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**Department of Earth Sciences and Petroleum**

**College of Sciences**

**University of Duhok**

**Subject: Igneous Petrology**

**Course Book – (Year 3)**

**Lecturer's name Ahmed M. Aqrawi(Ph.D.)**

**Academic Year: *2022-2023***

**Course Book**

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| **1. Course name** | **Igneous Petrology** |
| **2. Lecturer in charge** | **Ahmed m. Aqrawi (Ph.D.)** |
| **3. Department/ College** | **Earth Sciences and Petroleum/ Sciences** |
| **4. Contact** | **e-mail: ahmed.aqrawi@su.edu.krd****Tel: 07504470939** |
| **5. Time (in hours) per week**  | **Theory: 2** **Practical: 2**  |
| **6. Office hours** | **10-15 hours**  |
| **7. Course code** |  |
| **8. Teacher's academic profile**  |  I graduated from the University of Mosul in 1982, and then I got an M.Sc. in geochemistry and petrology from Mosul University. I was engaged to work as an assistant lecturer in 1992 at Salahaddin University/ College of Science. I hold a Ph.D. in petrology and mineralogy 2001 from Baghdad University. I was awarded the assistant professor degree in 2009. During my work, I carried out nine published research and scientific reports. From 1992 till now I gave many courses in the Department of Earth Sciences and petroleum such as Optical Mineralogy, Igneous petrology, metamorphic petrology, Petrology, and many courses for M.Sc.& Ph.D. students such as advanced petrology, Industrial rocks, minerals, and geochemistry of igneous and metamorphic& Middle East Geology  |
| **9. Keywords** | **Science, Igneous , Metamorphic, peridotite, basalt**  |
| **10. Course overview:** The course will cover the structure of the inner earth with a focus on the upper mantle as the main igneous and metamorphic processes take place there. The first semester will concentrate on igneous rocks which is the continuation of the igneous rock course of the 2nd year, while the second one will be on metamorphic rocks. Concerning the first semester, it will cover the physics and chemistry of the magma which are related to a system of crystallization (binary and ternary), and the effect of water on these systems. In addition, magma differentiation processes and petrogenesis of igneous rocks are dealt with. Finally, the course will deal with the tectonism of igneous rocks with examples from the Iraqi Kurdistan Region. The 2nd semester will cover the petrology of metamorphic rocks. It starts with metamorphism, the chemistry of metamorphic rocks, metamorphic facies with examples from different parts of the world, and tectonism of metamorphic rocks. Finally, metamorphic reactions and metamorphic systems will be discussed.  |
| **11. Course objective:**1. The student should be able to understand the earth composition and the classification of its different parts according to seismic data.
2. The student should be able to understand the upper mantle structure and its petrology because all the igneous and metamorphic processes take place in this part of the earth.
3. The student should be able to be familiar with the different systems of crystallization designed in lab and their actual occurrence in nature.
4. The student should able to understand magma differentiation processes leading to the formation of the igneous rocks.
5. The student should understand the petrogenesis of igneous rocks including crystallization and partial melting.
6. The student should be able to know about the tectonic settings of igneous &metamorphic rocks according to geochemical data.
7. The student will be given examples on igneous rocks in the Iraqi Kurdistan Region and their relation with the geology of Iraq.
8. The student should be able to identify the different types of igneous rocks in thin sections.
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| **12. Student's obligation**The student’s obligation during the course is attendance in the class for two hours for studying the theoretical part of the course the he applied it in the laboratory (about three hours). There are many tests before the beginning of the labs |
| **13. Forms of teaching**Different forms of teaching will be used to reach the objectives of the course: power point presentations for the titles and definitions and summary of conclusions, all figures that related to the lectures. Furthermore, students will be asked to prepare research papers on selective topics, these topics need to be from printed media or internet. There will be classroom discussions at the last ten minutes of the lecture. To get the best of the course, it is suggested that you attend classes as much as possible, read the required lectures before the time of lecture, teacher's notes regularly as all of them are foundations for the course. Try as much as possible to participate in classroom discussions.  |
| **14. Assessment scheme**The students are required to do an exam after each five lectures. The midterm exam will be from 50 and the final exam from 50  Theoretical Mid-semester exam From 15 as followMid term exam from 10  Activity : 5 Practical midterm exam from 35 is as follow Midterm from 15**Quizzes (6****Weekly reports (%8)****Activities (%6)**  |
| **15. Student learning outcome:** In the last year, many companies come to Kurdistan Region for minerals exploration, in wide areas along the region, so several geologists are followed these companies and others are working with the geological survey where the mineral resources are available in the region. Some of the students who graduation they employed in water resources companies in the public and private sectors |
| **16. Course Reading List and References‌:**▪ Required books:Hughs,C.H., 1982: Igneous petrology Wilson, S, !989:Igneous pertogenesisTurner, F.J., 1981, Metamorphic Petrology, 2nd edition McGraw Hill.Aziz, R.M., Al-Hafdh, N.M., Al-Samman, A.H., and Aswad, K.J., 1988, Metamorphic Petrology Internet reference <http://www.union.edu/PUBLIC/GEODEPT/COURSES/petrology/> <http://www.geosci.unc.edu/Petunia/IgMetAtlas/mainmenu.html>* MacKenzie and Guilford - Atlas of rock-forming minerals in this section
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| **17. The Topics:** | **Lecturer's name** |
| **17. The Topics:****First Semester ( Igneous Petrology)**Week 1: Introduction, course outline and what to study Week 2: Principal subdivisions of earth interior Continental crust Oceanic crust Week 3: upper mantle Physical criteria Petrological criteria Week 4: pyrolite modelWeek 5: Phase rule Silica system+ QuizWeek 6: Binary Systems Anorthite—Diopside system Nepheline- silica system Forsterite – silica system Albite –Anorthite System Week 7: ternary systems Silica-forsterite –anorthite Diopside –forsterite – silicaWeek 8: Albite –orthoclase – waterAlbite- Orthoclase- Silica -waterNephiline-Kalsilite – SilicaFirst Exam : out of classroom table Week 9: magmatic differentiationIntroductionCrystal fractionation Flow differentiation CongelationcrytallizationGravitational segregationFilter pressingWeek 10: Magma Differentiation  Liquid Immiscibility  Diffusion Process and Gas Transfer  Hybridization  Assimilation Week 11: Variation Diagrams  Geochemical Classification of Trace Elements  Comparison between Skaagared Intrusion (Greenland) and Bulfat Intrusion (Iraqi Kurdistan Region)Week 12: Petrogenesis  Introduction Mechanism of Melting  Generation of Magma from Solid Rocks Week 13: Generation of Granitic Magma  Upward Ascending of Granitic Magma Week 14: Tectonic Setting of Granitic and Basaltic Magma  Discrimination Diagrams for Tectonic Interpretation Week 15: second examThis syllabus may be subject to changes, i.e, we may take either longer or shorter time to finish a topic, and if any changes happened you will be notified well in advance | Ahmed Aqrawi (2 hrs) 2/9/2023 |
| **18. Practical Topics (If there is any)** |  |
| Week 1: Review of rock igneous forming mineralsWeek 2: Steps of slide description "igneous petrography" Week 3: Texture of igneous rockWeek 4 & 5: Description of ultrabasic igneous rock**Week 6, 7 & 8:** Description of basic igneous rock**Week 9:** Presentation of Ultrabasic and basic rock on triangle classification**Week 10:** First examination**Week 11:** Description of intermediate igneous rock**Week 12:** Description of intermediate igneous rock**Week 13:** Description of acidic igneous rock**Week 14:** Description of acidic igneous rock and Presentation of intermediate and acidic rock**Week 15:** Last examination of igneous petrography | Lecturer's name Mohammed Sofi Ph.D 2 2/9/2023 |
| **Draw wherever necessary** **Q1)A-** Follow the path of crystallization of Binary system with intermediate compound  that melted congruently (**10 marks)**B- The Fig. to the right is a phase diagram of Silica - Forsterite. Liquid A cools under equilibrium Conditions. Answer the following fo- msc 1. The name of the first crystal? **(1 mark)**
2. Calculate the percentage of crystal and

liquid at B. **(1 marks)**1. When and why the mineral which crystalline react

 with the melt? **(2 marks**1. At eutectic point what will crystallized? Do you think that

The melt reach this point under non equilibrium condition? **(2 marks)**1. When the forsterite and silica crystalline together and why? **(2 marks)**
2. What do we call this system? Why? **(2 marks)**

  plag B- The Fig. to the right is a phase diagram of Forsterite- Anorthite -Silica. A, B, C and, D are liquids cool under equilibrium Conditions.  Answer the following 1. Complete the diagram, and What is the difference

between liquid A, B, and C 1. Last solid crystalline of liquid B, and what is the

 name of the rock1. Follow the crystalline path of liquid D
2. Which liquid will reach the point H,

Calculate the percentage of liquid and solid at point H1. Follow the path of crystallization of liquid C

Are the liquid A and B reach the eutectic point? Why?**Q2)** **Complete the following Sentences :-** ( **20 Marks)**1. Oceanic crust in oceanic basin composed of three layers which are---------
2. There are two types of transformation in Silica system which are------------------------------
3. Diopside – Anorthite system is -------------
4. Ringwood (1975) gave two possibilities for the formation of eclogite in upper mantle,which are----------
5. The effects of increasing water vapor pressure in albite –orthoclase are-----------
6. Ophiolite complex is----------------
7. The Petrological evidences of peridotite theory are -----------------------
8. The origin of Alpine peridotite according to Coleman, 1971 is--------------
9. Jackson and Thayer,1972 classified alpine peridotite to -------------
10. If upper mantle is eclogite, the density contrast must be equal to-------

  **Q3) Give the reasons for the following** (**10 marks)**1. upper crust composition is closer to granodiorite than granite
2. Pisson’s ratio is used to differentiate between peridotite and eclogite
3. pyrolite is not a rock
4. In Albite – Orthoclase system, if the pressure less than 5Kbar one k-feldspar crystalline but if pressure 5 Kbar two K-feldspar crystalline
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| **20. Extra notes:**Non  |
| **21. Peer review**Dr. Nihad Jamel‌  |