UNIVERSITY OF MISKOLC

FACULTY OF
EARTH AND ENVIRONMENTAL
SCIENCES AND ENGINEERING

APPLIED GEOPHYSICS

MS in Petroleum Engineering

Semester 1, 2023/24

COURSE COMMUNICATION FOLDER

University of Miskolc
Faculty of Earth and Environmental Sciences and Engineering
Institute of Exploration Geosciences

Course datasheet

<table>
<tr><td rowspan="2">Course Title: Applied Geophysics
Instructor: Gábor Pethő Dr., private university professor, Péter Vass Dr., associate professor</td><td>Code: MFFGT710005
Responsible department/institute: MFGFT</td></tr>
<tr><td>Type of course: C</td></tr>
<tr><td>Position in curriculum (which semester): 1</td><td>Pre-requisites (if any): -</td></tr>
<tr><td>No. of contact hours per week (lecture + seminar): 2+1</td><td>Type of Assessment (examination/ practical mark / other): examination</td></tr>
<tr><td>Credits: 3</td><td>Course: full time</td></tr>
<tr><td colspan="2">Study goals: to have knowledge in applied geophysics and well logging used in HC exploration in the level of discussion with geophysicists and log analysts.
Course Description: the most important geophysical parameters used in HC exploration. Geophysical exploration (magnetic, gravity, electromagnetic, radiometry, geothermal) methods, their resolutions and their role in HC exploration. Seismic reflection method, corrections made on seismic data to gain seismic section in depth. VSP. Geophysical methods detecting HC in direct way (bright spot, AVO analysis). Time-lapse (including 4D) geophysical measurements. Physical bases and instrumentation of bore-hole geophysical measurements. The main features of wire line logging. The main features of logging while drilling and production well logging. The determination of porosity, permeability, water and HC saturation. Log indicators of over pressured zones. Technical measurements and their applications. Information gained by logging in cased holes. Detecting well problems. Application of logging in injection, production and monitoring wells. Geophysical case histories including exploration and production.</td></tr>
<tr><td colspan="2">Competencies to evolve:
Knowledge:
Knows the economic processes related to the hydrocarbon industry.
Knows the equipment and methods required for the drilling and completion of oil, natural gas and water wells and has the necessary knowledge to plan drillings.
Knows the malfunctions that typically occur during the construction of oil, natural gas, and water wells and how to resolve them.
Knows the properties of the fluids found in petroleum, natural gas and geothermal reservoirs, as well as the storage rocks; characteristics of flow in such reservoirs.
Knows the production mechanisms of underground reservoirs and the primary or enhanced extraction mechanisms that ensure optimal production.
Knows the basics of numerical simulation of underground storages.
Knows the methods and tools of computerized design and analysis in the hydrocarbon industry.
Ability:
Able to interpret the economic processes related to the hydrocarbon industry and to give adequate answers to them.
Capable of predicting the behaviour of fluids in petroleum, natural gas, and geothermal reservoirs, the properties of reservoir rocks, and the characteristics of flow in such reservoirs.
Able to recognize the production mechanisms of underground reservoirs and select the primary or enhanced extraction mechanisms that provide optimal production.
Capable of numerical simulation of underground storages.
Capable of hydrocarbon industrial computer design and analysis.</td></tr>
</table>

Attitude:
Autonomy and responsibility: Able to independently manage hydrocarbon industrial complex planning works and perform project management tasks, or participate in them.
Capable, as an efficient part of a group, of planning the drilling and completion of fluid producing wells and conducting deep drilling; to optimize the costs of deep drilling; to prevent malfunctions occurring during deep drilling.
Capable of independently choosing the appropriate mechanisms for the production of underground reservoirs; to implement the most favourable "reservoir management".
Able to autonomously plan the use of energy carriers produced from renewable natural resources and residual materials in the energy supply system, and manage the operation of the established system.
Takes responsibility for his/her professional decisions and the work processes carried out by him/her or under his/her control.

Assessment and grading:
Students will be assessed with using the following elements.
Attendance: 5 %, Homework: 20 %, Midterm exam:25 %, Final exam:50 %
Grading scale:

% value	Grade
90 -100%	5 (excellent)
80 – 89%	4 (good)
70 - 79%	3 (satisfactory)
50 - 69%	2 (pass)
0 - 49%	1 (failed)

Compulsory or recommended literature resources:

- updated slide decks edited by the lecturers and converted in pdf format: http://geofizika.uni-miskolc.hu/education.html
- Telford W. M., Geldart L. P., Sheriff R. E.: Applied Geophysics. 2nd Edition. Cambridge University Press, 1990.
- Sheriff R.E., Geldart L.P. : Exploration Seismology 2nd Edition, Cambridge University Press, New York, ISBN-10 0-521-46826-4, 1995.
- Bacon M., Simm R., Redshaw T.: 3-D Seismic Interpretation, Cambridge University Press, Cambridge, ISBN 978 0 521 71066, 2003.
- D. V. Ellis, J. M. Singer, 2007: Well logging for earth scientists. Springer, Dordrecht, The Netherlands, ISBN 978-1-4020-3738-2 (HB)
- O. Serra, L. Serra, 2004: Data Acquisition and Applications, Editions Serralog, France, ISBN: 978295156125
- Schlumberger: Cased Hole Log Interpretation Principles/Applications, Schlumberger Educational Services, Houston, 1989
- James J. Smolen, Ph.D., 1996: Cased Hole and Production Log Evaluation, PennWell Publishing Co., Tulsa

Syllabus of the semester

Date	Lecture
11/09/2023	The role of geophysics and well logging in the course of the different phases of HC exploration. The most important rock physical parameters.
18/09/2023	Brief overview of surface geophysical methods applied in HC exploration.
25/09/2023	Basic principles and practice of borehole geophysics. The main features of wireline logging and logging while drilling. Well logging in open-hole and cased-hole environments. Physical bases and instrumentation of wireline logging operations.
02/10/2023	Effect of borehole environment on the well logging measurements. Depth of investigation. Minimum bed resolution. Investigation geometry Petrophysical model of reservoir rocks. Reservoir parameters.
09/10/2023	Caliper and SP logging methods.
16/10/2023	Resistivity and induction logging.
23/10/2023	Holiday
30/10/2023	No education
06/11/2023	Physical principles of gamma ray logging. Gamma ray devices. Spectral gamma ray logging.
13/11/2023	Conventional porosity logging methods.
20/11/2023	The physical principle of seismic methods
27/11/2023	The instrumentation of conventional and vibroseis seismic methods.
04/12/2023	Seismic reflection methods detecting HC in direct way (bright spot, AVO analysis)
11/12/2023	On land and marine case histories showing the efficiency of the simultaneous application of different geophysical methods.

Date	Seminar
11/09/2023	The role of geophysics and well logging in the course of the different phases of HC exploration. The most important rock physical parameters.
18/09/2023	Brief overview of surface geophysical methods applied in HC exploration.
25/09/2023	Basic principles and practice of borehole geophysics. The main features of wireline logging and logging while drilling. Well logging in open-hole and cased-hole environments. Physical bases and instrumentation of wireline logging operations.
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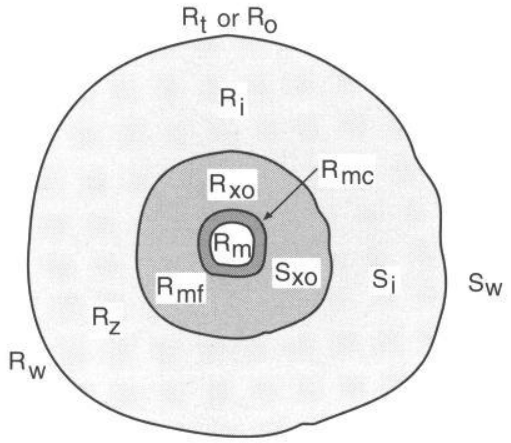
13/11/2023	Conventional porosity logging methods.
20/11/2023	The physical principle of seismic methods.
27/11/2023	Corrections made on seismic data to gain seismic section in depth.
04/12/2023	Seismic reflection methods detecting HC in direct way (bright spot, AVO analysis)
11/12/2023	On land and marine case histories showing the efficiency of the simultaneous application of different geophysical methods.

Example test paper

date

1. Write down the meanings of the notations below. (max. points 8 x 1)



R_m : ……. R_{mc} : ……

R_{mf} : ……. R_{xo} : ……

S_{xo} : ……. S_w : …….

R_t : ……... R_o : …….

2. Read the sentences below. Some of them are false. Find and correct them. Write the corrected form below the sentence. (max. points 6 x 2)

Effective porosity includes both the interconnected and the isolated porosities.

……
…..……

Compressional waves propagate in both solids and fluids.

……
…..……

The saturation of a fluid in a porous rock gives the ratio of the volume filled with the fluid to the total bulk volume of the rock.

……
…..……

Generally, the lower the formation porosity, the deeper the invasion.

……
…..……

Permeability is a measure of the ability of a porous medium to let a fluid through itself.

……
…..……

The velocity of compressional wave is significantly lower in a highly porous rock filled with water

than in a tight consolidated rock (without porosity).
……
…….

3. Complete the sentences with the right words. (max. points: 21)

It is important to note that not the particles travel through the medium during the propagation of an ……..., but the change in the stress and strain fields. (1 point)

The measured bulk density (ρ_b) depends on the ……..., the ……..., and the ……. in the pores. (3 points)

There are two types of body waves: (2 points)
……..
……..

During ……..., an incident neutron has not enough energy to excite a nucleus, but it can increase the kinetic energy of the nucleus by their collision. (1 point)

Because the nucleus of ……. is a single proton, whose mass is very similar to that of a neutron, …… has the greatest capability of neutron slowing down. (2 points)

There are three conventional porosity measurements in well logging: (3 points)
…….
…….
……

From a petrophysical point of view, the model of a reservoir rock has three main components: (3 points)
…….
…….
…….

The main components of a wireline logging system: (3 points)
……,
……,
……..

The natural radioactivity of rocks is caused by the following elements: (3 points)
…….
…….
…….

4. How the clay or shale content influences the *effective porosity*, the *residual water saturation*, the *permeability* and the (*electric) resistivity* of a reservoir rock? (4 points)

Maximum points: 45 Acquired points: ……

Range	Mark
0 ≤ and < 22	1
22 ≤ and < 29	2
29 ≤ and < 36	3
36 ≤ and < 41	4
41 ≤ and ≤ 45	5

Mark: ……

Solution of the test

1.

resistivity of mud	resistivity of mudcake
resistivity of mud filtrate	resistivity of flushed zone
mud filtrate saturation of flushed zone	formation water saturation
true resistivity of hydrocarbon-bearing bed	true resistivity of water-bearing bed

2.

False. Corrected statement.
Total porosity includes both the interconnected and the isolated porosities.

True.

False. Corrected statement.
The saturation of a fluid in a porous rock gives the ratio of the volume filled with the fluid to the total pore volume of the rock.

True.

True.

True.

3.

elastic wave

density of rock matrix, porosity, density of fluid,

compressional (or P-) wave, shear (or S-) wave

elastic scattering

hydrogen, hydrogen

formation density logging, neutron porosity logging, acoustic travel-time (or sonic) logging

solid rock matrix, fluid filled pore space, shale or clay

potassium, uranium, thorium

4.
The increase of clay or shale content in a rock formation decreases the effective porosity, permeability and electric resistivity of the rock, but increases the residual water saturation.