Geos 656 - Paleopedology (3 Credits)

Lectures: Tues., Thurs. 9:45-11:15 a.m. – REIC 237
Prerequisites: Graduate standing or permission of instructor

Instructor: Dr. Paul McCarthy
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Office Hours: Monday & Friday 9:00-10:30 a.m., or by appointment

Recommended supplementary reading:

There is no required text for this course. Students may find information in some of the following references helpful. This is NOT a required reading list.

Retallack, G.J., 2001. Soils of the Past: an introduction to paleopedology. Blackwell Science, London.

Martini, I.P. and Chesworth, W., 1992. Weathering, Soils and Paleosols. Elsevier, Amsterdam.

Schaetzl, R. and Anderson, S., 2005. Soils: genesis and geomorphology. Cambridge University Press, Cambridge.

Buol, S.W., Southard, R.J., Graham, R.C. and McDaniel, P.A., 2003. Soil Genesis and Classification. Iowa State Press, Ames.

Birkeland, P.W., 1999. Soils and Geomorphology. Oxford University Press, London.

Fanning, D.S. and Fanning, M.C.B., 1989. Soil morphology genesis and classification. John Wiley & Sons, New York.

Duchaufour, P., 1982. Pedology. George, Allen & Unwin, London.

Course description:

A survey course focusing on the recognition and use of paleosols (fossil soils) as paleoenvironmental indicators, stratigraphic markers, and in paleogeographic reconstructions from Precambrian to Holocene. Examination of theories of soil formation, major soil processes and approaches to soil classification. Review of geochemical, mineralogical, morphological and micromorphological techniques. Use of paleosols for paleolandscape evolution and basin analysis. Geological, tectonic, archaeological and environmental applications of paleosols are discussed.

Course goals:

This is a lecture course designed to provide students with basic pedological and geological tools so that they can interpret the fossil soil record. By the end of the course, students will understand basic soil processes and soil types, be aware of analytical methods that can be used in identifying these processes in ancient soils, and understand the uses and limitations of paleosols for paleoenvironmental interpretation, stratigraphy and paleogeographic reconstructions. Students will also be aware of tectonic, environmental and archaeological applications of paleosols. Analysis and interpretation of paleopedological data through a major term project.

Tentative Class Schedule:

Week 1: Soil profiles and horizonization

- Definition of soil & paleosol
- Profiles, pedons, solum
- Soil horizon nomenclature

Sept. 7 - Term project topic determined

Week 2: Models and concepts of soil formation

- Functional-factorial model
- Process-systems model
- Energy model
- Soil thickness model
- Soil evolution model
- Other models

Week 3: Soil genesis and profile differentiation

- Eluviation-illuviation
- Process bundles
- Surface additions and losses

Week 4: Soil and Paleosol classification

- Approaches to soil classification
- Soil taxonomy
- Duchaufour
- Paleosol classification

Week 5: Recognition of fossil soils

- Root traces
- Soil horizons
- Soil structure
- Bioturbation and trace fossils

Week 6: Chemical and mineralogical analysis of paleosols

- Pre-Quaternary paleosols – molecular ratios, concentration ratios, mass balance
- Quaternary paleosols – bulk geochemistry, organic matter, extractable elements
- Clay mineralogy
- Parent material uniformity – chemical and mineralogical methods

Week 7: Micromorphological analysis of paleosols

- Sampling and thin section manufacture
- Systematic thin section description
- Micromorphological characteristics of soil orders
- Presentation and interpretation of micromorphological data

October 21 - Mid-term examination

Week 8: Alteration of paleosols during burial

- Burial decomposition of organic matter
- Burial gley
- Alteration of iron oxides and hydroxides
- Cementation of primary porosity
- Compaction
- Illitization

Week 9: Soil hydrology, geomorphology and paleolandscape reconstruction

- Catenas and pedofacies
- Soil geomorphology case studies, models & paradigms
- Soil hydrology and landscape evolution

Week 10: Soil stratigraphy

- Stratigraphic terminology, principles and geomorphic surfaces
- Pedostratigraphic units (geosols, pedoderms)
- Soil-forming intervals
- Soil facies

Week 11: Paleoenvironmental reconstruction

- Environmental pedo-signatures
- Reconstruction of past climates from paleosols
- Reconstruction of paleo-atmospheres from paleosols
- Caveats and complications

November 18 - First draft of research project due

Week 12: Time: soil development and surface exposure dating

- Soil development indices
- Chronosequences
- Numerical dating techniques

November 25 - Peer review of other student's research project due

Week 13: Geologic applications of paleosols

- Paleosols in aggradational systems
- Paleosols at unconformities
- Paleosols and sequence stratigraphy
- Sediment accumulation rates

Week 14: Fossil record of soils

- Precambrian paleosols
- Paleozoic paleosols
- Mesozoic paleosols
- Quaternary paleosols

December 12 - Final project report due
December 16 – 8-10 am - Final examination

Evaluation:

Students in the course will be evaluated on the basis of two examinations and a term project. The term project should be decided upon in consultation with the instructor. It will constitute an actual research project focused on either data collected and analyzed by you or data provided to you by the instructor. The term project should focus on the solution of a clearly identified problem, and it should be written up in the format of a scientific manuscript to a quality that would be suitable for publication (although publication is not expected, nor required).

Students should meet with the instructor by the end of the first week of classes to discuss and determine a topic for the research project. A completed draft of the research paper is due one month before the end of classes. Each draft report will be collected and given to another student for peer review. Students will receive copies of their draft report with accompanying reviews from a student peer reviewer and the instructor. The final report should incorporate feedback from the draft review. Deadlines for the various stages of the final report are included in the tentative class schedule above. The term project forms the major component of the student's grade.

Grading scheme:

Mid-term examination – 15%
Final examination – 25%
Term paper – 60% broken down as follows:

30% - first draft
10% - peer review of other student's paper
60% - final draft of term project