Department of Geology and Environmental Science

Program Goals and Objectives
Course Goals for Major Core Classes

This is the third of four documents detailing the Goals and Objectives in the department and focuses on the subject matter explored in the core classes for the BS and BA majors.

BS Degree Core Classes

Lynn S. Fichter and Eric Pyle
(With contributions from teachers of the Core Classes)
September 19, 2007

To compile this list the core teaching faculty were asked this question: *"For any and all core classes you teach in either the BS or BA program please list three to five categories of knowledge, principles, concepts, and skills you want your students to leave the class with. These are not detailed lists of subject matter, but broad categories."* Below is the compiled list.

Geol 110 - Physical Geology (composite list from faculty teaching the course) [1]

1. Earth Fractionation
   a. How did the core, mantle, and crust differentiate.
2. Rock Cycle Differentiation
   a. How do rocks differentiate: stated a different way how does the rocks cycle work
3. Plate Tectonics
   a. How does plate tectonics work?
   b. How was plate tectonic "discovered"
   c. How does energy from within the Earth drive Earth Processes
4. Surficial Processes
   a. How does energy from the Sun cause processes to operate at the Earth Surface
   b. How does rock and mineral composition in conjunction with rock deformation influence landscape evolution?
   c. What are the relative importance of running water, wind, ice, and gravity in shaping the landforms in which humans interact?
5. Human-Earth Interactions

[1] Note that the department is developing a program of multiple entry points into the major, meaning eventually that students taking any General Education course taught by the department (e.g. GGEOL102, GEOL110, GGEOL115 and a newly developing course in Environmental Geology) can use that course, along with a newly developing Common Lab focused on physical geology knowledge, as an entry point to the next tier of courses in either the BS or BA degree programs. This is a change from the old path where the only entry point for the major was through GEOL 110. The consequence is students entering the department will likely possess a greater diversity of knowledge about the Earth than is presented in GEOL 110.

a. How do humans interact with the Earth?
b. How do humans impact the planet?
c. How to humans respond to the planet?
d. How does the local geology (e.g. Virginia) and resultant topography influence the level of risk (geological hazards) of humans?

Geology 230 - Evolution of the Earth (Fichter)

1. Time
   a. The ways time information is stored in and retrieved from the geologic record.
   b. Origin and history of the geologic time scale.
   c. How and with what precision time is stored in the geologic record.
2. Geologic history
   a. Flow Regimes and sediment transport and deposition.
   b. Clastic sedimentary environments.
   c. Carbonate systems.
   d. Facies and time.
3. Biogeochemistry
   a. How the lithosphere, atmosphere, hydrosphere, and biosphere have interacted through the Earth's history.
4. Tectonic evolution
   a. Mechanisms and tectonic conditions of igneous and metamorphic rock evolution.
   b. Wilson and Supercontinent cycles.
   c. Growth of continents.
   d. Geologic Evolution of North America
5. Evolution
   a. Complex Systems Theory as it relates to:
      i. Biological evolutionary theory (elaborating evolutionary processes)
      ii. Fractionating evolutionary theory
      iii. Self-organizing evolutionary theory

Geol 280 - Mineralogy (Kearns)

1. Crystallography
   a. Know and recognize the 6 crystal systems.
   b. Understand the 4 external symmetry elements of crystals.
   c. Identify the crystal class (32 point groups).
   d. Recognize common, characteristic crystal forms.
   e. Understand the concepts of unit cells, crystal structures, crystal lattices, and Bravais Lattices.
   f. Understand Miller Indices and Hermann-Mauguin notation of point group symmetry.
2. X-ray Diffraction
   a. Understand the interaction of high energy electrons and atoms that lead to the production of characteristic X-rays.
   b. Know and Understand Braggs Law.
   c. Understand the basic concepts of an X-ray Diffraction phase identification.
3. Mineral Chemistry
   a. Develop a working knowledge of the chemical composition of the common rock forming minerals and ores.

b. Understand the Periodic Table and its relationship to present day quantum theory electron configuration.
c. Convert standard chemical analyses (elemental or oxide) into mineral formula or empirical formula.
d. Understand the relationships between geologic environments and the resulting chemical compositions of the minerals.

4. Physical Properties of Minerals
   a. Know the types of physical properties that characterize minerals.
   b. Be able to test for and use physical properties to identify phases.
5. General Goals
   a. Be able to recognize the common rock forming minerals and common metallic ore minerals.
   b. Understand the classification of mineral species.
   c. Finally know the difference between a rock and a mineral.

Geol 300 - Introduction to Petrology (Amenta)

1. Importance of igneous processes in geology.
   a. Identifying and classifying common igneous rocks through handspecimen study and, where possible, through microscope & thin section study.
   b. Geographic distribution of these rocks in orogenic belts such as the Appalachian Piedmont and Blue Ridge provinces.
   c. Rock textures (grain size, grain shapes, patterns of inclusions in grains) and models for using this data to understand relative timing of growth of the various minerals and for the evolution of the rocks.
   d. Fractional crystallization and its importance in the evolution of the igneous rocks that form Earth's crust. This is specifically dealt with by the following pedagogical approaches:
   e. Critical thinking via problem solving using phase diagrams to predict crystallization paths, system behavior at peritectic and eutectic points, system behavior with solid solutions and with solids of fixed compositions.
   f. Critical thinking and problem solving via computer simulation of high temperature crystallization experiments which provide data for construction of phase diagrams.
2. Metamorphic processes
   a. Principles of metamorphism as processes which transform rocks, especially the role of temperature, confining pressure, and fluid pressure and original rock chemical composition in controlling grade of metamorphism.
   b. Similar to those in igneous processes above
3. Reading journal literature and writing reports.
   a. Read and evaluate journal articles which present examples of topics discussed in class or which present alternative models to explain petrologic phenomena are assigned for reading.
   b. Write summary reports on these readings and make critical comments where appropriate, on the methodology and conclusions of the authors.

Geol 364 - Stratigraphy and Basin Analysis (Fichter)

1. Scientific Method
   a. Explain and implement scientific strategies for solving geologic problems.
2. Flow Regime and other Facies Elements
   a. Knowledge of the way energy is dissipated in depositional environments,
   b. The way those varying energies mold sediments into patterns,

c. Interpret ancient energy conditions from evidence found in sedimentary rocks.
d. Interpret the meaning of texture, composition, and color for sedimentary interpretations.

3. Accommodation
   a. The way in which tectonics, eustasy, and sediment supply interact to create space in which sediments can accumulate and leave a geologic record - essentially basin analysis.
   b. Sequence Theory: recognition and interpretation of patterns in the stratigraphic record that result from changes in accommodation.
4. Depositional Systems
   a. Energy dissipation and processes in common depositional environments on Earth.
   b. The processes by which environments evolve downstream.
   c. The tectonic conditions which favor the formation of specific sets of depositional environments.

Geology 365 - Structural Geology (Whitmeyer)

1. Geometric, Kinematic, Dynamic analyses
   a. Understand the concepts and methods of Geometric, Kinematic and Dynamic analyses of geologic structures
2. Brittle/Ductile Fabrics
   a. Differentiate between brittle and ductile (plastic) fabrics and structures and understand the associated processes of formation
3. Field Analysis
   a. Develop confidence in analyzing structures in the field within characteristic tectonic environments
4. Lab Techniques
   a. Develop confidence with techniques of structural analysis, such as construction of geologic maps & cross-sections, use of stereonets, and stress & strain measurement.
5. Fractal Tectonic analysis
   a. Develop the ability to link microstructures, hand samples, and outcrop-scale structures into a "big-picture" regional tectonic scenario.

Geol 399 - Field Geology (Whitmeyer)

1. Field Methods
   a. Become familiar with a variety of geologic field methods and techniques.
2. Confidence Building
   a. Develop student's confidence with taking field measurements and collecting field data.
   b. Develop student's confidence with constructing geologic maps and supporting materials (cross-sections, stereonets, documentation).
   c. Develop students' confidence in their ability to independently "do" geology in a professional capacity.

BA Degree Core Classes

For any and all core classes you teach in either the BS or BA program please list three to five categories of knowledge, principles, concepts, and skills you want you students to leave the class with. These are not detailed lists of subject matter, but broad categories.

Geol 167 - History and Philosophy of the Geosciences (Pyle, Whitmeyer, Fichter)

1. Nature of the geosciences and geoscientists
   a. Articulate the nature of the geosciences and the activity of geoscientists;
2. Frameworks for understanding Earth phenomena
   a. Introduce the concepts of earth-based and anthropocentric frameworks for understanding Earth phenomena;
3. Inquiry in the geosciences
   a. Define meaningful questions, appropriate methods, and representative solutions in the geosciences;
4. Major paradigms in the geosciences
   a. Describe significant paradigms that have emerged in the geosciences in the transition from mythological/religious views of discrete Earth phenomena to a complex Earth Systems view;
5. Research thrusts in the geosciences
   a. Introduce major research thrusts that have existed or are underway, to better represent the geosciences to non-scientific audiences.

Geol 211 - Introduction to Oceanography (St. John)

Oceanography GEOL 211 (St. John)

1. Physiography and geology of the ocean basins.
   a. Formation of the ocean basins and the contribution of marine science to the unifying theory of plate tectonics.
   b. Multi-component nature of marine sediments, with each component subject to its own distribution and abundance filters
2. Physical Oceanography
   a. Effect of temperature and salinity on density, and the role of density in deepwater circulation.
   b. Development of waves and tides, and their affect on shorelines.
   c. Role of winds and Ekman transport in generating dynamic topography and surface currents.
3. Bio-Geo-Chemistry of oceans
   a. Role of CO_2 as a source of C and as an ocean buffer
   b. Role of oceans as a C sink.
   c. Relative stability of biologically important environmental parameters in oceans.
   d. Measurement and distribution of marine primary productivity.
   e. Constant ratio between major dissolved components and total salinity
4. Affective Goals
   a. Preservice Teachers: Positioned to confidently and competently teach oceanography concepts at the secondary level by drawing from their personal experiences studying the oceans and by using effective instructional strategies and resources, including real world samples and data sets.
   b. All Students: Make connections among geological, chemical, physical, and biological processes in the world's oceans.

Geol 320 - Meterology (Ulanski)

1. Radiation principles as they relate to:
   a. Atmospheric processes and optics.

   b. Earth's radiation budget.
2. Atmospheric Dynamics
   a. Coriolis effect.
   b. Geostrophic, gradient and surface winds.
   c. Global Circulation.
3. Synoptic Weather
   a. Air masses and fronts.
   b. Cyclogenesis.
   c. Weather forecasting.
4. Severe weather analysis
   a. Thunderstorms
   b. Tornadoes
   c. Hurricanes

Geol 367 - Genesis of Solid Earth Materials (Pyle)

1. Characterize minerals by their chemistry, structure, physical properties, and context of occurrence;
2. Analyze and classify rocks on the basis of the minerals that make up those rocks;
3. Interpret the conditions that a rock formed under as a function of the minerals present in the rock;
4. Using classic localities around the world, utilize the mineral formation and assemblages as descriptors of interactive systems in the genesis of the rocks found at these locations.

Geol 377 - Earth Surface Processes (Sherwood and Eaton)

1. Plate tectonics and the major constituents of the earth's crust.
   a. Major processes involved in the Wilson Cycle.
   b. Identify major rock forming minerals using physical properties.
   c. Describe rock forming processes for the most important rock types comprising the earth's crust.
   d. Apply hands-on principles for the identification of igneous, sedimentary, and metamorphic rocks.
2. Construction and use of topographic maps.
   a. Use of equal-elevation contour lines to visualize three dimensional space.
   b. Methodologies involved in producing topographic maps.
   c. Construct topographic maps using surveyed elevation points.
   d. Accurately determine earth surface elevations, distances, slopes, and relief using topographic maps.
3. Role of fluvial systems in landscape evolution.
   a. Chemical and physical properties of water.
   b. Apply water properties to the dynamics of the hydrologic cycle.
   c. Drainage evolution and the genesis of fluvial landforms.
   d. IEarth surface erosion and denudation rates and the role of running water.
4. Study rock weathering and the evolution and properties of soils.
   a. Physical and chemical processes that weather rocks.
   b. Soil horizonation and soil profiles.
   c. Physical properties of soils such as texture, structure, color, and plasticity.

d. Soil taxonomy and how this classification system is used.
e. Identify in the field soil horizonation, profile development, texture, structure, color, and land use.

5. Survey the spectrum of earth surface processes other than fluvial processes and examine their role in landscape evolution.
   a. Groundwater processes at the earth's surface.
   b. Types and results of slope processes.
   c. Causes and effects of marine coastal processes.
   d. Role of mountain glaciers and continental ice sheets in altering the earth's surface.

Geol 467 - Stratigraphy, Structure, and Tectonics (Fichter and Whitmeyer)

1. Follow the Energy.
   a. The sources of the various kinds of energy that effect and control the styles and distributions of tectonic structures, and sedimentary sources and basins.
   b. How sources of tectonic energy and sedimentary energy interact to produce geologic events and records.
   c. How these energies are dissipated in commonly found tectonic and sedimentary regimes.
2. Accommodation
   a. The way in which tectonics, eustasy, and sediment supply interact to create space in which sediments can accumulate and leave a geologic record.
   b. Sequence Theory: recognition and interpretation of patterns in the stratigraphic record that result from changes in accommodation.
3. Basin Analysis
   a. Understand how tectonics affects the kinds of depositional systems that develop.
   b. Explain the large scale patterns in the stratigraphic record and the conditions that cause them.
4. Geometric, Kinematic, Dynamic analyses
   a. Differentiate between stress an strain and learn appropriate techniques of measurement.
   b. Identify deformed rocks and materials, and interpret kinematic and dynamic conditions during deformation.
5. Fractal Tectonic analysis
   a. "No rock is accidental." Develop the ability to link microstructures, hand samples, and outcrop-scale structures into a "big-picture" regional tectonic scenario.
6. Regional Geological Evolution
   a. Apply principles of structural geology and stratigraphy to describing and explaining the sequential evolution of the Mid-Atlantic region through 1.8 billion years of Earth history.
   b. Apply knowledge of local principles and history to understanding ancient and modern examples around the world.
   c. Identify and interpret sedimentary, stratigraphic and structural features in the field to determine ancient tectonic environments

Geol 477 - Contemporary Issues in the Geosciences (Pyle)

1. Describe the interconnectivity within the geosciences as well as with other sciences.
2. Synthesize and communicate the knowledge, skills, conventions, and habits of mind in the geosciences to non-scientific audiences.
3. Deepen the imperative of the need of an informed population with respect to the Geosciences.
4. Engage in a reflective analysis of the ethical, policy, and moral basis for study in the Earth sciences.

5. Develop a knowledge framework with respect to the Earth with utility in professional and personal endeavors.
6. Reinforce problem-solving skills applicable to the Earth Sciences.
7. Represent an aesthetic awareness of the physical environment as a dynamic system.
8. Express the political, economic, and sociological consequences of Earth resource management and mismanagement.
9. Evaluate the fundamental differences between science and systems.