EXPLORATION GEOCHEMISTRY OF HYDROCARBONS

Petroleum Geosciences Engineer MSc

MFFAT720012

2024/25. 2nd semester

COURSE COMMUNICATION FOLDER

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

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1. COURSE DESCRIPTION

Course Title: Exploration geochemistry of hydrocarbons **Responsible Instructor:** Maria Hamor-Vido Ph.D Habil, honorary assistant professor Practice: Dr. Ferenc Móricz, associate professor	**Code:** MFFAT720012 **Responsible department/institute:** Institute of Exploration Geosciences **Type of course**: Compulsory
Position in curriculum (which semester):2nd	**Pre-requisites (if any): -**
No. of contact hours per week (lecture + seminar): 2+1	**Type of Assessment (examination/ practical mark / other):** exam
Credits: 3	**Course:** full time

Course Description: Natural systems and their classification, rocks, water, organic matter, and gases as a specific natural system. Systems approach in petroleum geology. Oil and gas-bearing rocks. Temperature and pressure in the subsurface. Water. Crude oils. Natural gases and condensates. Dispersed organic matter. Origin of oil and natural gas. Formation of hydrocarbon accumulations. Classifications of oil and gas accumulations. Mathematical modelling in petroleum geology.
Study goals: Fundamentals of organic geochemistry are discussed as a factor controlling the generation, deposition, accumulation and bio-/geochemical changes of organic carbon and petroleum. Inorganic geochemistry as a tool of understanding the reservoir rock evolution, cementation and dilution of the rock matrix. 3-D heterogeneity of reservoir rocks as a result of differential cementation. All these are connected to designing and implementing well stimulation operations. Fingerprint methods to correlate source rocks with discovered petroleum fluids and identification of migration path are introduced.
Practices: Organic and inorganic geochemistry applied to petroleum geology, overview and evaluation of different parameters. Textural and mineralogical analysis. Fluid inclusions. Stable isotopes. Radiogenic isotopes. Porosity and permeability prediction. Fluid migration. Correlation. Petroleum recovery. Oil fingerprinting for production allocation.
Competencies to evolve:
Knowledge: T1, T4, T5, T6, T8, T9, T12
Ability: K2, K3, K4, K5, K6, K7
Attitude: A1

The short curriculum of the subject:

Assessment and grading:
Writing of two scientific essays during the semester on the level of pass grading limit, at least. This equals to 40% of the requirements. The remaining 60% is procurable in the exam.
Grading limits:
>80%: excellent,
70-80%: good,
60-70%: satisfactory,
50-60%: pass,
<50%: unsatisfactory.

G.V. Chilingar, L.A. Buryakovsky, N.A. Eremenko & M.V. Gorfunkel 2005: Geology and geochemistry of oil and gas, DEVELOPMENTS IN PETROLEUM SCIENCE vol: 52, Elsevier

Killops S, Killops V. 2005: INTRODUCTION TO ORGANIC GEOCHEMISTRY. Blackwell Scientific Publications,

Welte D.H, Horsfield B., Baker D.R. (Eds.) 1997. PETROLEUM AND BASIN EVOLUTION; INSIGHTS FORM PETROLEUM GEOCHEMISTRY, GEOLOGY AND BASIN MODELLING.- Springer-Verlag Berlin Heidelberg New York, ISBN 3-540-61128-2, pp. 535.

Lawson M., Formolo M.J., Eiler M.J.(Eds.) 2018. FROM SOURCE TO SEEP: GEOCHEMICAL APPLICATIONS IN HYDROCARBON SYSTEMS, Geological Society, London, Special Publications 468., pp. 208.Hoffman R.V. 2004: ORGANIC CHEMISTRY; AN INTERMEDIATE TEXT. John Wiley & Sons Publisher, Hoboken, New Jersey, 495 p.

Dominic Emery & Andrew Robinson 1993: INORGANIC GEOCHEMISTRY, APPLICATIONS TO PETROLEUM GEOLOGY, Oxford, Blackwell Scientific Publications,

Barry Bennett, Jennifer J. Adams, Stephen R. Larter 2009: OIL FINGERPRINTING FOR PRODUCTION ALLOCATION: EXPLOITING THE NATURAL VARIATIONS IN FLUID PROPERTIES ENCOUNTERED IN HEAVY OIL AND OIL SAND RESERVOIRS, Frontiers + Innovation – 2009 CSPG CSEG CWLS Convention, Calgary Alberta, Canada, pp: 157-160.

Dembicki, H., Jr. 2017: PRACTICAL PETROLEUM GEOCHEMISTRY FOR EXPLORATION AND PRODUCTION, Elsevier 2017

Waples, D. W. 1985: GEOCHEMISTRY IN PETROLEUM EXPLORATION, International Human Resources Development Corporation

2. CURRICULUM OF THE SUBJECT

Exploration geochemistry of hydrocarbons
Year 2024/25, semester 2nd

Date	Lecture
2025.02.13.	Natural systems and their classification, rocks, water, organic matter, and gases as a specific natural system. Systems approach and geochemistry in petroleum geology.
2025.02.20.	Systems approach in petroleum geology; bio productivity, depositional environment and related source rock – kerogen types. Oil and gas composition related to the time, temperature and pressure changes in the subsurface.
2025.02.27.	Water. Crude oils. Natural gases and condensates. Dispersed organic matter. Origin and compositional differences of solid organic matter, oil and natural gas. Biosynthetic and geosynthetics compounds, biomarkers, stable isotopes. Formation of hydrocarbons, thermal maturity parameters of sedimentary organic matter and hydrocarbons, molecular maturity parameters of kerogen and petroleum.
2025.03.06.	Geochemical modeling in petroleum geology, hydrocarbon potential of source rocks and yields. Practices: Organic and inorganic geochemistry applied to petroleum geology, overview and evaluation of different parameters.
2025.03.13.	Textural and mineralogical analysis. Fluid inclusions. Stable isotopes. Radiogenic isotopes.
2025.03.20.	Porosity and permeability prediction. Fluid migration. Correlation. Petroleum recovery. Oil fingerprinting for production allocation.
2025.03.27.	Midterm test (scientific essay) writing
2025.04.03.	Carbon circle in general and importances; Overview of the different HC types; Pyrolysis as a useful measuring methods
2025.04.10.	Rock-eval pyrolysis, TOC measuring with LECO method, comparison of the two method; Vitrinite reflectance;
2025.04.17.	Van Keverlen diagram; Classification of liptinite, vitrinite and inertinite based on H/C ratio
2025.04.24.	Holiday
2025.05.01	Holiday
2025.05.08.	Consultation and deadline of the practice task submission
2025.05.15.	Consultation regarding the exam topics
2025.05.22.	Exam writing

3. EXAMPLE FOR MIDTERM TEST

Q1. What is the definition of kerogen and bitumen?

Kerogen: is insoluble part of organic matter afer the extraction with hydrocarbons e.g. hexane, benzene etc. Chemically it is composed of C,H,N,S,.

Bitumen: is the soluble part of organic matter afer the extraction with hydrocarbons e.g. hexane, benzene etc. Chemically it is composed of C,H,N,S,.

Q2. What are their origin; in which type of vegetation and depositional environment these compound are charactersics: n-alkanes, aromatics, hetero compounds?

n-alkanes are dominant in the epidermis parts of alga and of pollens organic remains, their characteristic environment is lake and marine environment.

aromatics: are major compounds of high plant origin organic matter residuals (lignin, cellulose), depositional environment is terrestrial accumulation, coal forming environment.

Hetero-compounds NSO: These compounds are called hetero- because not only carbon and hydrogen but e.g. sulfur or oxygen occur in them. Their occurrence is frequent in marine carbonate rich sedimentary environment (S) and in coal-forming environment (O).

Q3. In Rock-Eval analysis what is the definition and meanings of the following parameters?

S1: Primary, accessable free hydrocarbon yield of the source rock.

S2: Thermally pyrolised, residual hydrocarbon yield of the source rock.It is proportional to the H content of kerogen so high HI corresponds to oil prone kerogen type.

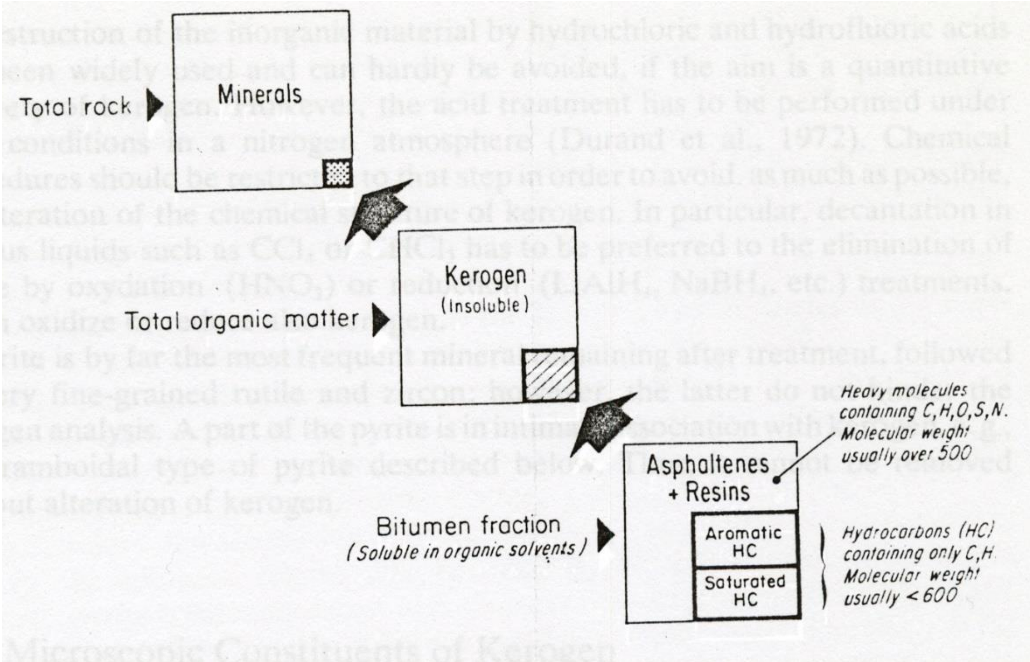
S3: Thermally pyrolized ammount of carbon-dioxide derived from the source rock.

S4: residula carbon content, derived from the transformation of carbonate minerals.

Hi: hydrogen index (mg S2 hydrocarbon /g rock) shows the ammount of pyrolized hydrocarbon from the source rock. Calculated as follows: HI= S2/TOC*100 where, TOC is the mass weight of organic carbon % in the sample.

4. EXAMPLE FOR FINAL EXAM

<u>Q1. Please give a sketch or a short description on the relationship between source rock, total organic matter TOC, kerogen and bitumen and its main groups.</u>



10 points

<u>Q2. What is the range of the hydrocarbon potential "source rock potential" for the gas, gas & oil prone and oil prone source rocks? Please consider only the HI value ranges.</u>

gas prone source rock: HI ranges from 50-200
gas & oil prone source rock: HI ranges 200-300
oil prone source rock: HI bigger than 300

3 points

<u>Q3. What is the range of the hydrocarbon potential "source rock potential" according to the total organic matter TOC weight/mass?</u>

none: TOC is below 0.5%
poor source rock: TOC ranges from 0.5-1 %
fair source rock: TOC ranges 1-2%
good source rock: TOC ranges 2-5%
very good source rock: TOC bigger than 5%

4 points

<u>Q4. Please describe shortly the factors affecting the organic matter from production to deposition.</u>

- primary organic productivity. The more the nutrients in the water the higher is the productivity.

- residence time in the water column; water depths, sinking ratio. The role of productivity and sinking ratio is more or less equal factors for the preservation of OM. If the productivity is high preservation ratio is also higher, or if the sinking is fast the preservation is better.
- anoxia, depleted oxygen content in the water column increases the chance for the preservation of OM. Oxygen demand is higher if the productivity was high so oxygen depleted environment is characteristic with smaller decomposition.
- Circulation of water, curves with oxygen transport increase the oxygen level and supports the decomposition of OM. Lateral transport at bottom surface or at the vicinity supports the decomposition of OM. The higher the energy of water the longer distance can be transported the floccules of sediment with OM. This may cause partial oxidation and reworking of OM.
- at bottom anoxia, anoxic or dysoxic conditions supports the preservation of OM. The lower the O2 level the better the chance for the preservation of OM. Rapid burial of the bottom surface support the preservation of OM.

10 points

5. a) What kind of thermal maturity stages are distinguished in hydrocarbon generation?
b) What are the main hydrocarbon products of the different stages?
c) Please give a sketch or a short description of hydrocarbon generation with the burial and thermal maturity changes. Please provide the sketch of "Dow" diagram.
d) Please describe which type of n-alkane compounds are the dominant in the different thermal maturity stages of saturated hydrocarbon products of oil according the atomic carbon number of compounds.

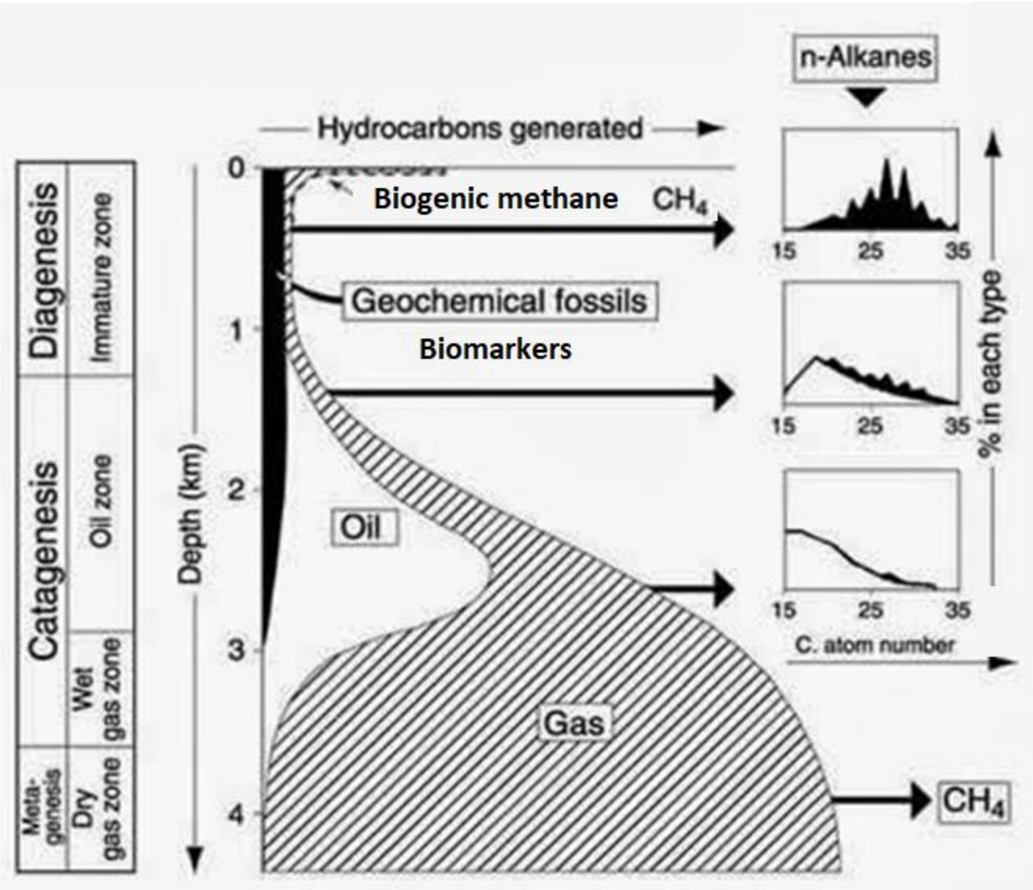
a) diagenesis – immature zone;
catagenesis – 1 oil zone, 2 wt gas zone;
metagenesis – dry gas zone

3 points

b) diagenesis – biogenic methane;
catagenesis – 1 oil zone- oil, 2 wet gas zone –gas and light oil;
metagenesis – gas, mainly CH_4, CO_2, H_2S, N_2, H_2

3 points

c)



4 points

d) diagenesis – high C atomic number compounds, heavy oils, paraffin;
catagenesis 1 – medium C atomic number compounds, heavy oils
catagenesis 2 – low C atomic number compounds, light oils

3 points

Maximal reachable points: 50

Grading:

0-25: 1 (unsatisfactory)

26-32: 2 (pass)

33-37 3 (satisfactory)

38-44 4 (good)

45-50 5 (excellent)

The grade of the exam is determined by the average of the grades obtained in the written exam and the practical and report tasks.

5. FURTHER REQUIREMENTS

The ratio of the absence cannot exceed the 30%, which equal with 12,6 hours during the semester. The higher ratio automatically resulted as denial of the signature.

Miskolc, 06/02/2025

Maria Hamor-Vido Ph.D Habil	Ferenc Móricz, Ph.D.
Responsible instructor, honorary assistant professor	Practice, associate professor