Universitat Autònoma de Barcelona

2020/2021

Sedimentary Petrology

Code: 101056
ECTS Credits: 4

Degree	Type	Year	Semester
2500254 Geology	OB	3	1

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

Contact

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Use of Languages

Principal working language: catalan (cat)
Some groups entirely in English: No
Some groups entirely in Catalan: Yes
Some groups entirely in Spanish: No

Teachers

Xavier Coll Carrillo

Prerequisites

There are no prerequisites. However, it is recommended for students to have previously taken the courses "Geology, Earth Chemistry, Mineralogy, Sedimentology and Stratigraphy.

Objectives and Contextualisation

The specific objectives of the Sedimentary Petrology course are as follows:

Objectives of the cognitive field

- Recognize the characteristics of the different types of sedimentary rocks, both in the field and from hand samples and thin sections.

- Identify the most common minerals and most common components of sedimentary rocks, both with the microscope and naked eye.

- Integrate terminology and classifications of sedimentary rocks.

- Become familiar with the common workflow in the analysis of sedimentary rocks and with the analysis and interpretation of the obtained data.

- Understand the mechanisms and processes that generate sediments and sedimentary rocks based on the physical and chemical parameters involved in their formation.

- Highlight the usefulness of sedimentary rocks in the various fields of their potential application.

Objectives of the emotional field

- Communicate a holistic approach of the Sedimentary Petrology and their related disciplines, in order to promote a unitary view of Earth Sciences.

- Promote the motivation of the students by developing in him an attitude of intellectual curiosity towards the natural phenomena.

Objectives of the psychomotor field

- Achieve the necessary skills to make observations, obtain data and represent them in a way that the information will be durable and transmissible.

-Get used to the scientific terminology related to Sedimentary Petrology.

- Learn how to use the petrographic microscope as the basis for sedimentary rocks identification, coupled with observations with a magnifying glass. Learn to use other usual tools in the field and laboratory work.

Competences

- Draw up and interpret geological maps and other means of depicting geological information (columns, correlation frames, geological cross-sections, etc.)
- Identify and characterise minerals and rocks through instrumental techniques, determine their formation environments and know their industrial applications.
- Learn and apply the knowledge acquired, and use it to solve problems.
- Show an interest in quality and incorporate it into practice.
- Suitably transmit information, verbally, graphically and in writing, using modern information and communication technologies.
- Synthesise and analyse information critically.
- Work independently.

Learning Outcomes

1. Learn and apply the knowledge acquired, and use it to solve problems.
2. Recognise the principal types of rocks in hand specimen and using a petrographic microscope.
3. Relate each type of rock to its genesis and the temporal dimension.
4. Relate field observations of minerals and rocks to laboratory observations and to genetic theory, based on the textures.
5. Show an interest in quality and incorporate it into practice.
6. Suitably transmit information, verbally, graphically and in writing, using modern information and communication technologies.
7. Synthesise and analyse information critically.
8. Work independently.

Content

Theoretical Class Program

Summary of the Sedimentary Petrology Program. Teaching units and subjects.

I. INTRODUCTION

Topic 1. Presentation of the subject and introduction to the Sedimentary Petrology

Topic 2. Nature and origin of sedimentary rocks. The external geological cycle

II. GENESIS OF SEDIMENTS AND ROCKS

Topic 3. Geochemistry of natural waters

Topic 4. Hypergenesis (I). Mechanisms of weathering and chemical reactions

Topic 5. Hypergenesis (II). Alteration products: Detritus and soils

Topic 6. Hypergenesis (III). Environmental controls

III. CHARACTERIZATION OF DETRITAL SEDIMENTS AND ROCKS

Topic 7. Components of sediments and detrital rocks. Textures

Topic 8. Components of sediments and detrital rocks. Composition

Topic 9. Classification of sediment and detrital rocks and geological significance

IV. CHARACTERIZATION OF NON-DETRITAL SEDIMENTS AND ROCKS

Topic 10. Mineralogy of sediments and carbonated rocks

Topic 11. Components of carbonate sediments and rocks

Topic 12. Classification of carbonate sediments and rocks and geological significance

V. DIAGENESIS

Topic 13. Diagenetic processes and stages

Topic 14. Diagnostic of sediments and detrital and carbonate rocks. Dolomites

The INTRODUCTION (Lessons 1 and 2), intends to guide the student about various conceptual and methodological aspects that are fundamental in the development of the subject: general content of the Sedimentary Petrology, its own peculiarities regarding Petrology and Sedimentary Geology, history and evolution, and its relationship with the Natural Sciences and other disciplines. The introduction in the world of Sedimentary Petrology is done by analysing the concept of sedimentary deposits and rocks. The presentation of the Oil Cycle and the Exogenous Cycle helps the student to understand the context of processes in which the formation and evolution of the sediments and sedimentary rocks takes place.

Lesson 1, also aims to promote the motivation of the student by highlighting the scientific and economic importance of the program contents. A brief description of the methods and the most commonly used study techniques, regarding the analysis of sedimentary rocks and sediments, lead to the familiarization of the student with their work habits during the course. The presentation of the organization, objectives and how the course will be driven is complemented with information of bibliographical sources, by means of a list of references of texts of general character and of easy access. In Lesson 2, it is essential to remark the basic differences between sediments and sedimentary rocks, introducing the textural concept of the fabric (clastic, chemical and organogenic) and compositional and genetic concepts of the different components of sedimentary deposits (such as detrital, chemical, allochthones, autochthonous). These concepts are used to elaborate a classification of sedimentary rocks, and help to understand their relative abundance and the total volume of sediments and sedimentary rocks with respect to other rock types.

In GENESIS OF SEDIMENTS AND ROCKS (Lessons 3 to 6) the analysis of the chemical and physical parameters that control the main reactions in the exogenous environment, takes place in the first topic (Lesson 3). It verses about how these are essentially controlled by the geochemistry of natural waters and the nature of the chemical reactions that have a crucial role in the processes of mineral alteration and mineral phase formation. These former basic concepts, are applied in the three following topics of the unit (Hypergenesis I, II and III), in which the modification of the materials (igneous rocks, metamorphic or sedimentary organisms) that constitute the source of elements and debris leads to the generation of sediments and sedimentary rocks. Hypergenesis I (Lesson 4) deals with the mechanisms that produce the physical and chemical weathering of the rocks in the source area. In hypergenesis II (Lesson 5), the alteration products of rocks (debris and soils) are explained as well as its importance regarding the characterization of sedimentary deposits and their

interpretative and economic interest. Finally, Lesson 6 studies the environmental controls (climate, vegetation, relief) in the source area and the links between the intensity of the weathering processes and the generated detrital components.

The CHARACTERIZATION OF SEDIMENTS AND DETRITAL ROCKS (Lessons 7 to 9) This unit verses about descriptive and interpretative aspects of the observable textural features of these types of materials, taking into account the spatial distribution of their individual components (rock fabrics) and the properties derived from this arrangement. The subject is completed with a review of the mineralogy of the most common clastic components. Textural and compositional characteristics are used to introduce the existing detrital rocks classifications and to justify the chosen one.

Lesson 7 focuses on the size of the clasts as a basic textural characteristic to describe detrital sediments and rocks. At the same time, it has high relevance in several specific fields, such as Soil Mechanics and Rocks and Industrial Minerals. A detailed analysis of clast size (diameter of screening) related concepts, particle morphology, the spatial arrangement of the completely clastic components, and introduction to various concepts about related properties (apparent density, solid particle density, porosity, permeability) is also carried. All these concepts constitute the basis of applied aspects are developed in the practical sessions and provide basic knowledge for a better understanding of the diagenesis sections.

Lessons 8 and 9 couple previous knowledge with compositional aspects. Mineralogical analysis of the most common clastic components is based on previous experience acquired by the student in former subjects such as Mineralogy and Petrology, especially regarding silicates. The Sedimentary Petrology contributions to this knowledge refer to typology of grains and their morphological, mineralogical and geochemical aspects. Lesson 9 reviews the traditional textural and compositional criteria used in the classification of sediments and detrital rocks. Finally, it provides the student with a classification scheme to carry a systematic description and interpretation of the different types of detrital materials.

Lessons 10 to 14 constitute the unit CHARACTERIZATION OF NON-DETRITAL SEDIMENTS AND ROCKS, in which the study of "chemical" or "organogenic and biogenic" rocks is approached. The student is provided with a set of common terminologies mainly used in the field of carbonate Petrology, siliceous rocks, evaporites, organic matter, sedimentary iron and phosphate deposits, formation controls, distribution and genetic models.

Lessons 10 to 12, specifically address the study of carbonate rocks, the most abundant sedimentary rocks together with detrital rocks. Lesson 10 focuses on the mineralogical composition of carbonate rocks as well as the physical, chemical and biological processes that affect the balance of the CO_2-H_2O-$CaCO_3$ system, which governs the precipitation, dissolution, and transformation of Carbonates in natural marine and continental waters. Lesson 11 explains carbonate rock fabrics (grains, matrix, cement, and pores), whereas Lesson 12 focuses on the classification criteria of carbonate rocks.

In Lesson 13, the compositional, textural, and genetic aspects of evaporitic, siliceous, phosphatic and ferruginous rocks are approached. Finally, Lesson 14 deals with fossil fuels by analysing organic matter sources and characteristics, as well as description and classification of coal and hydrocarbons.

The last lessons (Lesson 15 and 16) complete the program of Theoretical Classes of the subject and are all included under the heading DIAGÈNESI. All of the aspects related to the description, genesis and geological meaning of sediments and sedimentary rocks, are complemented with the study of the stages and diagenetic processes that may occur during sediment burial (Lesson 15). This topic outlines the concept of diagenesis and its importance regarding Sedimentary Petrology studies. It also helps the student to understand the unique features of the main diagenetic processes such as cementation, dissolution, compaction, mineral transformations and other reactions that have their basis in the first topics included in the contents of the subject. Lesson 16 addresses the on the importance of the composition and initial grain size of sedimentary deposits as a control of the diagenetic processes as well matrix and porosity generation. At the same time, porosity evolution models related to burial are established, which have a direct application in the field of hydrocarbon reservoir generation. Finally, Lesson 16 deals with lithification processes and carbonate transformations, both in the sedimentation environment and during burial. The influence of the deep burial diagenesis and the importance of the replacement processes is analysed, particularly dolomitization due to its wide representation in the sedimentary register.

Subject contents are complemented with the unit CHARACTERISTICS AND THE GEOLOGICAL MEANING OF THE MAIN TYPE OF SEDIMENTS AND SEDIMENTARY ROCKS. The main petrologic groups (conglomerates, breaches, sandstones, and lutites) are reviewed in Lesson 9, as well as no-detrital carbonate rocks (Lesson 12). In all these topics, aspects related to textures, mineralogy, and formation environments are developed, with special emphasis to the links between composition and geotectonic contexts in which they have been formed. The description and interpretation of the sedimentary structures and the environments where they occur is not the goal of this course, and reference to the knowledge acquired by the student in other subjects (for example, in Stratigraphy and Sedimentology of Second Course) is expected.

Practical Classes Program

Practice 1. Introduction to the study of sedimentary rocks. Differentiation of large groups of sedimentary rocks. Clastic rocks structure: framework, matrix, cement, pores. Rock components nomenclature: grain, clast, crystal, allochthonous, autochthonous, authigenic.

Exercises: Microscope and naked eye

1) Recognition of the main elements of a clastic rock: framework, matrix, cement, and pores (2 samples and 2 thin sections from the collection).

2) Estimation of the relative percentages of these elements in the samples and thin sections.

3) Recognition of the main clastic rocks textures: size (modal and centile class), roundness, sphericity, and selection.

Practice 2. Framework: types of components I. Framework components: classification criteria. Non-carbonate extrabasinal components (NCE): monomineral (quartz, feldspar, micas and other minerals) and polymineralic (rock fragments). Carbonate extrabasinal components (CE): monomineral(calcite, dolomite, ankerite) and polymineral (rock fragments).

Exercises: Microscope and naked eye

1) Recognition of the extrabasinal components of the framework (2 samples and 2 thin sections from the collection).

2) Estimation of the relative percentages of these elements in the samples and thin sections.

3) Study of the rock fragments. Scheme and description.

4) Main framework components relationship.

Practice 3. Framework: types of components II. Non-carbonate intrabasinal components (NCI): evaporitic, glauconitic, phosphate, ferruginous grains. Carbonate intrabasinal components (CI): skeletal grains (bioclasts) and non-skeletal grains (oolites, pisoliths, oncolites-stromatolites, pellets, intraclasts).

Exercises: Microscope and naked eye

1) Recognition of the intrabasinal components of the framework (2 samples and 2 thin sections from the collection).

2) Estimation of the relative percentages of these elements in the samples and thin sections.

3) Study of the rock fragments. Scheme and description.

4) Main framework components relationship.

Practice 4. Matrix and Cement. Differentiation between matrix and cement in the different textural groups: rudites, arenites, and lutites. Types of matrix and mineralogical composition. Cement: types of textures and mineralogical composition.

Exercises: Microscope and naked eye

1) Recognition of the different textures and compositions of the matrix (2 samples and 2 thin sections from the collection). Scheme and description.

2) Estimation of the relative percentages of matrix and cement.

3) Timing of the different types of cement.

Practice 5. Porosity. Differentiation between porosity and intergranular volume. Type of porosity. Loss of intergranular volume with burial. Mechanical and chemical compaction. Effects of the compaction in the sediment components.

Exercises: Microscope and naked eye

1) Recognition of the various types of porosity and their origin (4 samples and thin sections from the collection). Scheme and description.

2) Estimation of the relative percentages of the different porosities.

3) Recognition of the effects of mechanical and chemical compaction. Description of the types of contacts between grains and preferred orientation.

Methodology

Theoretical classes

The theoretical knowledge is transmitted through master classes and notes of the topics that cannot be developed in the virtual classroom (webinar). Apart from the selected bibliography, students will be provided with several presentations, figures, diagrams or notes of the topics and aspects that are developed throughout the course. All of this information is available on the Virtual Campus as well as exercises to test rock classification, links to educational webpages and figures or interesting pictures related to the topics of study.

Laboratory Sessions

The practical contents will be developed in the microscopy laboratory, in groups of up to 25 students and in accordance with the requirements established by the sanitary and academic authorities. Each class is 2 hours long; therefore a maximum of six sessions is set.

The aims of the Lab Sessions are the familiarization of the student with the most common study techniques of sedimentary materials. Learning the methods of obtaining textural data of sediments and rocks. The recognition through the petrographic microscope and naked eye the components of the sedimentary rocks, as well as developing its potential to describe, classify and interpret them. It is based on the knowledge of optical mineralogy acquired by the student in previous courses. The development of the Lab Session is done based on a self-published Guidebook that helps to follow the classes easily and eliminates excessive time to present the contents of the practice.

In addition, the student is advised to use individual learning methods (especially web pages) that have been recently published in the field of Sedimentary Petrology. Use of this material allows illustrating and complementing the developed concepts and learning skills of the student.

Fieldtrips

Practical contents are also developed in the field, in groups of 25 students maximum and in accordance with the requirements established by the sanitary and academic authorities. The time available for the student for field sessions is 7.5 hours; therefore, a one-day fieldtrip is set.

The aim of the Fieldtrip is to gain experience in the recognition of sedimentary rocks in the outcrop, using the necessary techniques for their correct description and representation.

Throughout the fieldtrip, students must get familiar with the workflow in the field regarding sedimentary rocks: observations, data collection, sampling, etc. Therefore, they must learn and acquire skills in using the necessary materials (field book, magnifying glass, hammer, compass, granulimeter, HCl....).

The main goal is that the students observe, describe and classify as many sedimentary rocks as possible and to analyse those structures that help them to interpret the depositional environment. At the same time, they must recognize and interpret those diagenetic processes that are observable.

The fieldtrip concludes with a discussion of the results obtained by the students based on their own observations and with a synthesis and final explanation by the teacher in order to facilitate the understanding of the geological history of the visited area. The end of the fieldtrip is used to make a questionnaire, which is answered individually by the students with the help of all the annotations collected in their field notebooks.

The fieldtrip ends with the exposition of a problem related to the knowledge acquired in the zone. In this way, the student must present a final report with the development and resolution of the problem posed with the one that is finished by the practice of field.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Field practices	7	0.28	1, 5, 2, 3, 4, 8
Laboratory Practices	16	0.64	1, 2, 3, 4, 8
Theory	11	0.44	7, 1, 5, 3, 6, 8
Type: Supervised			
Classroom Tutorials	6	0.24	7, 5, 3, 6
Tutorials and supervision of the Field Work and the Laboratory Practice Report	9	0.36	7, 5
Type: Autonomous			
Study, preparation of field work and preparation of laboratory practice repor	47	1.88	7, 1, 5, 3, 6, 8

Assessment

The evaluation of the work of the student of the subject Sedimentary Petrology is as follows:

- Global exam combining multiple-choice test with written exposition questions where the capacity for synthesis and relation of concepts and ideas of the student in the whole of the subject prevails. It is done in December and all students must do it. Its value over the final grade is 50%.

- Second-chance examination with written exposition questions and short questions. Only students that have failed to pass the global exam should apply and will only be used to overcome the note.

- Laboratory Practical exam, through an exercise of identification, description, and interpretation of sedimentary rocks, both in thin section and in hand sample. It is held in December and its value over the final grade is 35%. There will be a laboratory second-chance examination, where only students that have failed to pass the Laboratory Practical exam.

- The evaluation of field practices is carried out based on the correction of individual field books or fieldwork. Its value over the final grade is 15% and will not have a second-chance examination.

- The minimum grade for averaging the Global exam as well as the Laboratory Practical exam is 3.5.

The final grade is also obtained based on the attitude and interest shown by the students during the various teaching activities carried out throughout the course. Although it can introduce a certain degree of subjective elements in the assessment, it records, in some way, the differential participation of some students.

Scheduling of the assessment activities

The dates of the assessment tests and the submission of exercises are published in the Virtual Campus (VC) and may be subject to changes in programming due to unforeseen eventualities. Any modification will be reported through this platform.

It is important to bear in mind that no assessment activities will be permitted for any student at a different date or time to that established, unless for justified causes duly advised before the activity and with the lecturer's previous consent. In all other cases, if an activity has not been carried out, this cannot be re-assessed.

Grades review

The marks obtained by students in each of the tests are published in the VC. Along with the grades, the place, date and time of review will be indicated, allowing students to review the activity with the lecturer. In this context, students may discuss the activity grade awarded by the lecturers responsible for the subject.

If the student does not take part in this review, no further opportunity will be made available.

Irregularities committed by the student, copy and plagiarism

Notwithstanding other disciplinary measures deemed appropriate, and in accordance with the academic regulations in force, assessment activities will receive a zero whenever a student commits academic irregularities that may alter such assessment. Assessment activities graded in this way and by this procedure will not be re-assessable. If passing the assessment activity or activities in question is required to pass the subject, the awarding of a zero for disciplinary measures will also entail a direct fail for the subject, with no opportunity to re-assess this in the same academic year.

Irregularities contemplated in this procedure include, among others:

- the total or partial copying of a test, practical exercise, report, or any other evaluation activity;
- allowing others to copy;
- presenting group work that has not been done entirely by the members of the group;
- presenting any materials prepared by a third part as one's own work, even if these materials are translations or adaptations, including work that isnot original or exclusively that of the student;
- having communication devices (such as mobile phones, smart watches, etc.) accessible during theoretical-practical assessment tests (individual exams).

Assessment of students who followed the subject last year but do not successfully passed it

Students who completed and passed the laboratory practices and field trip in the previous course but did not pass the subject may choose not to make them again in the current course. In that case, the laboratory practices mark (LT) will be 5, regardless of the grade reached the previous year.

The list of students who can choose this option will be published at the beginning of the course in the VC. If, anyway, the student wants to make the laboratory practices again, he/she must communicate it by mail to the professor responsible for the practices.

Special grades

- A "non-assessable" grade cannot be assigned to students who have participated in any of the individual partial tests or the final test.
- In order to pass the course with honours, the final grade must be ≥ 9.0. Because the number of students with this distinction cannot exceed 5% of the number of students enrolled in the course, this distinction will be awarded to whoever has the highest final grade.

To consult the academic regulations approved by the Governing Council of the UAB, please follow this link: https://www.uab.cat/doc/TR_Normativa_Academica_Plans_Nous

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Correction Notebook Work Field Practices	15	0	0	7, 1, 5, 3, 4, 6, 8
Global exam	50	2	0.08	7, 3, 6
Laboratory exam	35	2	0.08	1, 2, 3, 4, 6

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