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**Department of Earth science and petroleum**

**College of Science**

**University of Salahaddin**

**Subject: Clay Mineralogy**

**Course Book – Year 4 / Second semester**

**Lecturer's name: Ass.Prof. Dr. Farhad Ahmad Mohammed**

**Academic Year: 2023/2024**

**Course Book**

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| **1. Course name** | Clay Mineralogy | |
| **2. Lecturer in charge** | Ass.Prof. Dr.Farhad Ahmad | |
| **3. Department/ College** | Earth science and petroleum / Science | |
| **4. Contact** | e-mail: farhad mohammed@su.edu.krd  Tel: 07508178183 | |
| **5. Time (in hours) per week** | Theory: 2  Practical: 2 | |
| **6. Office hours** | 15 hours per week | |
| **7. Course code** |  | |
| **8. Teacher's academic profile** | I graduated from University of Salahaddin on 1987, and then I got the M.Sc. in medical geochemistry from Baghdad university. I was engaged to work as an assistant tetchier on 2002 at Salahaddin University/ College of Science from 2002 to 2007. I hold Ph.D. in geochemistry on 2007 from Mosul University. I awarded the assistant professor degree in 2013. During my work I carried out tens of published researches and scientific reports.  From 2002 till now I gave many courses in the Department of Geology such as Mineralogy, Geochemistry, Ore Geology, Industrial rocks and minerals and many courses for M.Sc. students such as advanced geochemistry, Mineral Exploration and geochemistry of sedimentary rocks . | |
| **9. Keywords** | Clays, Weathering, Identification, Structure, Clay mineral groups, Genesis, Green and red clays. | |
| **10. Course overview:**  Clay minerals have many scientific importance such as; stratigraphic correlation and depositional environment study andwell logging, at dispersion, it reduces the permeability of sandstone, the organic matter in clay may convert to hydrocarbons, it is important for agricultural soils, study and interpret the engineering properties for soil. In addition to that, clay minerals have many industrial uses such as; Ceramic industry, paper, rubber, paint, drilling mud, cement industry, lightweight aggregates, radioactive waste preservation, spreading an oil floor in factories, as a source for aluminium (Bauxite) and insecticides.The understandings of the fundamental concepts of the subject were carried out by the direct application of the theoretical partin laboratory.Therefore, this subject will be important to the students after graduation in many fields like agriculture, industry and petroleum. | | |
| **11. Course objective:**  The essential objective of the theory course of clay mineralogy is to give an overview for students on the clay minerals and their sedimentology, as well as giving a better idea on the origin, structure, groups, depositional environments, and diagenesis of clay minerals. Also study the analytical techniques used in clay minerals analyses, and how we can distinguish between different groups. As well as connecting this subject with our life especially in industry. In the practical part emphasize on the preparation of clay slides and interpretation of clay minerals as a single minerals and in mixed layer, in addition to quantitative analysis and studying the crystallinity indexes of some groups. | | |
| **12. Student's obligation**  Throughout this course, the students contribute in the lectures by asking and answering. Also they assign by homework during each lecture. Most of the students attend to the lecture and laboratory. All of the students are committed in their exams and instructions. | | |
| **13. Forms of teaching**  Different forms of teaching are used during the course:  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**  **Grading:**  There are one theoretical exam at the mid, and one practical exam at the end of the semester, in addition to quiz exams during course.  - The final mark of semester is **50%**, and divided to:  **15%** for theoretical part, and  **35%** for practical part; also the practical mark is divided to two marks: exam and reports.  - The final exam is from **50%** on theory  Therefore the total mark will be **100%**. | | |
| **15. Student learning outcome:**  Clay minerals course is related with many other geological specializations. During this course the student learn details things about this relation, in addition to application of clay minerals in the future. In our life many industries include clay minerals as a raw material, such as cement industry, ceramic industry, paper industry, rubber …etc. Therefore, it is very important for student to have an enough idea about the origin, structure, types and uses of clay minerals. | | |
| **16. Course Reading List and References‌:**   * Herve Chamley, 1989: Clay sedimentology. * H.H. Murray, 2007: Applied clay mineralogy. * D. Carroll; Clay Minerals: A guide to their X-ray identification. The geological society of American. * Hand book of clay science, 2005, many authors. * Lectures notes and internet preview. * Chapters from other sedimentary references. | | |
| **17. The Topics:** | | **Lecturer's name** |
| Week 1:  Course outline and some instructions about the engagement and requirements.  Week 2:  Clay term, the concept of clay minerals, factors controlling the properties of the clay minerals, dispersion, scientific and industrial implications of clay minerals, the clay minerals cycle.  Week 3:  Weathering; physical, chemical, rates of weathering, hydrolysis, chemical weathering of basalts and andesites; granites and gneisses, abundance of minerals with increasing weathering rates, the effect of annual rainfall on clay minerals in soil, aquatolysis, halmyrolysis, bauxite and laterite.  Week 4:  Mudrocks, composition, colour, depositional environments, sedimentary structures characteristic to mudrocks, soil horizons, types of clays.  Week 5:  Analytical techniques, X-ray powder diffraction, Bragg's equation, relative intensity, the routine tests, differential thermal analysis (DTA), thermo-gravimetric analysis (TGA), IR spectral analysis, electron microscope, electron microprobe.  Week 6:  Clay minerals internal structure, tetrahedral and octahedral units, phyllosilicate families, diphormic, triphormic, tetraphormic. Inosilicate clay minerals, allophone and zeolites.  Week 7: Examination.  Week 8:  Ion exchange and sorption, cation exchange capacity, anion exchange capacity, causes and importance in clays. The clay-water interaction, the clay-organic matter interaction.  Week 9:  Mixed-layer clay minerals, regular, irregular, migration curves I-M and C-M, degraded clay minerals.  Week 10:  Classification of the phyllosilicates (Engelhard); kaolinite group, dioctahedral, crystallinity index, trioctahedral, genesis of kaolinite.  Week 11:  Illite group, structure and characteristics, degradation process, polytypes, dioctahedral and trioctahedral varieties. Chlorite group, structure and characteristics, the main chemical varieties, degraded, swelling and the soil chlorites.  Week 12:  Smectites group, structure and characteristics, dioctahedral, trioctahedral, expansibility, comparison with illites, origin of smectites, occurrence. Vermiculite group, structure and characteristics, varieties.  Week 13:  Genesis of clay minerals; thermodynamic stability fields, deep sea red clays: submarine alteration volcanic rocks, stages of palagonitization; celadonite, tonstiens, and characteristic of bentonites.  Week 14:  Green coloured mudrocks; varieties, forms of recent green-clay granules, the intensity of glauconitization, zonal and bathymetric distribution of the recent granules.  Week 15:  Burial diagenesis of clays; stages of water loss from sediments with depth, distribution of clay minerals in modern sediments, distribution of clay minerals through geological time.  Week 16:  Red coloured mudrocks; their environment and diagenesis. | | Dr. Farhad A. Mohammed (Ph.D.)  2 hours  20 /1 /2024 |
| **18. Practical Topics (If there is any)** | |  |
| Week 1:  Course outline and some instructions about the engagement and requirements.  Week 2:  *Setting velocity employing pipette method.*  Week 3:  *Sample preparations, pipette method and centrifuge method.*  Week 4:  *Oriented specimens.*  Week 5:  *X.R.D. pattern, diffractogram analysis.*  Week 6:  *Diagnosis of clay minerals in mixtures (K, I, M, C, V, Cg, Sep, Pal, Srp).*  Week 7: Examination.  Week 8:  *Semi-quantitative analysis of the X-ray diffractograms.*  Week 9:  *Mixed-layer clay minerals, regular, irregular.*  Week 10:  *Kaolinite group, crystallinity index-Hinckley, differentiation between kaolinite and chlorite in a mixture.*  Week 11:  *Illites, polytypes (dioc), open illite varieties, kubler acute index, Esquevin ratio.*  Week 12:  *Smectites, crystallinity index (Biscaye), crystallinity classes (Thorez). Vermiculites*  Week 13:  *Chlorites.*  Week 14:  *Clay minerals in hand specimens.* | | Dr. Farhad A.Mohammed (Ph.D.)  Mrs. Sirwa Saaed  2 hrs. per week |
| **19. Examinations:**  **Q/ Complete the following sentences:**  1- ---------------------------- is iron-rich trioctahedral chlorite.  2- Bentonite horizon characterized by --------------------------------- contacts.  3- Sodium montmorillonite has ---------------------------------- of water.  4- ------------------- imparts the green colour to chlorite.  5- ----------------------------- is removal of the adsorbed and absorbed molecules.  6- In ------------------------ mixed layer, there are rational series of basal reflections.  7- Dioctahedral layers are rich in -------------------- ions.  8- In DTA analysis, when deflection below, ---------------------------------- take place.  9- The open marine environment is ------------------------- in organic matter.  10- Smectite supplied to the marine farther than other minerals due to their ------------------.  **Q/ Rewrite the following sentences, and correct the underlines if they are wrong:**  1- The basal spacing of montmorillonite various with **calcium** molecules.  2- **Chamosite** is iron-rich illite with bright green colour.  3- Due to highly plasticity, **ball clay** is good for ceramic.  4- When deflections **bellow** in DTA analysis, recrystallization take place.  5- TEM resolution is **less** than SEM.  6- **Absorption** process is addition of molecules onto the grain surface.  7- Zeolite in chemistry is similar to **clays** .  8- In mudrock facies, the **black** colour is indicator to poor circulation.  **Q/ Talk about the following:**  1- Characteristics of bentonite horizon.  2- Importance of ion-exchange reactions in clays.    **Q/ Give the reasons of the following:**  1- Swelling in chlorite.  2- Degradation in illite.  **Q/ Compare between: (12)**  1-Kaolinite; and serpentinite structure.  2-Macrovermiculite; and desaturated vermiculite.  **Q/ Illustrate (with labeling):**  1- Stages of water loss from muddy sediments.  2- Relative abundance of minerals with increasing weathering rates.  3- Structure of inosilicate clay minerals. | | |
| **20. Extra notes:**  The course book lacks to the problems which affect the educational process. These problems include the large number of students in each stage, diminution of instruments, and absence of appropriate rooms for lecturers to develop themselves. Finally, about the department of geology absence of financial support to carry out scientific trips and field course in a typical situation. | | |
| **21. Peer review**  Assistant Prof. Dr. Hikmat S. Mustafa Al-Jaleel  College of Science / Department of Geology | | |