Universidad Zaragoza

**Academic Year/course: 2021/22**

# 26435 - Applied Geochemistry

## Syllabus Information

**Academic Year:** 2021/22
**Subject:** 26435 - Applied Geochemistry
**Faculty / School:** 100 - Facultad de Ciencias
**Degree:** 296 - Degree in Geology
**ECTS:** 5.0
**Year:** 4
**Semester:** First semester
**Subject Type:** Optional
**Module:**

# 1. General information

## 1.1. Aims of the course

This course is designed to illustrate the applications of geochemical principles for solving geological and environmental problems. It includes an introduction in aqueous geochemistry and geochemical modeling of water-rock reactions and some applications of isotopic and high temperature geochemistry. Widely distributed geochemical modeling software will be used for training on different types of applications ranging from groundwater systems to igneous or metamorphic systems.

These objectives are in the line of the following Sustainable Development Goals of the UN 2030 Agenda (https://www.un.org/sustainabledevelopment/):

- SDG 4: Quality Education
- SDG 6: Clear water and sanitation
- SDG 12: Responsible consumption and production

in such a way that the acquisition of the knowledge given in this course provides the ability and competence to contribute to their achievement.

## 1.2. Context and importance of this course in the degree

Applied Geochemistry is one of the optional courses that can be taken in the last year of the Geology Degree inside the module called *Applied Geology*. It is considered a continuation of the compulsory course in Geochemistry that is given in the 3$^{rd}$ year of the Degree inside the module *Geology Fundamentals.*

In general, this course provides the necessary skills to be able to use the geochemical tools available inside the field of the Geochemical Modelling, and to apply them to solve various academic and environmental problems. This is why it can be a good complement to other compulsory or optional courses in the fourth year of the degree.

## 1.3. Recommendations to take this course

It is recommended to have taken (and passed) the compulsory course in Geochemistry in the 3rd year of the degree.

It is also suggested to have a continuous working plan with constant review of the theoretical and practical concepts and to use the resources indicated by the teachers in terms of web pages and academic tuition.

# 2. Learning goals

## 2.1. Competences

The student will be able:

- To know the main water-rock (soil)-gas geochemical processes and the main tools to their treatment and quantitative modelling.
- To estimate the influence of these processes in the composition of the resulting products and be able to determine the processes from the study of the final composition.

- To assess and solve several types of problems (with the help of data and geochemical calculations) in the context of low and high temperature environments.
- To select the most suitable methods to get the data, to treat and to model them depending on the type of material (rock, soil, sediment, water) and geological system.
- To apply quantitative methods for the resolution of geochemical problems (contaminated systems, geochemical anomalies, change of phase processes...).
- To summarise geological and geochemical information for communication to technical audiencies.
- To plan and develop sampling strategies in different materials and with different analytical objectives. And to asses the representativity and influence of the sampling in the quantitative results.

### 2.2. Learning goals

Successful students will learn to:

- Apply fundamentals of aqueous geochemistry to interpret and quantify water-rock interaction processes.
- Apply computer modeling methods to quantify the geochemical processes operating in geological systems, both in low and high temperature environments.
- Plan a field campaign, encompassing sampling and assaying, for different geological and environmental problems, selecting the more appropriate and effective methods.
- Link theoretical geochemical concepts to geological problems and real-world environmental issues.

### 2.3. Importance of learning goals

The geochemical methodologies that will be used in this course are very frequently used to different disciplines in Geology, Earth and Environmental Sciences (Petrology, Mineralogy, Hydrogeology, Edaphology?). Additionally, many environmental problems involve an important load of geochemistry (contamination, global warming, radioactive wastes disposal, $CO_2$ sequestration and storage?) that has enhanced the use and diffusion of these methodologies during the last years for their treatment and mitigation. Therefore, this course will help the students to be able to apply effectively the quantitative geochemical methodologies.

## 3. Assessment (1st and 2nd call)

### 3.1. Assessment tasks (description of tasks, marking system and assessment criteria)

**Continuous Assessement:**

- **Activity 1** will be assessed through individual questionaires of each course unit with theoretical questions and practical exercises (maximum one per thematic unit). This activity is worth 50 % of the final grade.

- **Activity 2** will be assessed through the evaluation of the reports from every practical activity that will be presented at the end of the class or before the Friday of the week after the corresponding practical class. This activity is worth 35 % of the final grade.

- **Activity 3** will be assessed through the evaluation of the report about the field trip and the activity developed during and after that. This activity is worth 15 % of the final grade.

Each questionaire/exercise or presentation will be graded on a scale from 0 to 10. Each item will be passed with a grade equal or greater than 5. The final/global grade will be calculated applying the corresponding weights for each activity provided every activity has a grade greater than 4.

**Final Assessement**
The student that decides to take only the final exam, or the student that has not passed the continuous assessement, will have to pass a final assessment consisting of two exercises:

1. Theoretical exercise: Questionaire with questions about the different issues treated in the course (50 % of the global grade).
2. Practical exercise: Questionaire with exercises related with the practical issues developed in the course (50 % of the global grade).

Each questionaire/exercise will be graded on a scale from 0 to 10. Each item will be passed with a grade equal or greater than 5. The final/global grade will be calculated applying the corresponding weights for each activity

provided every activity has a grade greater than 4.

# 4. Methodology, learning tasks, syllabus and resources

## 4.1. Methodological overview

The learning process has been designed to provide the knowledge on the methodologies and tools needed to solve all types of geochemical problems, both, in natural and in antropically modified systems.

The learning process is thought to have three educational actions that complement each other and that correspond to each assessment activity indicated above.

## 4.2. Learning tasks

The course includes the following learning tasks:

Activity 1 - Lectures (2.5 ECTS). Development of the concepts and theoretical basis of the course.
Activity 2 - Practice Sessions (2 ECTS). Management and assessment of real and/or theoretical-practical cases about the different types of geochemical problems described in the course.
Activity 3 - Special Practice in the Field (1 ECTS) to practice sampling methodologies for waters.

*Note: the teaching and evaluation activities will be carried out on-site unless, due to the Covid-19 health situation, the provisions issued by the competent authorities and by the University of Zaragoza require them to be carried out online or mixed on-site-online with reduced-capacity rotating groups. Online teaching will not be applied to field practices.*

## 4.3. Syllabus

***Lectures***

The course consists of two parts: Part 1 (Low Temperature Aqueous Geochemistry), dedicated to the basic principles of aqueous geochemistry, geochemical modeling and environmental applications of geochemical exploration; and Part 2 (High Temperature Geochemistry) dedicated to applications on igneous petrogenetic processes and volcanic hazards.

*Part I. Low Temperature Aqueous Geochemistry*

- Lecture 1. Basic concepts in aqueous geochemistry. Chemical background.
- Lecture 2. Behavior of dissolved elements in aqueous solutions: speciation, activity and activity coefficient calculations. Geochemical modeling and environmental applications.
- Lecture 3. Redox processes. Contamination and biodegradation. Practical examples and cases.
- Lecture 4. Water mixing processes. Practical examples and cases.
- Lecture 5. Surface processes: sorption/desorption and ion exchange. Practical examples and cases.
- Lecture 6. Evaporation processes. Practical examples and cases.

*Part II. High Temperature Geochemistry*

- Lecture 7. Stable Isotopes in high temperature systems. Isotope fractionation and geothermometry. Applications to petrogenetic processes.
- Lecture 8. Modelling petrogenetic processes using trace elements. Basis and case studies.

***Practicals***

Practicals are divided in problem classes and field work. Problem classes are divided in the same parts as the lectures:

*Part I. Low Temperature Aqueous Geochemistry*

- Topic 1. Speciation and activity calculations: effects on the quantification of sinkhole hazards in evaporitic rocks.
- Topic 2. Speciation-solubility calculations with different types of waters.
- Topic 3. Reaction-path calculations (I). Application to tufa precipitation processes.
- Topic 4. Reaction-path calculations (II). Geothermal systems and geothermometry.
- Topic 5. Reaction-path calculations (III). Simulation of weathering processes.
- Topic 6. Reaction-path calculations (IV). Mixing of waters
- Topic 7. Reaction-path calculations (III). Evaporation processes.
- Topic 8. Mass balance calculations. Groundwater evolution in carbonate aquifers.

*Part II. High Temperature Geochemistry*

- Topic 9. Isotope geothermometry in igneous rocks. Fractionation and evaluation of isotopic equilibrium.
- Topic 10. Identification of differentiation processes in igneous rock series: fusion, fractional crystallisation,

assimilation. Approach on a real case.

*Field work*

One all-day field trip is scheduled in this course to practice sampling methodologies for waters.

### 4.4. Course planning and calendar

The course includes the following learning tasks:

- Hours of autonomous work: 70
- Hours for assessment: 5
- Hour of Lectures: 25
- Hours of Practice/Problem Classes: 20
- Hours of Fieldwork: 5

The classes will start at the beginning of the second semester following the academic calendar of the Sciences Faculty.

### 4.5. Bibliography and recommended resources

**http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=26435**