SEDIMENTOLOGY OF CARBONATE RESERVOIRS

Earth Sciences Engineering MSC
2020/21 I. Semester

MFFTT730015

COURSE COMMUNICATION FOLDER

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

Course Title: Sedimentology of carbonate reservoirs	**Credits: 4**

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

Neptun code: MFFTT730015

Type of Assessment (exam. / pr. mark. / other):**exam**
During the semester 2 written examinations will be written, if both is insuffitient, then there is a possibility for oral exam. Only one unjustified lecture/practice is tolerated.
Grading limits:
> 80%: excellent,
70-80%: good,
60-70%: fair,
50-60%: sufficient,
<50%: insufficient.

Position in Curriculum (which semester): **3**

Pre-requisites *(if any)*:

Course Description:

Acquired store of learning:
Study goals:To understand the carbonate reservoirs: the geometry and the petrophysical characteristics of carbonate reservoirs. To understand the main control factors influencing the formation of carbonate reservoirs: (1) sedimentology, (2) diagenesis (3) burial history.
Course content: Introduction to carbonate rocks and reservoirs. Carbonate vs. siliciclastic sediments, and reservoirs. Mineralogy of carbonate rocks. Controls on carbonate production and accumulation. Fundamental rock properties: texture, fabric, composition, sedimentary structures. Classification of carbonate rocks. Porosity and permeability in carbonate rocks. Petrophysical properties of carbonate reservoirs: saturation, wettability, capillarity. Capillary pressure and reservoir performance. Capillary pressure, pores and pore throats. Carbonate depositional environments (beach-dune, tidal-flat, lagoon, shallow subtidal (neritic), slope-break, slope environment, basinal environments) and reservoirs. Depositional porosity. Paleotopography and depositional facies. Diagenetic carbonate reservoirs. Diagenesis and diagenetic processes. Diagenetic environments and facies. Diagenetic porosity. Diagnosing and mapping diagenetic reservoirs. Fractured reservoirs. Carbonate sequence stratigraphy and cyclicity. Relationship of primary depositional facies, sequence stratigraphic framework and diagenetic history to pore architecture and reservoir quality. Sequence sratigraphy in exploration and development.
Eduction method:Lectures with powerpoint presentation, field practice consisting of two parts: 1. visiting carbonate outcrops, representing a wide range of carbonate facies, 2. practical workshop in the MOL redepository core house in Szolnok.
Competencies to evolve:
T1, T2, T4, T5, T6, T8, T12, K5, K9

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

- Moore C.H., Wade W. (2013): Carbonate reservoirs. Porosity and diagenesis in a sequence stratigraphic framework. Developments in sedimentology 67. Elsevier. 374.
- Ahr Wayne M. (2008): Geology of Carbonate Reservoirs. Wiley Publication. 1-273.
- Lucia F. Jerry (1999): Carbonate Reservoir Characterization. Springer. 1-226.
- Scholle P. A., Bebout D.G., Moore C.H. ed. (1983): Carbonate Depositional Environments. AAPG Memoir 33. 1-704.
- Tucker M. (2003): Sedimentary Rocks in the Filed. Wiley.1-234.
- Scoffin (1987) An Introduction to Carbonate Sediments and Rocks. 274 Blackie
- Haas (1998) Karbonát szedimentológia. 147. ELTE Eötvös kiadó.

Responsible Instructor(*name, position, scientific degree):*
Velledits Felicitasz Dr., Phd, part-time associate professor

Syllabus of the semester
Wednesday, 8:00 – 12:00

Date	*Lecture*
2020.09.09.	Drop out
2020.09.16.	Introduction to carbonate rocks and reservoirs.
2020.09.23.	Mineralogy of carbonate rocks.
2020.09.30.	Controls on carbonate production and accumulation.
2020.10.7.	Fundamental rock properties: texture, fabric, composition, sedimentary structures.
2020.10.14.	Classification of carbonate rocks.
2020.10.21	Porosity and permeability in carbonate rocks.
2020.10.28.	Petrophysical properties of carbonate reservoirs: saturation, wettability, capillarity.
2020.11.04.	Capillary pressure and reservoir performance. Capillary pressure, pores and pore throats.
2020.11.11.	Carbonate depositional environments (beach-dune, tidal-flat, lagoon, shallow subtidal (neritic), slope-break, slope environment, basinal environments) and reservoirs.
2020.11.18.	Depositional porosity. Paleotopography and depositional facies. Diagenetic carbonate reservoirs.
2020.11.25.	Diagenesis and diagenetic processes. Diagenetic environments and facies. Diagenetic porosity.
2020.12.02.	Case study
2020.12.09.	Diagnosing and mapping diagenetic reservoirs. Fractured reservoirs. Carbonate sequence stratigraphy and cyclicity.

Midterm exam

1. What are the main carbonate minerals?

Calcite $CaCO_3$ (scalenohedral or " dogtooth spar ", rhombohedral form, hexagonal prism) and dolomite $Ca,Mg(Co_3)_2$ hexagonal

Aragonite $CaCO_3$ orthorombic

Calcite and aragonite are polymorphs of calcium carbonate because they share the same composition but have different crystal structures.

Dolomite: $Ca,Mg(CO_3)_2$

Mg ions are smaller than Ca ions, dolomite has bigger porosity than limestone.

2. What are the main questions in reservoir characterisation, and what are the sources of Data on Reservoirs?

Main questions: how pore systems (depositional, diagenetic, fracture) were formed and how are they connected?

- 1) Direct examination of cores, cuttings.

(texture, mineral and grain composition, fossil content (taxonomic diversity), and sedimentary structures)
Give information on depositional characteristics

- 2) Petrographic study

diagenetic history of both the rock matrix and the pore system.

- 3) Microscopic descriptions of borehole cores

presence or absence of through - going, natural fractures.

- 4) Lab measurements

Porosity, permeability

- 5) Wireline logs

lithology, porosity, saturation, fractures, dip

- 6) Capillary pressure measurements on cores

Behavior of fluids in the reservoir pore system,
Height of the hydrocarbon column above free water in a reservoir,

- 7) Borehole testing

Geological and engineering information:
Fluid content of the reservoir (oil, gas, water)

- Hydrocarbone quantity
- Presence or absence of fracture permeability
- Pressure and temperature of the reservoir

8) Three - dimensional (3D) **seismic** data
Differentiate reservoir, non reservoir zones (impedance contrast)
Detect zones with high porosity
Paleostructure (strong influence on facies distribution)
Fractures
These data help to determine the size and shape of the reservoir body, the spatial distribution of the pore types within it, and how the pore system interacts with reservoir fluids.

3. What influence carbonate platform facies and morphologie distribution?

- Underlying topography, or structure
- Synsedimentary tectonic
- Rate and amplitude of sea-level change
- Latitude, bathymetry, climate, currents
- Presence or absence of margin constructing communities

4. What are the mian differences between carbonate and siliciclastic rocks and reservoirs?

Origin:

Carbonates:

90% of the carbonates has organic origin. Produced mainly by biological activity of creatures, and chemical precipitates. „Carbonates are born, not made"
They are autochton. Made up of: skeletal remains, cements, chemical constituents (ooids, pisoids) and lime mud.

Siliciclastic rocks:

have inorganic origin, consists of the fragments of parent rocks, which were eroded, transportated, and sedimented. They are allochton, consist of sand (SiO_2), clay.

Diagenesis

Carbonates:
Consists of instable minerals (calcite, aragonite, dolomite). Dissolution, cementation, and recrystallisation are rapid
Cementation: rapid on seafloor or in near-surface environments
Diagenesis happens in many diagenetic environment, through many diagenetic events: from shallow marine until deep burial
Siliciclastic sediments:
Consists of stabil minerals (sand (SiO_2) clay, is very resistant.
Cementation: remain unconsolidated on seafloor or in shallow burial environment
Diagenesis happens only in deep burial.

Texture

(the size, shape, and arrangement of detrital grains in a sedimentary rock.)
Carbonates:
Alters considerably during diagenesis. Depositional texture and fabric alter considerably.
Siliciclastic sediments:
Alters only during deep burial diagenesis. Texture and fabric are formed during deposition.

Porosity

Carbonates:
Primary porosity: 40-70%, 5-15% of the original porosity remain intact. Different pore types, pore size and shape are formed during diagenesis
Siliciclastic sediments:
Primary porosity: 25-40%, 15-30% of the primary porosity remain intact. mainly interparticle porosity

Pore system

Carbonates:
Heterogenous. Can be very variable even within one rock body. Many pore types. Porosity not always corresponds with permeability. Small plug are not representative, we need cores.
Siliciclastic sediments:
Homogeneous sand bodies. Porosity and permeability are closely related. Small plugs are representative

Reservoir characteristics

Carbonates:
Diagenesis can alter porosity, permeability considerable.
Siliciclastic sediments:
Depositional facies determines reservoir characteristics.

Fractures

Carbonates:
Cery often, major importance in reservoir properties if present
Siliciclastic sediments:
Rare, not of major importance in reservoir properties

Electrofacies map from gamma-ray and resistivity logs

Carbonates:
Not indicative to depositional facies
Siliciclastic sediments:
Indicative to depositional facies

5. What are the main controls on carbonate deposition?

90% of the carbonates were deposited in marine environment
Animals need light and warm temperatures, this is the reason, why most carbonates are formed in the upper 20m of the water column.
They are formed in shallow tropic, subtropic seas between 30N, and 30S and deep see bottom.
Salinity must be between 32-40‰.
Water temperature: 25C
Siliciclastic pollution must be minimal.

Miskolc, 2020. szeptember 7.

Dr. Velledits Felicitász
egyetemi docens