INTRODUCTION TO PETROPHYSICS

Petroleum Geoengineering MSc

2021/22 Semester 1

COURSE COMMUNICATION FOLDER

University of Miskolc
Faculty of Earth Science and Engineering
Institute of Geophysics and Geoinformatics

Course datasheet

Course Title: Introduction to petrophysics	**Credits: 3**

Type (lec. / sem. / lab. / consult.) and Number of Contact Hours per Week: **lec. 2, sem. 1**

Neptun code: MFGFT710006

Type of Assessment (exam. / pr. mark. / other): **exam**
Condition for obtaining the signature: attendance at minimum 60 % of the lessons in the semester. The examination grade is determined on the basis of examination performance. The form of examination is typically written, but oral questions must be answered when the result of test is ambiguous.

Grading limits:
0 – 49 % → 1 (fail), 50 – 64 % → 2 (pass), 65 – 79 % → 3 (satisfactory), 80 – 89 % → 4 (good), 90 – 100 % → 5 (excellent)

Position in Curriculum (which semester): **first**

Pre-requisites *(if any)*:

Course Description:

Acquired store of learning:
Study goals: The course provides petrophysical basis and detailed information on the well logging methods frequently used in oil and gas industry.
Course content: Petrophysical properties of rock formations. Petrophysical modeling of reservoir formations. Electric, electromagnetic, acoustic, radioactive and nuclear properties of rocks. The borehole and its environment. Physical principles of well-logging methods. Open-hole wireline logging methods: lithological (natural gamma-ray intensity, spectral gamma-ray intensity, spontaneous potential, photoelectric factor), porosity (neutron-neutron, gamma-gamma, acoustic) and saturation-sensitive (resistivity and induction) logs. Corrections of open-hole logs for rock composition, fluid content, shaliness. Resistivity and acoustic methods for borehole imaging.
Education method: lectures with projected PowerPoint presentation, basic practice in petrophysical calculations and well log evaluation.

Competencies to evolve:
T1, T4, T5, T11, T12, K2, K4, K5, K6, K7, K9, K10, A1

The 3-5 most important compulsory, or recommended **literature** (textbook, book) **resources**:

- updated slide decks of the lectures converted in pdf format: http://geofizika.uni-miskolc.hu/education.html
- O. & L. Serra, 2004: Well Logging Data Acquisition and Applications, Serra Log.
- Ellis D V, Singer J M 2007: Well logging for earth scientists, Springer.
- Asquith, G. B, Krygowski, D., Henderson, S., & Hurley, N. 2004: Basic well log analysis. 2nd edition, American Association of Petroleum Geologists.
- Rider, M. H. 1986: The geological interpretation of well logs. 2nd edition. Whittles Publishing.
- Z. Bassiouni, 1994: Theory, Measurement, and Interpretation of Well Logs, Society of Petroleum Engineers Inc., USA, ISBN: 1-55563-056-1

Responsible Instructor (*name, position, scientific degree):*

Péter Vass Dr., associate professor

Syllabus of the semester

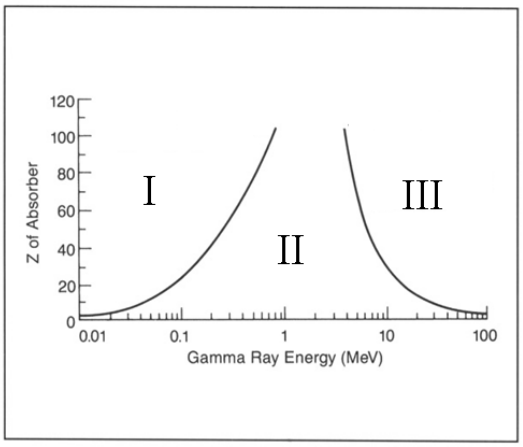
Date	Lecture
08/09/2021	Introduction. Fundamental rock properties. (composition, textures, fabric, sedimentary structures)
15/09/2021	Derived rock properties (porosity, permeability). Petrophysical properties.
22/09/2021	No education
29/09/2021	Well logging, borehole environment, mud filtrate invasion, investigation geometry, depth of investigation, minimum bed resolution
06/10/2021	Caliper logging
13/10/2021	Physical principles of electrical logging. Resistivity of rocks. Spontaneous potential logging. Applications.
20/10/2021	Resistivity logging. Conventional (unfocused) electrode devices.
27/10/2021	Focused electrode devices. Applications. Physical principles of induction logging.
03/11/2021	No education
10/11/2021	Induction devices. Applications.
17/11/2021	Physical principles of gamma ray logging. Gamma ray devices. Spectral gamma ray logging. Applications.
24/11/2021	Gamma ray scattering and absorption. Density logging. Applications.
01/12/2021	Physical principles of neutron porosity logging. Neutron porosity devices. Applications.
08/12/2021	Physical principles of acoustic logging. Acoustic waves in porous rocks and boreholes. Borehole compensated acoustic logging.

Date	Seminar
08/09/2021	Petrophysical models of reservoir rocks. Calculation of hydrocarbon volume in a reservoir
15/09/2021	Calculation of total porosity for different grain packing arrangements
22/09/2021	No education
29/09/2021	Calculation of reservoir thickness, fluid saturations, Producible Oil Index (POI), relative permeability curves.
06/10/2021	Calculation of diameter of invasion. Caliper log exercise.
13/10/2021	Spontaneous potential log exercise.
20/10/2021	Resistivity log exercise.
27/10/2021	Resistivity log exercise.
03/11/2021	No education
10/11/2021	Lithology determination exercise.
17/11/2021	Gamma ray log exercise.
24/11/2021	Density log exercise.
01/12/2021	Density and neutron porosity log exercise.
08/12/2021	Exercise to porosity logging methods

Petrophysics test paper in (example)

date

1. The following graph separates the area determined by the gamma ray energy and atomic number of absorber into three fields. The fields are denoted by Roman numbers. Give the name of the dominant interaction for each field of the graph. (max. points 3)



I. ……. II. …….

III …….

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

The energy of elastic scattered gamma photons coming from a rock which is exposed to an artificial radioactive source is mostly less than 1 MeV.

……
……..……
……..

Photoelectric absorption depends on rather the atomic number of elements than the electron density.

……
……..……
……..

A material with high slowing down power is characterized by shorter slowing down length and a large number of collisions to slow down.

……
……..……
…….

In the far zone (at about 20-25 cm from the source), the thermal neutron density increases with the porosity.

……
……..……
……..

Since the hydrogen concentrations of water and oil are very similar, the oil/water contact can not be indicated by the neutron - thermal neutron logging method.
……
……..……
……..

The rate of thermal neutron absorption is lower in salt water than in oil or fresh water.
……
……..……
…….

3. Complete the sentences with the right words. (max. points: 10)

The effect of photoelectric absorption becomes dominant for ……. atomic numbers and …….. energy of gamma rays. (2 point)

The more important neutron interactions can be divided into two main groups: (2 points)
……...
……...

List three different types of neutron source applied in well logging: (3 points)
……..
……..
……..

The sigma of a rock formation primarily depends on the (3 point)
……..
……..
……..

4. Select the right answer or answers from the list below the question or sentence to be completed by putting a ring around the small letter in front of the item(s) (max. points 7)

The photoelectric factor logging primarily responds to the
a) porosity of the formation,
b) clay volume of the formation,
c) mineral composition of the rock matrix,
d) water saturation of the formation.

Select the element (or elements) whose isotope can be used as a radioactive source for gamma – gamma logging:
a) potassium,
b) cesium,
c) californium,
d) uranium,
e) cobalt.

Which is the relation between slowing down length and diffusion length for a given material?
a) slowing down length is greater,
b) diffusion length is greater,
c) they are more or less equal.

Which is the relation between slowing down time and diffusion time for a given material?

a) slowing down time is greater,
b) diffusion time is greater,
c) they are more or less equal.

Which contact can be indicated by the application of neutron – thermal neutron method?

a) oil/water contact,
b) gas/liquid contact.

Which contact can be indicated by the application of thermal neutron die-away logging?

a) gas/liquid contact,
b) oil/fresh water contact,
c) oil/salt water contact.

5. Compare the three neutron porosity methods qualitatively by filling the fields of the table with suitable attributes. (max. points 6)

	neutron-epithermal neutron	**neutron-thermal neutron**	**neutron-gamma**
source-detector spacing			
minimum bed resolution			
depth of investigation			
sensitivity to thermal neutron absorbers			

Maximum points: 32 Acquired points:

……

interval mark Mark:

…….

< 16	1
16 ≤ and < 21	2
21 ≤ and < 26	3
26 ≤ and < 29	4
29 ≤	5

Solution of example test

1.
I. photoelectric absorption
II. Compton scattering
III. pair production

2
False. Corrected statement:
The energy of Compton scattered gamma photons coming from a rock which is exposed to an artificial radioactive source is mostly less than 1 MeV.

True.

False. Corrected statement:
A material with high slowing down power is characterized by shorter slowing down length and a few number of collisions to slow down.

False. Corrected statement:
In the far zone (at about 20-25 cm from the source), the thermal neutron density decreases with the porosity.

True

False. Corrected statement:
The rate of thermal neutron absorption is higher in salt water than in oil or fresh water.

3
high, low
scattering, absorption
Am-Be chemical source, Californium source, neutron generator
porosity, water saturation, salinity of formation water

4
c) mineral composition of the rock matrix
b) cesium, e) cobalt.
a) slowing down length is greater
b) diffusion time is greater
b) gas/liquid contact
c) oil/salt water contact

5

short	medium	long
good	medium	bad
shallow	medium	deeper
not sensitive s	ensitive	very sensitive