CORE ANALYSIS

PETROLEUM GEOENGINEERING MSC

2018/19 II. semester

COURSE COMMUNICATION FOLDER

University of Miskolc
Faculty of Earth Science and Engineering
Institute of Mineralogy and Geology

Course Title: Core analysis	**Credits: 3**

Type (lec. / sem. / lab. / consult.) and Number of Contact Hours per Week: **sem. 3**

Neptun code: MFFAT720015

Type of Assessment (exam. / pr. mark. / other): **pr. mark**

Written examination: recommended mark based on test paper, in case of disagreement oral examination.

Grading limits:

90 -100% 5 (excellent)
80 – 89% 4 (good)
70 - 79% 3 (satisfactory)
60 - 69% 2 (pass)
0 - 59%1 (failed)

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

Pre-requisites *(if any)*:

Course Description:

Acquired store of learning:

Study goals:Technical subject giving basis for specialization, which demonstrates the students the conventional (CCAL), and the so called special (SCAL) petrophysical measurements, measurement procedures and the documentation of measurement outcomes. Starting with the beginning of the process (the drifting of the core drilling), the student can get familiar with the different techniques of core drilling, treating/maintaining the core (preservation, discription, modelling), the core examining programme and through its documentation information deriving from cores.

Course content:Gaining the knowledge of core examining/measuring methods. Aim of coring. Coring technologies. Processing core. Non destructive processing (description, GR, Core Scanner, Computer Tomography). Grain size analysis (methodes: wet and dry etc). SEM and XRD@XRF etc. CCAL (plug): residual fluid saturation (Dean Stark), carbonate content, densities (bulk, grain, in conjuctions with porosity), porosity (Boyle's Law and restauration method), gas permeability (horizontal and vertical, Klinkenberg), liquid permeability (horizontal and vertical). SCAL (plug): porosity at overburden pressure (Boyle's Law method), gas permeability at net overburden pressure (pressure decay method), two phase relative permeability (steady, unsteady state methodes), capillary pressure tests, electrical resistivity measurements, acoustical velocity. Full Diameter Core Analysis (FDCA). Mechanical measurements (elastic – Young - modulus, Poisson, UCS etc).

Education method:Visiting core storing facilities.

Competencies to evolve:

T1, T4, T5, T6, T7, T8, T9, T10, T12, K1, K2, K4, K5, K6, K7, K10

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

- Recommended Practices for Core Analysis. API RECOMMENDED PRACTICE 40, 1998, *w3.energistics.org/RP40/rp40.pdf*
- Tavakoli, Vahid: Geological Core Analysis, Application to Reservoir Characterization. Springer, 2018. DOI: 10.1007/978-3-319-78027-6
- DP Murphy, GV Chilingarian, SJ Torabzadeh: Core analysis and its application in reservoir characterization. Developments in Petroleum Science Volume 44, Part 2, 1996, Pages 105-153
- C McPhee, J Reed, I Zubizarreta: Core Analysis: A Best Practice Guide, Volume 64, Elsevier, 2015
- RG Rothwell, FR Rack: New techniques in sediment core analysis: an introduction. Geological Society, London, Special Publications Volume 267, 2006

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

Velledits Felicitász Dr., PhD, part-time associate professor

Core analyses syllabus

Friday, 8:00 – 11:00

Date	Practical
2019.02.15.	Basic sedimentary rock properties I. Classification and properties of sediments and sedimentary rocks. Siliciclastic sediments and sedimentary rocks. Chemical and biogenic sedimentary rocks.
2019.02.22.	Basic sedimentary rock properties II. Chemical and biogenic sedimentary rocks.
2019.03.01.	Sedimentary structures and their significance. Physical sedimentary structures. Biogenic sedimentary structures. Chemical sedimentary structures.
2019.03.08.	Application of core analysis in reservoir description and characterization Basic knowledge in petroleum exploration which related to geological description, analytical measurement of rock samples for determination of mineralogical and chemical compositions, calculations of petrophysical parameters (porosity, permeability, saturation and others) and etc. Principles core analysis and its application in laboratory measurement, extraction technology and preservation mechanism and others.
2019.03.15.	Holiday
2019.03.22.	Application of core analysis in reservoir description and characterization Basic knowledge in petroleum exploration which related to geological description, analytical measurement of rock samples for determination of mineralogical and chemical compositions, calculations of petrophysical parameters (porosity, permeability, saturation and others) and etc. Principles core analysis and its application in laboratory measurement, extraction technology and preservation mechanism and others. Coring process and the value of core analysis, Core handling at the well-site. Core types, chips, side wall core, core, oriented core. Core handling. Selection of representative samples for different labour investigation. To show the students the importance of core planning and evaluate the various options available. Porosity systems, petrophysics, core cleaning and drying. Why effective porosity is important is discussed as well.
2019.03.29.	Core description. Describing core enhances our ability to predict reservoir architecture and performance, and maximize hydrocarbon recovery. Properly handled and analyzed cores provide direct evidence of basic geologic, petrophysical and geochemical properties, essential to correctly calibrate other petrophysical and geophysical tools. Core description includes color, texture (grain size, roundness, sorting), cement and matrix, sedimentary structures, porosity, oil shows. Practice on core description. Every student have to describe one sandstone and one carbonate samples. Some cuttings, and one sidewall core.

2019.04.05.	Scanning Electron Microscopy, How Scanning Electron Microscope (SEM) works. Scanning Electron Microscope (SEM) with Energy Dispersive X-ray analysis (EDX). They learned how they can involve these methods into their analytical tool set if they need to solve certain task of CH geologists.
2019.04.12.	X-ray powder diffraction The students are introduced to instrumental analitical methods commonly used in mineralogy and petrology during detailed core investigatons (focusing to CH industry). These methods included X-ray powder diffraction (some parts for clay mineralogical investigations and quantitative methods). Wavelenght Dispersive X-ray analysis (WDX) (for morphology and local chemical investigation) and Wavelenght Dispersive X-ray Fluorescence (WDXRF) investigatioons (for bulk main component and trace element analysis). They learn how they can involve these methods into their analytical tool set if they need to solve certain task of CH geologists.
2019.04.19.	Holiday
2019.04.26.	Visiting the MOL lab in Békásmegyer: PVT, CL microscope. PVT analysis delivers results for reservoir engineering purposes and also supports the design and optimization of processes and facilities. Representative samples are examined at actual reservoir pressures and temperatures to determine phase behavior and compositional changes through the life of the reservoir as pressure declines Cathodoluminescence microscope gives insights into such processes as crystal growth, replacement, deformation and provenance. These applications include: investigations of cementation and diagenesis processes in sedimentary rocks, provenance of clastic material in sedimentary and metasedimentary rocks, details of internal structures of fossils, growth/dissolution features in igneous and metamorphic minerals. Micro-CT. What is Micro CT, what are the advantages, and what for is it used? Micro-CT is a non-destructive 3D imaging and analysis method, for studying the internal structure of all types of samples, with diameters from 1 mm to 20 cm and full drill cores. Take virtual slices through objects and build stacks of slices for 3D volume rendering. This has applications is used in oil and gas industry, in sedimentologcal investigation, in structural geology. Gives three-dimensional information about the structure of the samples. It is used in porosity analysis (pore networks, connectivity and flow paths), 3D mineral distribution, 3D analysis of shape and morphometries, including grains, sedimentary patterns, fossils, etc. It is a non-destructive internal imaging method, requiring no sample preparation:
2019.05.03.	The two lectures hold at the Research Institute of Applied Earth Sciences (AFKI) first started with a brief presentation covering the topics of: Process of data gathering, Coring and representativity, Petrophysical

	properties, Measurements, Lab ethics and safety This presentation was made in order to give a better understanding of the measurements and the technologies used in general at the institute. Also to prevent any injuries during the implemented lab works. After the presentation the students were introduced to all equipment and measuring procedures covering porosity (Helium and Mercury penetration porosimetry); permeability (absolute and effective) rock compressibility, Relative permeability (rock centrifuge method) and EOR Flooding technics during the first occasion.
2019.05.10.	The lab works were held during the second occasion where the students were introduced to the Helium porosimetry and effective permeability measurements in details, also measured these parameters on sandstone samples. Applying these knowledge, they were given the task of evaluating these parameters on artificially made data handed to them in form of Lab Reports. Those that reached the minimum of 65% during the Lab Reports have passed these lectures.
2019.05.17.	Planning of core sampling. We will dicuss petrophysical rock types for reservoir evaluation. Two case studies will be covered, one over sandstone and the other over carbonate, both of these studies showing why these types of petrophysical rock types are important. Core-log integration. With the help of a case study it will be demonstrated, how the log reflect the changes in the sedimentology.

12.02.2018 – 12.05.2018.

Basic sedimentary rock properties I. Classification and properties of sediments and sedimentary rocks. Siliciclastic sediments and sedimentary rocks. Chemical and biogenic sedimentary rocks.

Sedimentary rock properties II. Chemical and biogenic sedimentary rocks.

Sedimentary structures and their significance. Physical sedimentary structures. Biogenic sedimentary structures. Chemical sedimentary structures.

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Coring.
Coring process and the value of core analysis, Core handling at the well-site.
Core types, chips, side wall core, core, oriented core. Core handling. Selection of representative samples for different labour investigation.
To show the students the importance of core planning and evaluate the various options available. Porosity systems, petrophysics, core cleaning and drying. Why effective porosity is important is discussed as well.

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Visiting the MOL lab in Békásmegyer: PVT, CL microscope.
PVT analysis delivers results for reservoir engineering purposes and also supports the design and optimization of processes and facilities. Representative samples are examined at actual reservoir pressures and temperatures to determine phase behavior and compositional changes through the life of the reservoir as pressure declines

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Written exam questions and answers:

1. What is a coring bit?

   A coring bit is attached to the bottom of the outer barrel and a core catcher is fitted to the bottom of the inner core barrel.

2. Please describe the work principles of core handling procedures and preservation?

   Wellsite core handling procedures and preservation should follow the best possible practices because the value of all core analysis is limited by this initial operation. Obtain rock material that is representative of the formation. Minimize physical alteration of the rock material during core handling and storage.

3. What kind of information can we get using Cathodoluminescens Microscope?

   CL provide information on the trace elements contained in minerals. It gives fundamental insights into such processes as crystal growth, replacement, deformation and provenance.

   CL can be used for investigations of cementation and diagenesis processes in sedimentary rocks, details of internal structures of fossils, provenance of clastic material in sedimentary and metasedimentary rocks, discrimination of different generations of the same mineral as a result of differences in trace amounts of activator elements.

4. How does Micro Ct works, and what is the big advantage of the Micro Ct investigation?

   Take virtual slices through objects and build stacks of slices for 3D volume rendering. It is a non-destructive method, requires no sample preparation, and gives 3D picture on the internal structure of the sample.

5. What kind of geological information can we get from micro Ct?

   It gives three-dimensional information about the inner structure of the samples.
   We can use in porosity analysis. Pore networks, connectivity and flow paths are visible in 3D. 3D mineral distribution, sedimentary patterns, fossils are also visible. 3D information about the properties of the pore network, measure the size of closed pores and the thickness of open pore networks.

6. What are the differences between routine core analyses, and special core analyses?

   Routine core analysis is the determination of generally, non-dynamic petrophysical properties. In includes the description of the lithology of the core. Measurement of porosity, permeability, saturation. Often include a core gamma log, and measurements of vertical permeability.

   Special core analysis (SCAL) includes measurement of capillary pressure, relative permeability, wettability determination, reservoir condition corefloods, improved oil recovery (EOR) studies, petrophysical correlation measurements.

7. What kind of sample do we need for PVT test?

   We need representative fluid samples collected at the earliest opportunity, normally during the drilling of the first exploration well and certainly before the reservoir is put into full production.

8. What can we determine with the help of PVT measurement?

   Representative samples are examined at actual reservoir pressures and temperatures to determine phase behavior and compositional changes through the life of the reservoir as pressure declines.

9. For what do we use the blue resinated thin section?

To visualise porosity. The pores will appear as blue paches in microscope.

10. What kind of reservoir character can we predict based on basic properties of sedimentary rocks and borehole-image logs?

The reservoir’s external geometry and internal architecture, the reservoir rock’s orientation, and trend, and potential interactions between reservoir fluids and reservoir rock.

Blak for AFKI measurement

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Laboratory Report_A

Names ……..

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I. Helium Porosimetry

Calculate the sample's matrix/solid volume, pore volumeand porosity!

Measurement data:

d:	3.774	cm	Diameter of the sample
l:	6.943	cm	Length of the sample
and			
p_1:	1.194828	bar	Reference pressure
p_2:	1.119696	bar	Pressure after expansion
p_a:	1.02	bar	Atmospheric pressure
V_c:	100	cm^3	Sample chamber volume
V_R:	50	cm^3	Reference chamber volume

$$V_S = V_C - V_R\left[\frac{p_1 - p_2}{p_2 - p_a}\right]$$

Calculation:

V_s:……..

V_p:…….

Φ:……

II.Effective permeability determined by water (incompressible fluid)

Determine the flow rates, then calculate the effective permeability of the sample using the given data! Plot the results and the average of them on the diagram attached.

The data recorded during the measurement:

time [sec]	V_i [cm^3]	Q [cm^3/s]	$p_{avg.}$ [bar]	k_w [mD]	k_w [mD]
26	5		1.515		
40	7.5		1.515		
52	10		1.515		
66	12.5		1.515		
80	15		1.515		

$$k_w = \frac{1000\ \mu_w\ l\ q_w}{A\ p_{avg}}$$

Calculation:

k_w:……