PETROPHYSICS – WELL LOG INTERPRETATION

MS in Petroleum Geoengineering

Semester 2, 2017/18

COURSE COMMUNICATION FOLDER

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

Course datasheet

Course Title: Petrophysics - Well log interpretation	Credits: 4
Type (lec. / sem. / lab. / consult.) and Number of Contact Hours per Week: **lec. 2, sem. 2**	
Neptun code: MFGFT720017	
Type of Assessment (exam. / pr. mark. / other):**exam** Condition for obtaining the signature: the presence in at least 60 % of the lessons. The determination of the examination grade is entirely based on the result of examination. **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): **second**	
Pre-requisites *(if any)*:**Introduction to petrophysics**	
Course Description:	
Acquired store of learning: Study goals:The course gives detailed information on well-logging and well log interpretation techniques used in oil and gas industry. Course content: The nuclear magnetic resonance (NMR) log. The estimation of free fluid index, permeability and pore-size distribution. Electromagnetic wave propagation (EPT) logging. Borehole radar surveys. Radar tomography. Resistivity and acoustic reflection methods for borehole imaging. Data processing steps and interpretation of borehole imaging methods. The basic approaches of the interpretation of well logs: deterministic, statistical and inverse modelling. The forward problem of well logging. Tool response functions. The calculation of parameter sensitivity. Calibration of zone parameters. The local inversion of well logging data. The workflow and mathematical background. The quality check of inversion results. Estimation of clay volume, porosity, lithology, water saturation and permeability from well logs. Formation evaluation in shaly sands. Formation evaluation in Carbonates. Formation evaluation in Complex lithology. Well-to-well correlation. Cement bond evaluation. Introduction to the interpretation of production well logs. Well log interpretation techniques. Quick-Look Interpretation. Crossplots and overlays. Education methods: Lectures by means of MS-Powerpoint presentations. Solving well log analysis problems with deterministic/inversion-based methods. **Competencies to evolve:** T1, T3, T4, T5, T6, T8, T9, T12, K2, K3, K6, K7, A1	
The 3-5 most important compulsory, or recommended **literature** (textbook, book) **resources**:	
• Asquith G, Krygowski D (2004) Basic well log analysis, 2nd edn., AAPG, Tulsa. • M. Rider, 1986. The geological interpretation of well logs. 2nd edition. Rider – French Consulting Ltd., Sutherland, Scotland, ISBN: 0-9541906-0-2. • Schlumberger, 1989: Log interpretation principles / applications. Texas. • Ed. L. Bigelow, 2002: Introduction to Wireline Log Analysis Baker Atlas. • O. & L. Serra, 2004: Well Logging Data Acquisition and Applications, Serra Log. • R. M. Bateman, 1985: Open-hole Log Analysis and Formation Evaluation, International Human Resources Development Corporaton, Boston, ISBN: 0-88746-060-7 • Z. Bassiouni, 1994: Theory, Measurement, and Interpretation of Well Logs, Society of Petroleum Engineers Inc., USA, ISBN: 1-55563-056-1 • 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

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

Péter Tamás Vass Dr., associate professor, Norbert Péter Szabó Dr., associate professor

Syllabus of the semester

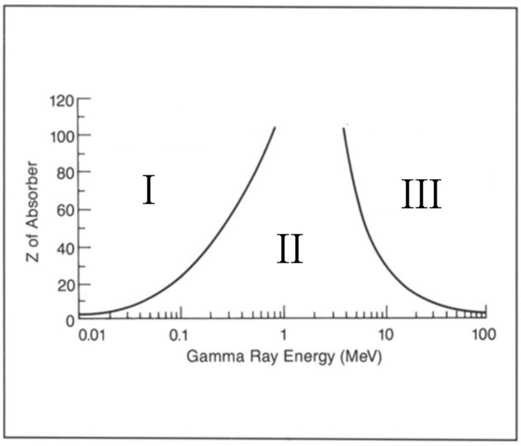
Week	Lecture
12/02/2018	The nuclear magnetic resonance (NMR) log. The estimation of free fluid index, permeability and pore-size distribution.
19/02/2018	Electromagnetic wave propagation (EPT) logging. Borehole radar surveys. Radar tomography.
26/02/2018	Resistivity and acoustic reflection methods for borehole imaging.
05/03/2018	Summary on well-logging methods. The basic approaches of the interpretation of well logs: deterministic, statistical and inverse modeling.
12/03/2018	The petrophysical (volumetric) model of hydrocarbon formations. The forward problem of well logging. Tool response functions.
26/03/2018	The calculation of parameter sensitivity. Calibration of zone parameters.
09/04/2018	The local inversion of well logging data. The workflow and mathematical background. The quality check of inversion results.
16/04/2018	Neutron methods in the formation evaluation
23/04/2018	Well log interpretation techniques. Quick-Look Interpretation. Crossplots and overlays.
07/05/2018	Formation evaluation in shaly sands.
14/05/2018	Formation evaluation in Complex lithology

Week	Seminar
14/02/2018	The mathematical and physical background of NMR method. Data processing steps and interpretation.
21/02/2018	The mathematical and physical background of EM methods and tomography. Data processing steps and interpretation.
28/02/2018	Data processing steps and interpretation of borehole imaging methods.
07/03/2018	Summary on well-logging methods. The basic approaches of the interpretation of well logs: deterministic, statistical and inverse modeling.
14/03/2018	The workflow and mathematical basis of deterministic, statistical and inverse modeling.
21/03/2018	Computer practice on well logging inversion using MATLAB and real oilfield data. The forward problem, parametrization and linearized inversion approach.
28/03/2018	Computer practice on well logging inversion using MATLAB and real oilfield data. The calculation of estimation error of model parameters. The illustration of inversion results.
04/04/2018	Photoelectric Factor Logging in the formation evalution.
18/04/2018	Neutron methods in the formation evaluation
25/04/2018	Estimation of clay volume, porosity, lithology, water saturation and permeability from well logs.
02/05/2018	Formation evaluation in shaly sands
09/05/2018	Formation evaluation in Carbonates
16/05/2018	Well-to-well correlation.

Example of test paper in petrophysics

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: …………….

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interval	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