Ministry of Education
Federal University of Santa Maria
Rural Science Center
Graduate Program in Soil Science

Course: Soil Mineralogy

Identification

Code: SOL884
Credits: 4 (2 hours lecture – 2 hours practical)
Level: Master's/Doctoral
Professor: Fabrício de Araújo Pedron
Offering: Annual (Second Semester)

Course Objectives

To understand the structure, properties, and classification of geogenic and pedogenic minerals found in soils of tropical and subtropical environments, with emphasis on soils from Rio Grande do Sul. To discuss the main methods used in soil mineralogy studies and to develop skills in interpreting mineralogical data. To understand primary and secondary minerals involved in pedogenesis and their mineralogical evolution, as well as their implications for soil morphological, chemical, and physical properties. To study the application of soil mineralogical information in environmental and technological planning. To understand the main analytical procedures used for mineralogical characterization of soils.

Syllabus

The course on Soil Mineralogy initially addresses the mineralogical composition of the Earth's crust. It then covers elements of crystallography and the characterization of the main primary and secondary minerals found in soils. The main methods of mineralogical analysis are also studied, including sample preparation for X-ray diffraction and exercises on the interpretation of diffractograms and other mineralogical data. In the final part of the course, an analysis of the mineralogy of soils from Rio Grande do Sul is presented.

Methodology and/or Teaching Instruments

The course uses lectures, seminars based on scientific articles and mineralogical data analysis, field trips for the collection of soil, saprolite, and rock samples, visits to laboratories related to soil mineralogy, laboratory practices for sample preparation for mineralogical analyses, use of computational tools for processing mineralogical data, extracurricular activities such as scientific writing and reading of texts on soil mineralogy, and the development of applied projects in soil mineralogy.

Assessment Methods

Students will be evaluated through written examinations (theoretical and practical), seminar presentations, discussions of laboratory results, reports from field trips and laboratory activities, and presentation of final results from projects developed during the course.

Program: Title and Breakdown of the Units

Unit 1 – Composition of the Earth's Crust (Minerals and Rocks)

1.1 – Fundamentals of geology and composition of the Earth's crust
1.2 – Main soil-forming rocks in Rio Grande do Sul: mineralogical and chemical composition
1.3 – Macroscopic identification of minerals and rocks

Unit 2 – Elements of Crystallography

2.1 – Basic concepts: unit cell, crystal lattice, etc.
2.2 – Bravais lattices
2.3 – Crystallographic symmetry
2.4 – Crystal systems
2.5 – Miller indices

2.6 – Concepts of crystallochemistry
2.7 – Physical properties of minerals

Unit 3 – Main Primary Minerals Found in Soil

3.1 – Genesis of primary minerals
3.2 – Crystallographic and chemical characterization of primary minerals
3.3 – Weathering conditions of primary minerals
3.4 – Identification of primary minerals in mineralogical studies
3.5 – Influence of primary minerals on soil behavior

Unit 4 – Pedogenic Minerals: 2:1 and 2:1 HE Mineral Groups

4.1 – Main 2:1 minerals in soils
4.2 – Genesis of 2:1 minerals in soil
4.3 – Physicochemical properties of 2:1 minerals
4.4 – Identification of 2:1 minerals
4.5 – Genesis and characteristics of 2:1 HE minerals in soil
4.6 – Identification of 2:1 HE minerals
4.7 – Influence of 2:1 and 2:1 HE minerals on soil behavior

Unit 5 – Pedogenic Minerals: 1:1 Mineral Group

5.1 – Main 1:1 minerals in soils
5.2 – Genesis of 1:1 minerals in soil
5.3 – Physicochemical properties of 1:1 minerals
5.4 – Identification of 1:1 minerals
5.5 – Influence of 1:1 minerals on soil behavior

Unit 6 – Pedogenic Minerals: Oxides (Oxides, Hydroxides, and Oxyhydroxides)

6.1 – Main oxides in soils
6.2 – Genesis of oxides in soil
6.3 – Physicochemical properties of oxides
6.4 – Identification of oxides
6.5 – Influence of oxides on soil behavior

Unit 7 – Mineralogical Analysis Techniques

7.1 – Chemical dissolution methods
7.2 – X-ray fluorescence (XRF)
7.3 – Differential thermal analysis (DTA)
7.4 – Thermogravimetric analysis (TGA)
7.5 – Scanning electron microscopy (SEM)
7.6 – Transmission electron microscopy (TEM)
7.7 – Magnetic susceptibility
7.8 – Diffuse reflectance spectroscopy
7.9 – Other techniques

Unit 8 – Fundamentals of X-ray Diffraction (XRD)

8.1 – Electromagnetic spectrum
8.2 – Historical development of X-ray use
8.3 – Safety considerations in X-ray use
8.4 – Generation of X-rays
8.5 – Fundamentals of X-ray diffraction
8.6 – X-ray diffractometers

Unit 9 – Sample Preparation for X-ray Diffraction

9.1 – Particle-size separation (sand, silt, and clay)
9.2 – Powder samples and oriented samples
9.3 – Procedures for mineral identification

Unit 10 – Treatment and Interpretation of X-ray Diffractograms

10.1 – Configuration and interpretation of X-ray diffractograms
10.2 – Use of computational tools for digital analysis of diffractograms

Unit 11 – Environmental and Technological Applications of Soil Mineralogy: Case Studies

11.1 – Agricultural applications
11.2 – Geotechnical applications
11.3 – Industrial applications
11.4 – Sanitary applications
11.5 – Paleoclimatic applications
11.6 – Other applications

Unit 12 – Mineralogy of Soils from Rio Grande do Sul

12.1 – Regions of mineral weathering in Rio Grande do Sul
12.2 – Main soils and their mineralogical composition

Recommended Literature

DIXON, J. B.; SCHULZE, D. G. Soil mineralogy with environmental applications (Soil Science Society of America Book Series, No. 7). Madison: Soil Science Society of America, 2002.

MELO, V. F.; ALLEONI, L. R. F. Química e mineralogia do solo: conceitos básicos. V.1, Viçosa: SBCS, 2009. 695p.

RESENDE, M. et al. Mineralogia de solos brasileiros: interpretação e aplicação. Lavras: ed. UFLA, 2005. 192p.

AMONETTE, J. N.; ZELAZNY, L. W. Quantitative methods in soil mineralogy. Madison: SSSA, 1994. 462p.

KÄMPF, N. et al. Mineralogia de solos brasileiros. In: KER J. et al. (Eds.). Pedologia: fundamentos. Viçosa: SBCS, 2015.

KÄMPF, N.; CURI, N. Argilominerais em solos brasileiros. In: CURI, N. et al. (Eds.). Tópicos em ciência do solo. Viçosa: SBCS, 2003. v. 3, p.1-54.

KÄMPF, N.; CURI, N. Óxidos de ferro em solos brasileiros. In: NOVAIS, R. F. et al. (Eds.). Tópicos em ciência do solo. Viçosa: SBCS, 2000. v. 1, p.107-138.

MOORE, D. M.; REYNOLDS Jr., R. C. X-ray diffraction and the identification and analysis of clay minerals. 2 ed., New York: Oxford University Press, 1997. 378p.