Svalbard. *American Assocation of Petroleum Geologists Bulletin* 78, p. 1018-1027.
- Use e-modules found on www.learninggeoscience.net/ (click GeoPhysics => Modules => GeoPhysics => Acquisition / Processing):
 - Geophysical Principles
 - Seismic Equipment
 - Logistics
 - Recording
 - OBS acquisition
- Use e-modules found on www.learninggeoscience.net/modules/uiib
 - VSP Data Principles
 - VSP Data Applications

Excercise 3:

- PDF-files found at <http://www.ux.his.no/~s-skj/Svalex2004/prelim/>
- Search for “j-function leverett” on the internet

Excercise 4: www.ipt.ntnu.no/~helan/Svalex_2003/Sedimentologi_from_logs_Svalex-1-filer/frame.htm

Other resources:

- www.glossary.oilfield.slb.com/
- www.gyldendal.no/undervisning/petroleum3/realindex.html
- www.ibg.uit.no/~bjarne/svalref.html
- www.svalex.net
- www.ibg.uit.no/~bjarne/Svalex.html

Resource personnel

Excercise 1: Arild Andresen (arild.andresen@geologi.uio.no), Sverre Ola Johnsen (Sverre.O.Johnsen@geo.ntnu.no)

Excercise 2: Jan Inge Faleide (j.i.faleide@geologi.uio.no), Rolf Mjelde (rolf.mjelde@geo.uib.no), Martin Landrø (mlan@ipt.ntnu.no), Bent Ole Ruud (Bent.Ruud@geo.uib.no), Egil Tjøland (tjaland@ipt.ntnu.no), Bjarne Rafaelsen (bjarne.rafaelsen@ig.uit.no)

Excercise 3: Jon Kleppe (kleppe@ipt.ntnu.no), Svein Skjæveland (svein.m.skjaeveland@tn.his.no), Ole Torsæther (olet@ipt.ntnu.no).

Excercise 4: Helge Langeland (helge.langeland@ipt.ntnu.no).