Program Report for the Preparation of Earth Science Teachers Education Standards and Practices Board

COVER SHEET

Institution: <u>University of North Dakota</u>	State:	ND
Date SubmittedJanuary, 2008		
Name of Preparer: <u>Ronald K. Matheney</u>		
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Program documented in this report: Name of Institution's program: <u>Geology Teacher Education</u> Grade levels for which candidates are being prepared: <u>9-12</u> Degree or award level: <u>B.S. in Geology</u>		
Is this program offered at more than one site?		<u>x</u> No
Title of the state license for which candidates are prepared Earth Science		
Program report status:		

Rejoinder
 Response to national recognition with conditions

State licensure requirement for national recognition:

ESPB requires 80% of the program completers who have taken the test to pass the applicable state licensure test for the content field, if the state has a testing requirement. Does your institution require such a test? Test information and data must be reported in Section II

x Yes 🗌 No

REPORT

I. Contextual Information – Provides the opportunity for institutions to present general information to help reviewers understand the program.

Candidate Information

Directions: Provide three years of data on candidates enrolled in the program and completing the program, beginning with the most recent academic year for which numbers have been tabulated. Please report the data separately for the levels/tracks (e.g., baccalaureate, post-baccalaureate, alternate routes, master's, doctorate) being addressed in this report.

Program: Earth Science	2	
Academic Year	# of Candidates Enrolled in the Program	# of Program Completers
Sum04- Spr05	0	0
Sum05- Spr06	0	0
Sum06- Spr07	0	0

SCIENCE EDUCATION

I. Contextual Information & Program Response To ESPB Standards

Program: Earth Science

Descriptive Information About the Program (In a paragraph or two, describe the program-this is your chance to put your best programmatic foot forward.)

The B.S. in Geology is an intellectually challenging program designed to develop students' comprehension of Earth as a dynamic planet — a planet whose developmental history, current state, and ongoing processes can be explored and understood through systematic observation, application of the principles of geology and **allied sciences** (biology, chemistry, physics), and formal hypothesis testing. The **interdisciplinary nature of geology**, its **relationship to other sciences**, and its **relevance to human society** are embedded in nearly every class, explicitly or implicitly.

Beginning with our survey classes [Geol 101 (Introduction to Geology) and Geol 102 (Earth Through Time)], students are asked not just to parrot conclusions they were taught, but also to identify *how* Earth scientists reached those conclusions about the natural world. Why have alternative explanations been judged unsatisfactory? How can scientific conclusions – always tentative – be overturned? Thus, these classes assess students' grasp of the **nature of science** as well as the **methods of inquiry common to all sciences**. Development and exposition of critical thinking skills are paramount, as these are essential to the application of the "scientific method" and the successful communication of scientific findings.

Students are also asked to demonstrate an understanding of geologic hazards: *where* are certain types of hazards (e.g., large earthquakes, devastating volcanic eruptions, floods) most prevalent and *why*? What consequences flow from living on a dynamic planet, or from choosing to live in close proximity to a particular known hazard? We emphasize the role of geological sciences in evaluating natural resources such as groundwater, coal and petroleum, and explore the environmental consequences of extracting and using them. Students are expected to understand and anticipate how fluvial systems will respond to the construction of a dam, and how coastal systems will respond to the construction of breakwaters, jetties, and groins, and how the erection of levees affects the evolution of adjacent floodplains and increases the peril to downstream areas. These and similar questions illustrate the **context of Earth science** and its **importance in our society**. We intend for our graduates to be capable of making *informed choices* for themselves and — where they have a role in education or a voice in political processes — to help society make informed choices as well.

Introduction to Geology (Geol 101) gently introduces **lithosphere-hydrosphere-atmosphere interactions** through the study of chemical and physical weathering reactions, erosion, deposition and lithification of sediments, fluvial processes (including channel migration and flooding), glaciation (including hypothetical triggers for natural climate change, glacial landforms, and the marine response to changing volumes of continental ice and changing temperatures), and the climatic effects of large volcanic eruptions. Earth Through Time (Geol 102) touches again on these topics, but gives further consideration to the **biosphere**. What is the geologic record of life on Earth? How has the biosphere altered the atmosphere (and, consequently, the lithosphere)? Can we deduce anything about the possible environmental triggers for colossal "mass extinction" events documented in the fossil record? How can we "read" the record of climate contained in rocks? In both classes, we ask students to demonstrate comprehension of the **intellectual tools** that allow us to reconstruct Earth history from evidence preserved in the rock record.

In higher-level classes [e.g. Geol 330 (Structural Geology), Geol 321 (Geochemistry), Geol 411 (Sedimentology and Stratigraphy), Geol 414 (Applied Geophysics), GeoE 417 (Hydrogeology), and Geol 420 (Evolving Earth)], our treatment of the relationships between geology and other sciences deepens, as does our depth and breadth of inquiry. Knowledge and skills developed in prerequisite physics, chemistry, biology and math sequences are applied to geologic problems. In geochemistry, for example, students are shown (and later asked to derive) equations describing radioactive decay (linking the study of geology to chemistry, physics and calculus). These equations are then adapted to specific radiometric dating systems applicable to Earth materials (viz., potassium-argon dating, rubidium-strontium dating, uranium-lead dating, radiocarbon dating). Students are asked to solve these adapted equations (using real or "provisional" data) and to draw conclusions from their results. (How old is this granite? Why mightn't a date obtained using one radiometric method agree with that obtained using a different radiometric method (when is a "date" not an "age")? Can conflicting (discordant) results be interpreted with reference to the post-formational history of the material being dated (e.g., a subsequent hydrothermal alteration event (a lithosphere-hydrosphere interaction))? In addressing all such questions, students engage with the methods of science. In another part of the class, students work through calculations to deduce how the oxygen-isotope geochemistry of seawater would be expected to evolve in response to expansions or contractions of Earth's glacial ice sheets. Students then apply these results to interpret the *geologic record of climate* change preserved in the oxygen-isotope composition of marine fossils extracted from sediment layers now residing beneath the seafloor. This exercise is thus an interdisciplinary (geologychemistry) inquiry in atmosphere-hydrosphere-lithosphere-biosphere interaction.

A student's last three semesters in our program include a battery of complexly interrelated classes intended to help them mature as scientists and synthesize the whole of their prior training. In Geoscience Lectures (Geol 356), the emphasis is on helping students discover the characteristics of an **effective oral scientific presentation**. (Society cannot be expected to **value** scientific results that are not communicated effectively.) Students prepare written critiques of several talks (some given by visiting scientists, some by more advanced students), addressing issues of style as well as content. In Research I (Geol 487), students consult with a faculty advisor to identify a **research problem** that is to become the subject of their senior thesis. Students prepare a formal proposal specifying the **scientific question** they plan to address, **identifying hypotheses** they intend to discriminate between, and describing the **scientific methods** they will use. In Seminar I (Geol 421), students present this research proposal orally to the department as one of three scientific talks they must give during the term. Faculty attending this presentation rate the student's ability to **identify multiple scientific hypotheses** that might account for the phenomenon being studied, and the **fitness of the chosen methodologies to**

provide results capable of falsifying the hypotheses. (Seminar I students also continue to critique others' scientific talks just as they did in Geol 356.) In Research II (Geol 488), students carry out the research project proposed in Research I, engaging fully in **scientific methods** and **scientific inquiry**. In Geol 494 (Senior Thesis), students write up their study as a **scientific paper**, while in Geol 422 (Seminar II), they present their completed work orally to the department. Faculty rate this presentation for the clarity of its communication of a central problem, its identification of reasonable hypotheses, its **documentation of data gathering procedures**, the **soundness of interpretations** drawn from the data and their explicit use in **hypothesis testing**, and the arrival at a **reasonable conclusion** or answer to the original question. Each student's experience in this sequence is unique, but all students are expected to demonstrate knowledge of the **nature of science**, of scientific methods of **inquiry**, and of the **context** and worth of science within the culture.

13035.1 EARTH SCIENCE

The earth science program requires study including:

- the interdisciplinary nature of earth and space science, including lithosphere, atmosphere, hydrosphere, space and their relationships to humans and the environment;
- specialization in one of the earth and space sciences: astronomy, geology, meteorology, or oceanography;
- minimum of eight semester hours in geology (physical geology with lab and historical geology with lab)
- minimum of one semester each in astronomy and meteorology;
- the impact of technologies on the lithosphere, atmosphere, and hydrosphere;
- general chemistry I & II with labs (8 semester hours minimum);
- physics and biology with labs (4 semester hours each);
- study of mathematics through pre-calculus (college algebra and above) and statistics.

List course number, title and description and any accompanying activities or experiences in which students engage to meet the standard.

<u>Note:</u> Syllabi for Geology classes accompany this document. Where syllabi were furnished by multiple instructors (e.g., in instances of multiple sections with different teachers), all the furnished syllabi are included.

Each of this Standard's several provisions is addressed individually below.

- The Standard's requirement of specialization in one of the Earth sciences in met by completion of the degree requirements for the B.S. in Geology, detailed elsewhere.
- The Standard's requirement of a minimum of eight semester hours in geology (physical geology with lab and historical geology with lab) is met by completion of Geol 101/L and Geol 102/L in our B.S. program requirements.
- The Standard's requirements of a minimum of one semester each in astronomy and meteorology are met by the curricular provision that "Additional hours in science,

computer science, statistics, engineering, mathematics, or a foreign language must include courses in Biology, Atmospheric Sciences, and Astronomy."

- The Standard's requirement of general chemistry I & II with labs (8 semester hours minimum) is met by Chem 121/121L and Chem 122/122L (8 credits).
- The Standard's requirement of a minimum of four semester hours of physics with lab is satisfied by Phys 211/211L, 212/212L. College Physics I & II (8 credits).
- The Standard's requirement of a minimum of four semester hours of biology with lab is met by the curricular provision that "Additional hours in science, computer science, statistics, engineering, mathematics, or a foreign language must include courses in Biology, Atmospheric Sciences, and Astronomy."
- The Standard's requirement of the study of mathematics through pre-calculus (college algebra and above) and statistics is met by Math 165, Math 166 and Math 321 or Psyc 241.
- Descriptions of extra-departmental coursework specified in our curriculum in satisfaction of these Standards are as follows.

<u>Chem 121</u>. General Chemistry I. 3 credits. Prerequisite: Math 102. Corequisites: Chem 121L, Math 103 or an appropriate score on the Placement Testing Program (PTP). Open to all students; no high school credit in chemistry required. Elementary principles and theories of chemistry; matter, measurement, atoms, ions, molecules, reactions, chemical calculations, thermochemistry, bonding, molecular geometry, periodicity, gases.

<u>Chem 121L</u>. General Chemistry I Laboratory. 1 credit. Corequisite: Chem 121. Laboratory to accompany Chem 121.

<u>Chem 122</u>. General Chemistry II. 3 credits. Prerequisite: Chem 121. Corequisite: Chem 122L. Elementary principles and theories of chemistry; Intermolecular forces, liquids, solids, kinetics, equilibria, acids and bases. Solution of chemistry, precipitation, thermodynamics, electrochemistry.

<u>Chem 122L</u>. General Chemistry II Laboratory. 1 credit. Prerequisite: Chem 121L. Corequisite: Chem 122. Laboratory to accompany Chem 122.

Math 165. Calculus I. 4 credits. Prerequisites: PTP* or completion of Math 107 with a grade of C or better. Limits, continuity, differentiation, Mean Value Theorem, integration, Fundamental Theorem of Calculus.

Math 166. Calculus II. 4 credits. Prerequisite: Completion of Math 165 with a grade of C or better or permission of the Mathematics Department. Techniques and applications of integration, exponential and logarithmic functions, parametric equations, infinite sequences and series.

Math 321. Applied Statistical Methods. 3 credits. Prerequisite: Math 166. Introductory statistics for students with a background in single-variable calculus. Topics include descriptive statistics, continuous and discrete probability density functions, sampling distributions, point and interval estimation, and tests of hypotheses.

<u>Psyc 241</u>. Introduction to Statistics. 4 credits. Prerequisite: Math 103 or 104. Descriptive and inferential statistics as applied to psychological measurement and experimentation.

<u>Phys 211/211L</u>, <u>212/212L</u>. **College Physics I & II.** 8 credits. Prerequisites: For Phys 211, Math 103. For Phys 212, Phys 211. The non-calculus general physics course sequence recommended for pre-medical or pre-professional students. Topics: Newtonian mechanics and gravitation, work and energy, solids and fluids, heat and thermodynamics, vibrations and waves, electricity and magnetism, light and optics, and an introduction to modern physics. The laboratory is a corequisite of each course. A student may receive credit for only one beginning level physics sequence.

• Standards requiring study of (1) the interdisciplinary nature of Earth and space science, including lithosphere, atmosphere, hydrosphere, space and their relationships to humans and the environment, and (2) the impact of technologies on the lithosphere, atmosphere, and hydrosphere, are addressed repeatedly and with increasing sophistication throughout the B.S. in Geology curriculum. Students have opportunities to meet these standards by completing homework exercises, completing laboratory exercises, responding to examination and quiz questions, and by researching and writing a scientific paper. Departmental classes in which these Standards are addressed are listed and described below.

<u>Geol 101/101L</u>. Introduction to Geology/Lab. 4 credits. Introduction to the dynamics of Earth—volcanoes, earthquakes, plate tectonics, streams, groundwater, glaciers, waves, wind, and landslides, with emphasis on the environmental applications of these processes. Introduction to the tools of the geologist—minerals, rocks, maps, and aerial photographs. An introductory laboratory complements Geol 101, and includes field trip(s)

<u>Geol 102/102L</u>. Earth Through Time/Lab. 4 credits. The tracing of changes in Earth and life through time, with emphasis on the record from North America. An introductory laboratory complements Geol 102.

<u>Geol 318</u>. Mineralogy. 3 credits. Prerequisite: Geol 101 or GeoE 203, and Chem 121 or consent of instructor. Survey of the origin, distribution and uses of rock-forming minerals. Introduction to mineral structures, crystal chemistry, and crystallography. Laboratory identification of common minerals in hand sample and petrographic thin section. Introduction to the use of the polarizing microscope. Includes field trip.

<u>Geol 320</u>. Petrology. 3 credits. Prerequisite: Geol 318. Description, classification and origin of igneous, metamorphic, and sedimentary rocks. Field and laboratory study of

rocks. Engineering properties of earth materials. Advanced aspects of optical mineralogy. Includes laboratory.

<u>Geol 321</u>. Geochemistry. 3 credits. Prerequisite: Geol 318, Chem 122 and Math 166, or consent of instructor. Application of the principles of chemistry to geologic and hydrogeologic problems. Origin and distribution of the chemical elements. Introduction to radiochemistry, isotopic geochronology, and stable-isotope geochemistry.

<u>Geol 330</u>. Structural Geology. 3 credits. Prerequisites: Geol 318, Geol 320, and Math 105. Mechanics of rock deformation, analysis of rock structures, preparation and interpretation of geologic maps and cross sections showing structural and tectonic features. Includes laboratory.

<u>Geol 411</u>. Sedimentology and Stratigraphy. 5 credits. Prerequisite: Geol 320. Origin, transportation, deposition, and diagenesis of sediments; principles and applications of stratigraphy. Includes field trip and laboratory.

<u>Geol 414</u>. Applied Geophysics. 3 credits. Prerequisites: Geol 101, Math 265, Phys 212 or 252. Principles of various geophysical methods and their application to geologic problems.

<u>Geol 415</u>. Introduction to Paleontology. 4 credits. Prerequisite: Geol 102. Recommended: Biol 150, 151. The principles of paleontology/paleobiology are presented using fossils to document the evolutionary, stratigraphic, and paleoecologic history of animal and plant life on Earth. Includes field trip and laboratory.

<u>GeoE 417</u>. Hydrogeology. 3 credits. Prerequisite: Math 166 or consent of instructor. Physical and chemical aspects of groundwater movement, supply, and contamination.

<u>Geol 420</u>. The Evolving Earth. 3 credits. Prerequisite: Senior standing in Geology. A synthesis of the physical, biological, and chemical changes on Earth through time set within geologic systems and unifying concepts.

Assessments

a. Earth Science Praxis II Exam - No takers in the last 3 years

b. Included below are numerous examples, from all levels in the curriculum, illustrating coverage of (1) the interdisciplinary nature of Earth and space science, including lithosphere, atmosphere, hydrosphere, space and their relationships to humans and the environment, and (2) the impact of technologies on the lithosphere, atmosphere, and hydrosphere. Examples drawn from survey courses are more numerous and typically require only superficial familiarity with other sciences and math, while examples drawn from upper-level courses typically demand high levels of cognitive development and advanced reasoning skills. Several of our examples could be repeated under "Nature of Science," as

they show relationships between the sciences.

Geol 101/L. Introduction to Geology/Introduction to Geology Laboratory

- 1 a). Geologists estimate Earth's age to be _____ years.
 - b). What material was dated to determine Earth's age?
 - c). Explain *why* the age of this material (see part b, above) can be taken to indicate Earth's age. (Explain the reasoning.)*

*Note to ESPB: Interdisciplinary. Requires familiarity with a model of the formation of the solar system, from the science of cosmology.

- 2. High viscosity of magma is most closely correlated with high content of:
 - a) magnesium and iron (Mg and Fe); b) vanadium (V); c) carbon I;
 d) calcium carbonate (CaCO₃); e) silica (SiO₂).

*Note to ESPB: Interdisciplinary – Chemistry.

3. If the temperature of a magma decreases, the viscosity of that same magma:a) increases; b) decreases; c) remains the same.

*Note to ESPB: Interdisciplinary – Physics.

4. In the U.S., broadly speaking, one type of soil dominates west of the Mississippi River, and another soil type dominates east of the Mississippi River. Why does this geographic pattern exist?

*Note to ESPB: Interdisciplinary – Climate science.

5. Suppose that a limestone in Wyoming contains fossils that are identical to the fossils in a limestone found in Wales (United Kingdom). *Why* can I conclude that the limestone from Wyoming and the limestone from Wales are the same age?

*Note to ESPB: Interdisciplinary – Biology/evolution/paleontology.

- 6. The half life of a radioactive isotope is:
 - a. the time it takes for the radioactivity from that isotope to be gone;
 - b. half the time it takes for the radioactivity of that isotope to be gone;

c. the time it takes for radiation levels to become environmentally safe;

d. the time it takes for half of any given amount of the isotope to decay away;

e. half the useful life of the element.

*Note to ESPB: Interdisciplinary – Chemistry/Physics.

7. 235 U decays to 207 Pb with a half-life of 700 million years. Of these two isotopes, a mineral sample from granite has 235 U = 49% and radiogenic 207 Pb = 51%. The age of the granite is nearest:

- a) 2,100,000,000 years;
- b) 1,400,000,000 years;
- c) 700,000,000 years;
- d) 350,000,000 years;
- e) none of these.

*Note to ESPB: Interdisciplinary - Chemistry/Physics.

- 8. The earliest known fossils were apparently:
 - a) trilobites; b) amoebae; c) tribbles; d) bacteria; e) viruses.

*Note to ESPB: Interdisciplinary - Biology/evolution/paleontology.

- 9. Reptiles evolved from:
 - a) birds; b) fish; c) amphibians; d) mammals; e) dinosaurs

*Note to ESPB: Interdisciplinary - Biology/evolution/paleontology.

- 10. Birds evolved from:
 - a) pterodactyls; b) fish; c) amphibians; d) mammals; e) dinosaurs

*Note to ESPB: Interdisciplinary - Biology/evolution/paleontology.

- 11. Mammals evolved from:
 - a) birds; b) fish; c) amphibians; d) reptiles; e) bacteria

*Note to ESPB: Interdisciplinary - Biology/evolution/paleontology.

- 12. Amphibians evolved from:
 - a) birds; b) fish; c) reptiles; d) mammals; e) dinosaurs

*Note to ESPB: Interdisciplinary - Biology/evolution/paleontology.

13. Refraction refers to the:

a) bending of waves

- b) wavelength divided by wave height
- c) horizontal distance between two wave crests
- d) depth below which water does not move as a wave passes
- e) vertical distance between two wave crests

*Note to ESPB: Interdisciplinary - Physics.

14. A difference between elastic deformation and plastic deformation is that:

- a) elastic deformation is permanent
- b) plastic deformation is permanent
- c) elastic deformation is brittle
- d) plastic deformation is brittle
- e) plastic deformation is temporary

*Note to ESPB: Interdisciplinary - Physics.

Use the following table to answer questions 15, 16, and 17. A seismograph in

Denver registers the arrival times of seismic body waves of five earthquakes over two days as follows:

Date	P-wave	S-wave
a) Dec. 12, 2006	8:33 a.m.	8:43 a.m.
b) Dec. 12, 2006	1:14 p.m.	1:17 p.m.
c) Dec. 12, 2006	4:20 p.m.	4:40 p.m.
d) Dec. 12, 2006	6:12 p.m.	6:22 p.m.
e) Dec. 13, 2006	9:15 p.m.	9:23 p.m.

15. (See table above.) Which earthquake was closest to Denver?a) b) c) d) e)

*Note to ESPB: Interdisciplinary - Physics.

16. (See table above.) Which earthquake was farthest from Denver?a) b) c) d) e)

*Note to ESPB: Interdisciplinary - Physics.

17. (See table above.) Which earthquake could have been an <u>aftershock</u> of another of the quakes shown?

a) b) c) d) e)

*Note to ESPB: Interdisciplinary - Physics.

18. One way we know Earth's outer core is liquid is that:

a) P waves are not received by seismographs in a large zone on the side of Earth opposite an earthquake

b) S waves are not received by seismographs in a large zone on the side of Earth opposite an earthquake

c) surface waves are not received by seismographs in a large zone on the side of Earth opposite an earthquake

d) P waves can only travel through liquids

e) the P waves and the S waves get closer together after moving through the core.

*Note to ESPB: Interdisciplinary - Physics.

- 19. The distance between a seismograph and the source of an earthquake can be determined from:
 - a) calculation of the earthquake's magnitude
 - b) the intensity of the quake as recorded on the seismograph
 - c) the height of the p waves
 - d) the height of the s waves
 - e) the arrival times of the p and s waves

*Note to ESPB: Interdisciplinary - Physics.

20. The epicenter of an earthquake can be determined if:

a) the quake is recorded by the Richter Memorial Seismograph in Washington, D.C.

b) three seismographs detect the p waves

c) P waves, S waves, and L waves from the quake are recorded by seismographs at two different locations

d) P waves and S waves from the quake are recorded by seismographs at three different locations

e) S waves and L waves from the quake are recorded by seismographs at four different locations

*Note to ESPB: Interdisciplinary - Physics.

21. In the diagram below, sketch in and label each of the following:



Then, add a <u>flowing artesian well</u>. Put shading within that well to indicate <u>precisely</u> how high water will rise. Then place <u>an arrow</u> within the confined aquifer to indication direction of its water flow.

*Note to ESPB: Interdisciplinary - Physics. Lithosphere/hydrosphere interactions. Human/environment relationships.

- 22. Piers or groins disturb the beach primarily by:
 - a) increasing the angle of wave refraction
 - b) interfering with longshore drift
 - c) decreasing the angle of wave refraction
 - d) lowering local wave base

e) raising local sea level

*Note to ESPB: Impact of technologies on lithosphere, hydrosphere, atmosphere. Human/environment relationships.

- 23. As water is withdrawn from a well, the water table near the well drops and forms a(n)
 - a) travertine deposit
 - b) artesian system
 - c) dowser
 - d) contamination zone
 - e) cone of depression.

*Note to ESPB: Impact of technologies on lithosphere, hydrosphere, atmosphere.

- 24. When a new dam is placed on a graded river, the portion of the river immediately *upstream* of the dam responds by:
 - a) straightening its channel;
 - b) meandering;
 - c) depositing its load;
 - d) increasing its competence
 - e) increasing its gradient.

*Note to ESPB: Impact of technologies on lithosphere, hydrosphere, atmosphere. Human/environment relationships.

25. What was the name of the volcano in Columbia that killed a bunch of geologists and injured Stanley Williams? How did the UND geologists who were there escape injury?

*Note to ESPB: Human/environment relationships.

26. The June 1991 eruption of Pinatubo (on the island of Luzon in the Philippines) was a very significant eruption for a number of reasons. What kind of eruption was it? Describe the nature of the eruption, how big it was, etc. What happened to the U.S. military people stationed at Clark Air Force Base? Pinatubo killed nearly 1000 people. How did they die?

*Note to ESPB: Human/environment relationships.

- 27. Maurice and Katya Kraft
 - a. invented the reflecting goniometer
 - b. were killed by a volcano
 - c. are the names of the (hypothetical) first minerals ever discovered
 - d. were the first people to figure out that continents drift

e. are responsible for coming up with the system for dividing minerals into classes

- 28. The reason over 50 people died when Mt. St. Helens erupted is because
 - a. the eruption took place on Monday
 - b. the eruption was a fissure eruption
 - c. the eruption was a complete surprise
 - d. people didn't believe the warnings and were too close
 - e. the basalt flowed over the ground at high speed
- 29. In what part of the world are petroleum reserves shrinking:
 - a. United States and Canada
 - b. South America and Central America
 - c. Africa
 - d. Persian Gulf
 - e. all of the above
- 30. Which of the following is a problem with coal as an energy source? a. it produces CO₂ when burned
 - b. mining it can sometimes turn surface areas into scarred wastelands
 - c. underground coal mining is very hazardous
 - d. it often produces sulfur and other pollutants when burned
 - e. all of the above
- 31. Most of the world's major economic mineral deposits are in a. shield areas
 - b. subduction zones
 - c. the deepest parts of the ocean
 - d. the shallowest parts of the ocean
 - e. depositional basins
- 32. Since the industrial revolution, the concentration of CO₂ in Earth's atmosphere has ______ and the average Earth temperature has
 - a. gone down; gone down
 - b. gone down; gone up
 - c. gone up; gone down
 - d. gone up; gone up
 - e. all of the above
- 33. Earth's climate has varied a lot throughout geological time. What are the (natural) short term causes for the variation? What are long term causes of climate change?
- 34. In what year (approx.) did U.S. oil production peak?

- 35. In what year (approx.) did world oil production peak?
- 36. Describe, in order, from first to last, the geologic <u>events</u> that have occurred at this roadcut location. Include both <u>specific</u> features <u>and</u> processes. One of the <u>events</u> is not labeled.





*Note to ESPB: In this task, students must come to grips with the realization that time is immense and that humans have been here but a geologic instant. Students cannot escape thinking about the relationship between humans and the environment once they learn of deep time and how briefly humans have been here. Homework involves students in working with geologic time puzzles, using relative dating principles to establish an order of events and processes.

37. Lab 7 Streams: Activity 2B,C) the figure shows a stream profile interrupted by a reservoir behind an earthen dam. What will happen to the stream gradient upstream of the dam? After the reservoir becomes filled with sediment, what will the stream eventually accomplish? Explain thoroughly.

38. Lab 8 Groundwater: Activity 2) Using actual case history data, predict groundwater flow paths through a residential area and predict basement water problems. Activity 3) Determine groundwater levels in a karst terrain and predict the flow path for municipal liquid wastes.

Geol 102/L. Earth Through Time/Earth Through Time Laboratory

1. Hydrogen and helium, the first two elements in the Periodic Table, formed very soon after the Big Bang. Where did the other elements in the Periodic Table (and 88 additional ones are found naturally on Earth) come from? [About two well-crafted sentences should suffice if you know the answer and are a capable writer.]

*Note to ESPB: Interdisciplinary - Astrophysics, nuclear physics, nuclear chemistry.

- 2. Many Earth scientists think the lithospheric plates move mainly because of: a) centripetal forces flinging them away from the poles
 - b) flip-flops of the North and South poles of Earth's magnetic field
 - c) the interaction between gravity and Earth=s rotation
 - d) convection in the crust
 - e) convection in the aesthenosphere

*Note to ESPB: Interdisciplinary - Physics.

3. ²³⁵U decays to ²⁰⁷Pb with a half-life of 700 million years. Of these two isotopes, a mineral sample from granite has ²³⁵U = 25% and radiogenic ²⁰⁷Pb = 75%. The age of the granite is:
a) 2,100,000,000 years; b) 1,400,000,000 years; c) 700,000,000 years;
d) 350,000,000 years; e) none of these.

*Note to ESPB: Interdisciplinary - Chemistry/Physics.

- The decay curve for radioactive isotope X is shown below [Omitted in ESPB report]. The y axis label says "% radioactive parent remaining." The x axis label says "elapsed time, in billions of years." The half-life of X is:
 a) 1 billion years
 - b) 2 billion years
 - c) 3 billion years
 - d) more than 6 billion years
 - e) unknown from this information

*Note to ESPB: Interdisciplinary – Chemistry/Physics.

5. *Explain* the concept of <u>Natural Selection</u>. (Your reader (me) must be able to tell that you understand it.)

*Note to ESPB: Interdisciplinary – Biology.

6. Reefs do not grow in muddy water because:

- a) muddy water is invariably too salty
- b) reef organisms feed on sand, not mud
- c) the silica content of mud is too high, and would be toxic to corals
- d) mud would clog the feeding pores of corals
- e) mud is just dumb spelled backward.

*Note to ESPB: Interdisciplinary – Biology.

7. In the process of evolution by natural selection, the genetic material that comes to dominate in succeeding generations is that possessed by individuals who:

- a) are strongest
- b) are smartest
- c) obtain the most resources
- d) reproduce the most successfully;
- e) are best adapted to struggle with a harsh environment.

*Note to ESPB: Interdisciplinary – Biology.

- 8. The hip bones of baleen whales have been cited as an example of:
 - a) an adaptation
 - b) a mutation
 - c) how ontogeny recapitulates phylogeny
 - d) vestigial organs
 - e) homologous organs.

*Note to ESPB: Interdisciplinary – Biology.

- 9. According to the concept of punctuated equilibrium:
 - a) the most common evolutionary trend is increase in size
 - b) most species that ever existed are now extinct
 - c) species change gradually and continually over millions of years
 - d) new species arise rapidly, in perhaps only a few thousand years
 - e) more species are alive now that at any other time in Earth history

*Note to ESPB: Interdisciplinary – Biology.

- 10. The evolution of a new species in a geographic area isolated from the remainder of the parent species is:
 - (a) homologous differentiation
 - (b) allopatric speciation
 - (c) geographic divergence
 - (d) genetic opportunism
 - (e) mosaic evolution

*Note to ESPB: Interdisciplinary – Biology.

- 11. The existence of embryological similarities between groups of animals that are dissimilar as adults is the subject of:
 - (a) fossil succession
 - (b) mosaic evolution;
 - (c) Haeckel's law
 - (d) adaptation;
 - (e) allopatric speciation

*Note to ESPB: Interdisciplinary – Biology.

12. Write down, in vertical order, the names of the levels in the Linnaean classification.

*Note to ESPB: Interdisciplinary – Biology.

- 13. The "Jupiter Jugs" experiment by Harold Urey and Stanley Miller produced:
 - a) the first artificial life forms d) chert nodules
 - b) amino acids e) stromatolite-like mounds
 - b) oxygen gas

*Note to ESPB: Interdisciplinary – Biology/Chemistry.

- 14. Results of the Jupiter Jugs experiment suggest that:
 - a) life could not have evolved without plenty of free oxygen gas
 - b) life could not have evolved in the presence of much free oxygen
 - c) cherts cannot form without abundant oxygen gas
 - d) greenstone belts are green because of oxygen gas from stromatolites
 - e) ontogeny recapitulates phylogeny

*Note to ESPB: Interdisciplinary - Biology/Chemistry.

15. Banded iron formations are significant because they may show that:

a) glaciers actually existed much closer to the equator than previously thought;

b) glaciation lasted much longer than previously thought;

c) the Jupiter Jugs experiment was flawed;

d) atmospheric oxygen levels had increased;

e) there were actually two intervals of intense glaciation in the Proterozoic, separated by hundreds of millions of years or more.

*Note to ESPB: Interdisciplinary - Chemistry.

- 16. Eukaryotes:
 - a) are all autotrophic consumers;
 - b) have a membrane-bounded cell nucleus;
 - c) are a Phylum within the Kingdom Protistae;

d) appear earlier in the fossil record than prokaryotes;

e) all of the above.

*Note to ESPB: Interdisciplinary - Biology.

17. If all other things remain constant, sea level drops when glaciers grow.a) true; b) false.

*Note to ESPB: Interdisciplinary - Lithosphere/Hydrosphere relationships.

- 18. The Proterozoic/Cambrian boundary represents approximately what stage in the evolution of life?
 - a) the appearance of the first eukaryotic consumers
 - b) the first appearance of invertebrates
 - c) the first appearance of vertebrates
 - d) the appearance of many animals with skeletons
 - e) the appearance of the first animals to leave the sea

*Note to ESPB: Interdisciplinary -Biology.

- 19. Fossils from the Burgess Shale in the Canadian Rockies:
 - a) record the exact moment of the "Cambrian explosion"
 - b) include rarely preserved internal organs of Cambrian animals
 - c) are also known as the Tommotian fauna or "small shelly fauna"
 - d) show that the number of Phyla have been increasing steadily over time e) all of these.

*Note to ESPB: Interdisciplinary –Biology.

- 20. The percentage of Earth history during which there were apparently <u>no</u> multicelled land plants is closest to:
 - a) 19%; b) 38%; c) 54%; d) 76%; e) 92%.

*Note to ESPB: Interdisciplinary – Biology.

- 21. Ferns and rushes are examples of:
 - a) gymnosperms; b) angiosperms; c) seed ferns; d) conifers;
 - e) spore-bearing plants.

*Note to ESPB: Interdisciplinary – Biology.

- 22. Flowering plants first appeared in the:
 - a) Paleocene; b) Ordovician; c) Mesozoic; d) Pennsylvanian;
 - e) Pleistocene.

*Note to ESPB: Interdisciplinary - Biology.

- 23. A characteristic of many gymnosperms is that they:
 - a) are amphibians;
 - b) have specialized teeth;
 - c) have seeds that hang naked on cones;
 - d) release spores for reproduction;
 - e) bury their eggs in a moist environment.

*Note to ESPB: Interdisciplinary – Biology.

- 24. Amphibians evolved from:
 - a) placoderms; b) reptiles; c) lobe-finned fish; d) archaeocyathids; e) mammals.

*Note to ESPB: Interdisciplinary – Biology.

25. The amniote egg was developed earliest by:a) birds; b) teleost fishes; c) mammals; d) reptiles; e) gymnosperms.

*Note to ESPB: Interdisciplinary – Biology.

26. Give the common names (not the "scientific names") of 5 angiosperms.

*Note to ESPB: Interdisciplinary – Biology.

27. ______undergo a dramatic metamorphosis during which they grow new limbs adapting them to a different existence. In a sense, these organisms have "two lives."

a) rushes; b) angiosperms; c) reptiles; d) amphibians; e) gymnosperms

*Note to ESPB: Interdisciplinary – Biology.

28. Current ideas favor that birds evolved from:a) pterosaurs; b) therapsids; c) mammals; d) ichthyosaurs; e) dinosaurs.

*Note to ESPB: Interdisciplinary – Biology.

- 29. Which of these is a reptile group that gave rise to the mammals?
 - a) thecodonts; b) saurischians; c) acanthodians; d) salamanders;
 - e) therapsids.

*Note to ESPB: Interdisciplinary – Biology.

30. A high abundance of ______ in some K-T boundary sediments may indicate that an asteroid struck Earth 66 m.y. ago.
a) thorium; b) uranium; c) iridium; d) cadmium; e) calcium.

*Note to ESPB: Interdisciplinary – Chemistry/Cosmochemistry.

31. Dinosaurs can be classified into two <u>Orders</u> on the basis of their:a) diets; b) teeth; c) forelimbs ("arms"); d) phalanges; e) pelvic bones.

*Note to ESPB: Interdisciplinary – Biology.

32. All dinosaurs belonged to the <u>Class</u>:a) mammalia; b) dinosauria; c) amphibia; d) saurischia; e) reptilian

*Note to ESPB: Interdisciplinary - Biology.

- 33. Egg-laying mammals are classified as _____; two examples are _____ and _____.
 - a) placentals; beavers, ostriches
 - b) placentals; cattle, humans
 - c) marsupials; ostriches, racoons
 - d) marsupials; opossums, kangaroos
 - e) monotremes; spiny anteaters, platypuses

*Note to ESPB: Interdisciplinary - Biology.

- 34. Mammals whose young mature in the mother's external pouch are classified
 - as _____; two examples are _____ and _____.
 - a) placentals; beavers, ostriches
 - b) placentals; cattle, humans
 - c) marsupials; ostriches, racoons
 - d) marsupials; opossums, kangaroos
 - e) monotremes; spiny anteaters, platypuses

*Note to ESPB: Interdisciplinary - Biology.

35. Mammals characterized by live birth and no external pouch are classified as

____; two examples are _____ and _____.

- a) placentals; beavers, ostriches
- b) placentals; cattle, humans
- c) marsupials; ostriches, racoons
- d) marsupials; opossums, kangaroos
- e) monotremes; spiny anteaters, platypuses

*Note to ESPB: Interdisciplinary - Biology.

- 36. Australia is noteworthy for its large native population of _____, all of which evolved from _____.
 - a) carnivores; herbivores
 - b) monotremes; diatremes
 - c) marsupials; opossums
 - d) marsupials; placentals
 - e) placentals; marsupials

*Note to ESPB: Interdisciplinary - Biology.

37. Mammals with high-crowned teeth are generally:

a) carnivores b) grazers c) browsers d) marsupials e) monotremes

*Note to ESPB: Interdisciplinary - Biology.

38. At some time prior to the arrival of Columbus, all of the following characterized *Cenozoic* life in North America <u>EXCEPT</u>:

a) tropical and subtropical forests retreated and grasslands and dry woodlands moved in

- b) horses became extinct here
- c) kangaroos and pterosaurs lived here
- d) elephants and camels lived here
- e) giant ground sloths and armadillos lived here

*Note to ESPB: Interdisciplinary - Biology.

39. Mammal fossils are readily identified by their:

a) increasing size through timeb) thick skullsc) vestigial leg bonesd) differentiated teethe) homologous organs

*Note to ESPB: Interdisciplinary - Biology.

- 40. What is (or was) *Glossopteris*?
- 41. Does the distribution of <u>Glossopteris</u> *support* or *challange* the idea that the continents were once connected?
- 42. Demonstrate critical thinking skills (a GER goal) by thoroughly explaining <u>why</u> the distribution of *Glossopteris* either *supports* or *challenges* the idea that the continents were once connected. Convince the reader that other potential explanations for Glossopteris' distribution are inadequate, and that yours is the most reasonable. Organize your thoughts before setting pencil to paper. Write legibly if you want any credit at all.
- 43. Earth's age has been determined from:a) the time elapsed since the Big Bang

b) radiometric age dating of rocks from Canada's Northwest Territories c) an estimate of how long it would take for the sea to reach its present saltiness

d) a calculation of how long it would have taken for Earth to cool to its present temperature, given its distance from the sun.

e) radiometric age dating of some meteorites and moon rocks that are thought to have formed at the same time as Earth

Geol 318: Mineralogy

- 1. Some people say that mineralogy is not really a field. They argue that it borrows from a bunch of other sciences, repackages ideas, and then calls it something new. What other sciences contribute the most to mineral science? And, what aspects of mineralogy, if any, are unique to mineralogy?
- 2. A few years ago the UND Plant Services came to put in some new computer wiring but spotted what they thought was asbestos and refused to do the work. I looked at it quickly using a petrographic microscope and assured them that it was fiberglass. (They didn't believe me and spent lots of money sending a sample out for analysis, but I was correct.) What property distinguishes asbestos from glass fibers (fiberglass) when they are viewed using a petrologic microscope?
- 3. Although sulfides are often good ore minerals, there are environmental problems associated with processing them. What are the problems and what can be done to solve them?
- 4. Mining companies often argue that "you have to mine ore deposits where you find them." They use this argument when they discover an ore deposit in an area that was previously off limits to mining. What do you think about their argument?
- 5. Oil, gas and coal are very important to our modern society. Yet, we develop and use them with a cost. There are costs associated with exploring, extracting and refining fossil fuels. And, there are costs associated with using fossil fuels. Discuss both kinds of costs, and tell me: what if anything should/can we do to control or limit those costs?

Geol 320: Petrology

- 1. When plagioclase feldspar melts, the melt is (initially) a different composition than the original feldspar. How can that happen if the overall composition of the system does not change?
- 2. How can trace element chemistry be used to determine the origins and relationships of igneous rocks?

- 3. Why are silicic magmas more viscous than mafic magmas?
- 4. What is the (approximate) weight % of SiO_2 in a granite and in a basalt?
- 5. What, in order, are the five most abundant elements in the Earth's crust?
- 6. What is a geotherm? Where on the globe can we find the steepest geotherms? Where the opposite where are the least steep geotherms?

Geol 321: Geochemistry

1. The data in the table below were obtained for minerals separated from a sample of the Taekitfore Granite in the Golden Hills of the Land of Oz.

Sample	⁸⁷ Rb/ ⁸⁶ Sr	⁸⁷ Sr/ ⁸⁶ Sr	
Biotite	250	2.1698	
K-spar	5.9	0.8126	
Plagioclase	0.510	0.7827	
11	1		

Use $\lambda_{87} = 1.42 \times 10^{-11} a^{-1}$.

a) Construct an Rb-Sr mineral isochron diagram, and use it to determine the age (t) and initial ratio $[({}^{87}\text{Sr}/{}^{86}\text{Sr})_o]$ of this igneous rock. Use your graph paper to full advantage.

b) Use the method of least squares to re-determine the age and initial ratio of the rock.

The answers you get by method (a) should agree well with the answers you get by method (b). If they do not, you have made a mistake.

2. Isotopic analyses of four whole-rock samples of the Icarus Pluton, Northern Light Lake, Ontario, are given below. Plot and fit a whole-rock isochron to these data (use the paper fully) and determine the age (t) and the initial ratio [(⁸⁷Sr/⁸⁶Sr)_o] of this rock.

Sample	⁸⁷ Rb/ ⁸⁶ Sr	⁸⁷ Sr/ ⁸⁶ Sr
21	0.1564	0.7068
22	0.0755	0.7037
23	0.2160	0.7091
24	0.3280	0.7133

Use $\lambda_{87} = 1.42 \text{ x } 10^{-11} \text{ a}^{-1}$.

- 3. A piece of biotite from an igneous rock yielded the following results: K = 7.34 wt.%, ${}^{40}Ar = 24.5 \times 10^{-7} \text{ cm}^3/\text{g} (25^{\circ}\text{C}, 1 \text{ atm})$. If all of the ${}^{40}Ar$ is radiogenic, calculate the age of the sample. Use the following quantities: ${}^{40}K = 0.01167\%$ of all K. $\lambda_{\beta} = 4.962 \times 10^{-10} \text{ a}^{-1}$ $\lambda_{\kappa} = 0.581 \times 10^{-10} \text{ a}^{-1}$
- 4. A sample of biotite and a sample of muscovite from a hand sample of a certain pluton gave the following results:

Mineral	wt% K ₂ O	⁴⁰ Ar* moles/g	
Biotite	7.90	6.996 x 10 ⁻¹⁰	
Muscovite	10.72	13.66 x 10 ⁻¹⁰	

Determine dates for each and offer a plausible explanation for why they are different. You can assume that the true crystallization ages of the biotite and muscovite are identical.

5. A small pluton in northeastern Washington contains biotite and hornblende with analyses as follows:

Mineral	wt% K ₂ O	⁴⁰ Ar* moles/g	
Biotite	8.71	12.83 x 10 ⁻¹⁰	
Hornblende	1.44	4.348 x 10 ⁻¹⁰	

Calculate dates for both minerals, explain why they are different, and then speculate about the *age* of this pluton assuming that it may have been reheated during a later phase of intrusive activity in this area.

6. (a) Construct a 207*/235 versus 206*/238 **concordia plot**. (First, complete the table on the next page by <u>calculating</u> 207*/235 and 206*/238 ratios for each of the times listed. Use $\lambda_{238} = 1.55125 \times 10^{-10}$ and $\lambda_{235} = 9.8485 \times 10^{-10}$. Then use a piece of graph paper to plot the solutions. Plot ${}^{207}\text{Pb*}/{}^{235}\text{U}$ on the horizontal axis, and ${}^{206}\text{Pb*}/{}^{238}\text{U}$ on the vertical axis. Plan ahead so that you use almost the entire sheet of paper. Draw a smooth curve to connect the points. Your final concordia curve should strongly resemble the one in Fig. 16.5, p. 289, of Faure.)

(b) <u>Calculate</u> concordant 207 Pb*/ 235 U and 206 Pb*/ 238 U values for a sample that is 2.65 billion years old.

7. The isotope ratios in the table below were obtained from minerals separated from a group of associated rocks. They have already been corrected for the isotopic composition of initial (non-radiogenic) lead.

(a) Recast the data as necessary, complete the appropriate columns in the table below, and plot the results on the concordia diagram developed in problem 6.

Don't forget that ${}^{238}U/{}^{235}U = 137.88$ today.

(b) Do the minerals give concordant dates or discordant dates?

(c) What is the age of the rocks?

(d) Where do you suppose these samples came from? (Hint: carefully consider the apparent crystallization age of the suite.)

	(Corrected ratio	DS			
Sample	206/204	207/204	238/204	207/235	206/238	
12070	433.4	251.7	495.5			
12033	1134.0	577.6	1581.0			
12013,10	1201.7	641.6	1612.0			

- 8. Explain why zircons are excellent candidates for dating by the U–>Pb methods. (Hint: carefully consider the geochemistry of Zr, U, and Pb ions, and how Goldschmidt's rules come into play. Refer back to problem 8.7 in the textbook if necessary.)
- 9. You discover a fossil tree in what appears to be an earthquake-related landslide deposit. The ¹⁴C activity of the dead wood is determined to be 1.3 disintegrations per minute per gram of carbon. The ¹⁴C activity of a similar living tree analyzed in the same way in the year 1950* was 13.56 dpm/gC. When did the earthquake occur (in years before the present)? Assume that the half-life of ¹⁴C is 5730 years.

*1950 is a landmark year because this is just before the U.S. and other countries began exploding H-bombs in the atmosphere. H-bombs trigger the formation of excess ¹⁴C, which would cause problems in dating material formed after about 1950. You need not worry about excess radiocarbon in this problem.

10. A sample of groundwater bicarbonate (HCO₃⁻) from a confined sandstone aquifer has a ¹⁴C activity of 2.0 dpm/gC. Soil water in the presumed recharge zone has bicarbonate with a ¹⁴C activity of 12.0 dpm/gC. What is the apparent age of the groundwater? Assume that the vegetation and climate have remained unchanged in the recharge zone and that the effects of nuclear testing are negligible. What is the apparent groundwater flow velocity (in m/yr) if the recharge area is 60.0 flow miles from the sampling site?

- 11. Groundwater bicarbonate from a well water sample has ${}^{14}A = 4.88$ dpm/gC. Using a method you will learn about later, it has been determined that the C in this bicarbonate came 80% from <u>organic matter</u> in the recharge zone and 20% from <u>Jurassic calcite cement and limestone fragments</u> that were dissolved by the groundwater as it passed through the aquifer. Model the age of this groundwater, assuming that <u>organic matter</u> in the recharge zone had the "normal" initial radiocarbon activity ${}^{14}A_0$ at the time of recharge.
- 12. Open ocean water is fairly well mixed and has ${}^{18}\text{O}/{}^{16}\text{O}_{wtr} = 2.0052 \text{ x } 10^{-3}$. A sample of fossil planktonic foraminiferal tests recovered by the Ocean Drilling Program has ${}^{18}\text{O}/{}^{16}\text{O}_{cc} = 2.0660 \text{ x } 10^{-3}$. A paleontologist tells you that these forams grew in the uppermost few meters of the water column. Model the surface temperature of the ocean when and where these forams lived.
- 13. Imagine that you wish to develop your own isotopic temperature equation for a new kind of sea shell. You analyze shells grown under controlled conditions in laboratory seawater ($\delta^{18}O_{seawater} = 0.0$ permil) and obtain the following results:

Temp (°C)	$\delta^{18}O_{shell}$ (SMOW scale)
25.0	25.1 1
15.0	28.7 1
0.0	35.0 1

(a) Derive your own equation relating T (in Kelvins) to isotope composition. Your equation must be of the form $1000 \ln \alpha_{\text{shell-water}} = A \times 10^6/T^2 + B$.

(b) Considering that the ¹⁸O/¹⁶O ratio of seawater (absolute isotopic abundances) is 2.0052 x 10⁻³, what is the ¹⁸O/¹⁶O ratio of the shell having $\delta^{18}O = 25.0 \ 1$? Report to 4 decimal places. Take care with the algebra.

(c) A Pleistocene sample of this shell was recovered from a drill core by the Deep Sea Drilling Project and has $\delta^{18}O = 31.6 \ 1$. At what temperature (in Celsius) did the shell grow if seawater had (i) $\delta^{18}O = 0 \ 1$? (ii) $\delta^{18}O = +1 \ 1$?

14. As part c of question (13) shows, the model growth temperature of a shell (and hence the modeled water temperature) depends on the assumed isotopic composition of the water in which the shell grew. You will now see that the isotopic composition of the oceans depends on the volume of water locked up as glacial ice.

The average eustatic rise of sea level between the Wisconsinan glacial maximum and the present was 120 meters. Assume that the surface area of the oceans remained constant over this period (this assumption introduces only a small error).

(a) What fraction (or percentage) of the present ocean volume was "tied up" as continental ice during the Wisconsinan maximum? Show all of your work and cite the source(s) of additional data you need to perform the calculation.

(b) What fraction (or percentage) of the present ocean volume would have to be transferred to the continental ice sheets to produce a glacial-age ocean with δ^{18} O of +1 1 (i.e., 1 1 *more* than at present) if the average δ^{18} O of the ice (SMOW scale) were:

i) -10 1; ii) -20 1; iii) -30 1; iv) -40 1. Show all of your work.

(c) During the Wisconsinan maximum, seawater is thought to have had $\delta^{18}O = +1$ 1. Based on your answers to (a) and (b) above, what was the probable average $\delta^{18}O$ of glacial ice during the Wisconsinan maximum?

Moral of the story—The foregoing problems show that to model the temperature history of the oceans using δ^{18} O, it is necessary to measure the δ^{18} O of a material that formed in equilibrium with the oceans at the time of interest and to make certain assumptions (or to have certain independent information) about the oceans' δ^{18} O at that time; oceanic δ^{18} O is influenced by the volume of glacial ice via the hydrologic cycle.

- 15. For some purposes, it is convenient (and defensible) to represent the chemical composition of plant material by the formula CH₂O. CH₂O is the simplest possible carbohydrate, and plants are largely composed of carbohydrates. The aerobic decay of plant tissues might then be represented by the reaction $2CH_2O + 2O_2 \rightarrow 2HCO_3^- + 2H^+$. Predict the $\delta^{13}C$ of the bicarbonate formed through this reaction if the original organic material consisted of land plants from a temperate climate.
- 16. Groundwater bicarbonate from a well water sample has ${}^{14}A = 6.88 \text{ dpm/gC}$ and $\delta^{13}C = -18.6 \text{ l}$. Model the age of this groundwater. You may assume that the only significant sources of C in the groundwater are from plants in the recharge zone and marine calcite cement in the aquifer. Yes, the stable isotope datum is needed to solve this problem. Explain your model in a narrative.
- 17. Pure water with a pH of 7.0 comes into equilibrium with pure limestone at a temperature of 25 degrees C. Will the pH of the water increase, decrease, or remain the same? Explain WHY the pH responds (or doesn't respond) in the manner you indicate.
- 18. Nontronite has the ideal formula $Na_{0.33}Fe^{3+}{}_2Al_{0.33}Si_{3.67}O_{10}(OH)_2$.
 - (a) Identify the tetrahedrally coordinated cation(s).

(b) Identify the octahedrally coordinated cation(s).

(c) Identify the interlayer (exchangeable) cation(s).

(d) Determine whether the clay is dioctahedral or trioctahedral and explain your reasoning.

(e) State whether this clay has a 2-layer or 3-layer structure and explain how you can determine that from the formula.

(f) Estimate the standard free energy of formation of nontronite by the method of Tardy and Garrels (1974), discussed in the text. The text gives detailed examples of the approach you should take. Be careful to write the octahedral cations as oxides, not as hydroxides (but see the special note about Mg, which is an exception, on p. 209).

(g) Determine the cation exchange capacity of this clay in meq/100g.
(h) About how many g of Na⁺ could be released from 100 g of this clay in a cation-exchange reaction if a suitable cation replaced it?

(i) About how many g of Ca $^{2+}$ could be absorbed by 100 g of this clay in a cation-exchange reaction?

- 19. What are the environmental conditions in terms of $[Mg^{2^+}]/[H^+]^2$ and $[H_4SiO_4]$ at which enstatite and forsterite coexist at equilibrium? Solve this problem by writing a reaction relationship between the two minerals, and solving for the desired relationships mathematically. After that, compare your answer with what you could read from Table 12.3, page 190.
- 20. Using the result of problem 19, consult figure 12.5 B (p. 188) and determine whether enstatite can be in equilibrium with forsterite in the presence of an aqueous solution in nature.
- 21. Redraw figure 12.7, p. 193, to show the total congruent solubility of hematite as a function of pH (0 < pH < 14). This problem is analogous to the example we will do in class for gibbsite. Show all calculations. Note that Table 9.3 on p. 120 does not list hematite, so you will need to determine the appropriate equations and equilibrium constants yourself. After you complete the diagram, state the total congruent solubility of hematite (in mg/kg) at pH = 7.0.
- 22. Make the necessary calculations (assuming $T = 25^{\circ}C$) to determine whether the Mississippi River at Baton Rouge is saturated, undersaturated, or supersaturated with respect to (a) calcite, (b) gypsum, (c) amorphous silica, (d) quartz, (e) dolomite. (Note that the chemical analysis of the river is given in the table at the top of p. 171 of the textbook.) (f) State which (if any) of these four compounds the Mississippi River might be precipitating. (g) State which (if any) of these four compounds the Mississippi might be expected to dissolve if they found their way into the river. (h) Also, explain whether the Mississippi River is a standard-state solution (you may pretend that $T = 25^{\circ}C$).

23. <u>Rainwater</u> in a U.S. coastal area has the following composition:

Analysis	Na^+	K^+	Mg^{2+}	Ca^{2+}	SiO_2	HCO_3^-	SO_4^{2-}	Cl
mg/L	3.68	0.24	—	0.58	—	1.10	2.45	4.83

<u>Shallow groundwater</u> from a sandstone aquifer in the same area has this composition:

Analysis	Na^+	K^+	Mg^{2+}	Ca^{2+}	SiO ₂	HCO ₃	SO_4^{2-}	Cl
mg/L	8.6	1.09	_	2.02	28.33	19.82	2.45	4.83

- (a) State which minerals you might reasonably expect to be contained in the sandstone aquifer.
- (b) Determine which minerals in the aquifer contributed ions to the groundwater, and calculate the number of mg of each mineral that dissolved (incongruently) per liter (mg/L).
- (c) In order to do part (b), you had to make implicit assumptions about the nature of some hydrolysis reactions. To make some of the assumptions explicit, write each of the weathering reactions you invoked in part (b). After that, give the name(s) of the stable solid product(s) of the weathering reactions (minerals stable in this weathering environment).

Geol 330: Structural Geology

Stress Analysis Exercise

We wish to develop an analytical model for rock fracture that accounts for the forces, stresses and orientations of structures.

Force is the vector quantity which tends to produce a change in velocity or direction and is expressed as Newton's 2^{nd} law: $\mathbf{F} = \mathbf{ma}$

We begin with an isotropic, homogeneous block of rock and apply an axially compressive force ${\bf F}$



- 1. The block has no preferred direction of fracture.
- 2. The load is uniformly directed
- 3. The block cannot move
- 4. Theta (θ) is an arbitrary angle showing the orientation of a potential fracture
- 5. The block should break along a plane where the shear stress is maximum

Stress is defined as force/area so we first develop expressions for the areas

A = ac and A' = bc $a/b = sin\theta \text{ so } b = a/sin\theta$ then $A' = A/sin\theta$

The stress on the top of the block of rock is $\sigma = \frac{F}{A}$

The normal and shear stresses on the A' plane are

 $Fn = F \sin\theta$ and $Fs = F \cos\theta$ $\sigma_n = Fn/A'$ and $\sigma_s = Fs/A'$

$$\sigma_{n} = \frac{F \sin \theta}{A / \sin \theta} = \sigma \sin^{2} \theta \qquad \sigma_{s} = \frac{F \cos \theta}{A / \sin \theta} = \sigma \sin \theta \cos \theta$$

Products and powers of trigonometric functions are unhandy to manipulate, but we can replace them using double angle trig identities

 $\cos 2\theta = 1 - 2\sin^2 \theta$ and $\sin 2\theta = 2\sin \theta \cos \theta$ which gives $\sin^2 \theta = \frac{1}{2}(1 - \cos 2\theta)$ and $\sin \theta \cos \theta = \frac{\sin 2\theta}{2}$ now $\sigma_n = \frac{\sigma}{2}(1 - \cos 2\theta)$ and $\sigma_s = \frac{\sigma}{2}\sin 2\theta$

The block should fracture along a plane where the shear stress is a maximum. Find the angle at which σ_s is a maximum.

Answer_____

Laboratory tests show that the block breaks at an angle less than your answer. This indicates that the approach is limited. We modify it to take into account the cohesive strength of the block which we designate as the coefficient of internal friction.

The friction force acts in the opposite direction of the shear force and our new equation from the effective shear stress becomes

$$\sigma_{s'} = \sigma_{s-\mu} \sigma_n = \frac{\sigma}{2} \sin 2\theta - \mu \frac{\sigma}{2} (1 - \cos 2\theta)$$

As before, the block should fracture along a plane where the shear stress is a maximum.

If μ varies between 0 and 1, what are the limiting fracture angles for the plane?

Answers

This analysis applies to a laboratory, but what do we need to consider for rocks underground where fracture actually takes place?

Load pressure = density x gravity x depth ($P = \rho gh$) and has units of stress kg m⁻³ We use the same analysis as above but we let the load pressure act in all directions. This is defined as confining pressure and the axial load now becomes $P_1 + P_3$.

A key difference is that the confining pressure acts in the opposite direction to the shear stress from the vertical load pressure.

 $\sigma_{1n} = \frac{\sigma_1}{2} (1 - \cos 2\theta) \text{ and } \quad \sigma_{3n} = \frac{\sigma_3}{2} (1 + \cos 2\theta)$ $\sigma_{1s} = \frac{\sigma_1}{2} \sin 2\theta \quad \text{and} \quad \sigma_{3s} = \frac{\sigma_3}{2} \sin 2\theta$

$$\sigma_n = \sigma_{1n} + \sigma_{3n}$$
 and $\sigma_s = \sigma_{1s} - \sigma_{3s}$

Substituting the relationships above yields

$$\boldsymbol{\sigma}_{\mathbf{n}} = \frac{\sigma_1 + \sigma_3}{2} - \frac{\sigma_1 - \sigma_3}{2} \cos 2\theta \quad \text{and} \; \boldsymbol{\sigma}_{\mathbf{s}} \frac{\sigma_1 - \sigma_3}{2} \sin 2\theta$$

These equations allow us to use the Mohr Stress Diagram to determine μ . The axes of the Mohr Stress Diagram are σ_n and σ_s . The center of the a Mohr circle is at

$$\frac{\sigma_1 + \sigma_3}{2}$$
 and the radius of the circle is at $\frac{\sigma_1 - \sigma_3}{2}$

Geol 411: Sedimentology and Stratigraphy

- 1. In shallow streams or flumes, where sand particles are moving as bed load, the larger particles (such as coarse sand) can sometimes be seen to move along the bed faster than the smaller ones (such as fine sand). Explain this phenomenon in terms of the processes acting to transport sediment.
- 2. What are the physical and chemical requirements for the deposition of evaporites? How are these requirements met in the models discussed in lecture?
- 3. Consider the following laboratory experiment: Sand is placed in the bottom of a flume, and the flow of water is increased from zero to a high value. In such an experiment:

(a) What is the sequence of bedforms you would expect to see with fine sand?

(b) Coarse sand?

Geol 414: Applied Geophysics

1. Electrical Resistivity -- Vertical Sounding Exercise

We use an expanding Wenner array to determine the variation of resistivity with depth.

A Wenner array employs four electrodes spaced at equal intervals in a line. The two current electrodes are on the ends and the two potential electrodes are in the center of the array.

We expand the array by moving the electrodes from the center. The analyses we use are **Cumulative Resistivity** and the **Barnes Parallel Resistor Method**.

Cumulative Resistivity: Make two columns for data; one is for the spacing interval and the second is for the cumulative resistivity. Plotting the data on an with the interval as the abscissa and the cumulative resistivity as the ordinate yields straight lines with slope breaks at horizontal boundaries.

Interval Cumulative Resistivity

A_1	$\Sigma R_1 = R_{a1}$
A_2	$\Sigma R_2 = R_{a1} + R_{a2}$
A ₃	$\Sigma R_3 = R_{a1} + R_{a2} + R_{a3}$

Barnes Parallel Resistor Method: In this method we assume that the apparent resistivity is the average resistivity in a layer reaching from the

surface to a depth equal to the electrode spacing. We assume that each time we increase the electrode spacing, the layer lies at the depth of the spacing. Adding a succession of equal layer increments is equivalent to adding a succession of equal resistors in a parallel electric circuit. The relation between the combined resistance and the individual resistances is:

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$$

We calculate the resistivity in any layer from two successive values of apparent resistivity from:

$$\frac{1}{R_i} = \frac{1}{R_{a,i}} - \frac{1}{R_{a,i}}$$

In this method we plot resistivity vs. depth.

2. Describe the difference between the geomagnetic poles and the magnetic or dip poles.

3. Describe the non-dipole field and how it is represented.

4. What are the seven elements of the magnetic field?

5. How do the elements of the magnetic field vary with altitude?

6. Describe the general pattern a ground or aeromagnetic survey would have for a magnetite ore body having a remanent magnetic field oriented parallel to the ambient field. What if the orientation of the ore body were opposite to the ambient field?

7. Discuss the Vine-Matthews-Morley hypothesis.

8. Describe hypothetical gravity and magnetics over the three types of plate boundaries.

9. Describe hypothetical gravity, magnetics and heat flow over the Colorado Plateau.

10. Can you detect the following using geophysical techniques? How?

Buried tunnels Old streets in Underground Atlanta Missile Silos Faults Stream beds Salt domes Anticlines Depth to basement Depth to an anomaly

11. **Magnetic surveying exercise:** shallow exploration uses ground magnetometers for surveys.

Instruments:	Proton Precession magnetometer
	Maps or GPS for position information.

Planning:

Magnetic cleanliness – eyeglasses, belt buckles, keys, watches, buttons on jeans, pens, clipboards, etc.

Avoid objects containing metal and avoid electrical lines

Keep the sensor at least 1 m above ground

Corrections to readings:

Diurnal variation and magnetic storms: visit base station or use a continuously recording instrument at the base station.

Elevation: Interesting question: dg = .3086 mgal/m and dF = 0.025 nT/m. g = 980,000 mgal and F = 70,000 nT so why not make the correction? dg varies by only about 5000 mg over the earth, but dF varies by 40,000 nT. the gradient signal is lost in the background noise and is generally not considered.

-(3/r)Ze 0.02521

Horizontal position: Use the IGRF to establish a regional field and use the GRID feature in SURFER@ to remove the regional.

12. Seismology exercise.

Given: $Vp = \sqrt{[(k+4/3\mu)/\rho]}; Vp = \sqrt{E/\rho[(1-\sigma)/((1-2\sigma)(1+\sigma))]}$ $Vs = \sqrt{[\mu)/\rho]}; Vs = \sqrt{E/(2\rho(1+\sigma))}$ $Vp/Vs = \sqrt{[k/\mu + 4/3]} = \sqrt{[(1-\sigma)/(1/2 - \sigma)]}$ $A = A_0 e^{-(ax)}/x$ Sin (i)/Sin(r) = V₁/V₂; Sin (i)/V₁ = Sin(r)/V₂ = P $T = \lambda/V$, $f=1/T = V/\lambda$, $V = f\lambda$

a. A P-wave produced by an explosion 5 m below the water surface reaches solid rock at an angle of incidence of 30 degrees. V_1 is 1500 m s⁻¹ and V_2 is 2500 m s⁻¹

How many reflected and refracted rays are generated?

What are the angles of refraction of the refracted P and S waves? What are the critical refraction angles?

What if $V_2 = 5000 \text{ m s}^{-1}$?

b. An S_H wave originating in a solid layer with properties μ_1 and ρ_1 refracts across a boundary into another solid layer where $\mu_2 = \mu_1$ and $\rho_2 > \rho_1$. Is the angle of incidence larger or smaller than the angle of refraction?

c. Suppose V $_{P1} = 4000 \text{ m s}^{-1}$ and Vs $_1 = 2200 \text{ m s}^{-1}$ in a layer on top of a layer where V $_{P2} = 4000 \text{ m s}^{-1}$ and $\sigma = 0.25$. An S_H wave refracts into the lower layer. Is the angle of refraction larger or smaller than the angle of incidence??

If the density in the deeper layer is 2800 kg m⁻³ what are the values for shear modulus and bulk modulus?

d. A P wave traveling at 3000 m s⁻¹ refracts into a layer where V_P is 4000 m s⁻¹. If the frequency of the wave is 30 Hz what happens to the wavelength?

e. An incident P wave traveling at 3000 m s^{-1} is critically refracted at 30 degrees. What is the velocity of the refracted wave?

f. At a distance of 100 m from a source, the amplitude of a P-wave is 0.1000 mm, and at a distance of 150 m the amplitude is 0.0665. What is the absorption coefficient of the rock?

Geol 415: Paleontology

1. Each student will submit a short paper and 15-minute presentation on a topic of their choice (with my approval).

The Process. The term writing assignment will be submitted as if to a journal for publication. This means you hope to get your manuscript published. I am your publisher, editor, and reviewer. If you submit a manuscript that does not meet the guidelines, it can be rejected for rewrite for resubmission. If accepted, the manuscript will be edited for style, grammar, and content. It can
be accepted provisionally, with revision, or as is, with no revision necessary. You may accept the grade you receive on the first review or resubmit with editor's suggestions for an improved grade "for publication" and a possible better grade. The purpose of the following-up on revisions is to learn how to improve your writing skills, accept a critique, and understand the professional review process.

General. The term paper will focus on a particular group of fossil organisms through a selected duration of geologic time. The overall purpose of the project is for the student to learn how to integrate, through literature study, the various facets of the fossil record of a specific group of organisms. Depending on the subject and/or interest of the student, the paper should include a review of a taxon's:

1) Morphology (distinguishing characteristics); 2) Paleoecology (utility in paleoenvironmental reconstruction); 3) Evolutionary trends (change in morphology of selected taxa through time, pattern of evolution); 4) Biostratigraphy (utility for interpreting geologic time); and/or 5) Paleobiogeography (geographic distribution through slices of geologic time and its historical significance; e.g., migration, local extinction, etc.).

Requirements. The text will be doubled spaced, with one inch margins on all sides. The paper will have a brief abstract (200 words), with an I. Introduction; II. Basic knowledge; III. Discussion; and IV. Conclusion sections (you may retitle these headers as appropriate). The suggested length of the paper is 5 pages, excluding references and illustrations. All references must be author cited (no anonymous Web citations). Additional style information will be provided. The references will be in a GSA format.

Presentations. Each student will give a PowerPoint presentation on their talk to be critiqued by the class. This informal opportunity to speak provides the student the opportunity to practice communication skills, both in presenting research and answering questions based on knowledge derived from course work and research. The presentation will be a maximum of 15 minutes in duration. Students will be subjected to classmate and my questions for as long as they last. (Examples of titles of talks include "Sphaeriidae" (Mollusca, Bivalvia), "Anomalocaris" (Invertebrates), "Euryperids" (Arthropods), "Smilodon" (Vertebrates), "Conodonts" (Vertebrates), "Mammoths" (Vertebrates), "Origin of Birds and Flight" (Vertebrates).

- 2. What is the difference between the modes of fossilization called permineralization and recrystallization? Give an example of each mode.
- 3. Name two sedimentary processes or environmental conditions that are most suitable for the fossilization of soft-bodied organisms.

GeoE 417: Hydrogeology

1. Laboratory #1 Aquifer Models.

Name:	Partner:	
Partner [.]	Partner [.]	

Objective: The objective of this assignment is to introduce some hydrogeologic concepts that will be covered in this course. It will also help familiarize you with your textbook.

Please review this assignment before working on the aquifer models and look up any unfamiliar hydrogeologic terms and concepts. Note the figure at the end of this assignment. Bring a watch to this lab exercise. Show all calculations. This assignment will be graded "S" for satisfactory work and "U" for unsatisfactory work. We gratefully acknowledge the Office of Instructional Development for contributing to the purchase of these models.

1. What is the driving force that causes the water to flow through the model?

2. Use the syringe to add ~10 cc of green-colored water to the blue injection well. Hold the syringe tip firmly in the tube while injecting the water. With a water-soluble ink pen mark on the back of the model the plume center and draw a circle around the outline of the plume. Note the time______. Continue with the questions below but measure the progress of the plume center at least one more time before the plume passes by piezometer E (see figure on back page). Note the time______ and distance traveled______. What is the horizontal velocity of the plume center in cm/s?

3. With a syringe apply some suction to each of the wells made out of clear tubing. This should remove any air bubbles trapped in the piezometers. With a water-soluble ink pen mark the water level in the wells located in the

unconfined aquifer (or water table aquifer). These marks indicate where the water table is located. With a different color, mark the water level in the wells located in the confined aquifer (or artesian aquifer). These marks indicate the potentiometric surface. Which level is higher? Why?

3.1. Is the water level in the syringe plugged into the artesian well above or below the lake level?

3.2. A well typically has a screen that allows water to flow from the aquifer into the well casing. Based on the water level in the artesian well, in which aquifer is the artesian well screened?

3.3. Water flows from areas of higher energy to areas of lower energy. Knowing this, would water just below the confining layer tend to have a vertical velocity component in the up or down direction?

3.4. Remove the syringe; briefly describe what happens. Replace the syringe.

4. Pour ~5 mL of red-colored water into the leaky landfill (or lagoon) and watch where it goes. Briefly describe its path. Does the red "contaminant" flow in more of a downward or lateral direction?

5. What is the hydraulic gradient in cm/cm (change in vertical distance divided by change in horizontal distance) of the water table between the inlet reservoir at the left of the model and piezometer D (see figure on back page)?

6. Use Darcy's law to estimate the horizontal hydraulic conductivity for the sand in the model in cm/s. How does your answer compare to Table 3.7 in Fetter?

7. How has the plume shape changed as it moved downgradient? What do you think caused the plume shape to change this way?

8. Take a syringe and remove ~ 10 mL of water from pumping well 2 (see figure on back page). Note what happens to the water levels in the wells

screened in the unconfined aquifer and those screened in the confined aquifer. In which aquifer are the water levels in the wells more affected? 8.1 Now repeat the procedure for pumping well 1. Now in which aquifer are the water levels in the wells more affected? How do you explain what happened in 8 and 8.1?

9. Switch the outlet to the lake (ask instructor for assistance). Watch the green plume for a few minutes (you may need to add more green water if the plume has already exited the model). What happens to its direction now that the lake is the outlet? Switch the outlet back to the right reservoir.

10. Look closely at the green plume. Can you see it separating into yellow and blue? Which color seems to be moving faster? Not all groundwater contaminants travel at the same velocity.

The questions below are for those that want an extra challenge:

11. Estimate the specific discharge in cm/s (or Darcy flux or Darcy velocity) for the model. Is it more or less than the velocity of the plume?

12. Assuming that the plume moves at the same velocity as the groundwater (Not all plumes do!), estimate the effective porosity of the sand in the unconfined aquifer. Is this a reasonable value for sand? If not, what may this tell us about the plume velocity relative to the groundwater velocity?



UW-STEVENS POINT GROUND WATER MODEL

The exercise shows that our leaky landfills may contaminate groundwater or associated water bodies (lakes, streams, etc.) and how contaminants, likely generated from modern technologies, interact differently with sediment and therefore are transported at different rates relative to groundwater flow rates and to each other.

2. A confined aquifer has a specific storage of $8.8 \times 10^{-6} \text{ m}^{-1}$ and a porosity of 0.33. The compressibility of the water is $4.6 \times 10^{-10} \text{ m}^2/\text{N}$. If the aquifer had a thickness of 16.0 m and pumping lowered the potentiometric surface 2.5 m, estimate how much the aquifer could compact.

This problem shows that pumping causes aquifers to compact. Lecture and reading materials complement this problem so that the student is aware that such compaction is irreversible; that is, injecting water back into the aquifer will not fully restore the thickness of the aquifer. As a result of this phenomenon, the land surface in one region of California has subsided by 30 ft in 50 years. Please note that I do not give this problem as a homework assignment every year; I change assignments each time the course is taught. However, each class is given similar assignments that show the impact of technologies in hydrogeology.

Geol 420: Evolving Earth

- 1. What is the Signor-Lipps effect?
- 2. What is an Extinction Event?
- 3. What is the background range of extinctions on Earth?
- 4. How many "mass extinctions" are recognized in the geological record?
- 5. Is there a connection between evolution and extinction?

- 6. What are the possible causes of mass extinctions?
- 7. Are there cycles in mass extinctions?
- 8. Why is it unlikely that the present atmosphere of the Earth contains any significant component of the earliest atmosphere which accreted from the solar nebula?
- 9. The strong heat generating isotope aluminum-26 (²⁶Al half-life ~700,000 years) was present in rocky material in the solar nebula at the time the meteorite parent bodies formed and was probably a major heat source that produced melting and differentiation of the asteroids. Briefly discuss why ²⁶Al is not considered as the heat source responsible for the early melting of the Earth or Moon.
- 10. List and briefly describe two effects that life had on the atmosphere and surface conditions of the early Earth.
- 11. What biological process is described by the equation "H₂O + CO₂ + Light \rightarrow CH₂O + O₂"? How did this process affect the early Earth?
- 12. A NaCl (sodium chloride) crystal can grow if placed in an appropriate "nutrient" (saturated saline) solution. It can reproduce; if broken into pieces, each piece can grow to form a new crystal. It responds to its environment; if the composition or concentration of the solution changes the crystal will grow differently or shrink. Briefly discuss why this doesn't qualify as life.
- 13. Briefly discuss the "RNA World" hypothesis.
- 14. What was the significance of the Miller (or Miller-Urey) experiment in 1953?
- 15. What distinguishes a "mass extinction" from the normal background extinctions?
- 16. What change in the global "environment" resulted in the deposition of the huge banded ironstone deposits between 2 and 2.5 billion years ago (Gyr)? What was the primary cause of this change?
- 17. How did the rapid increase in the oxygen content of the Earth's atmosphere approximately 2 Gyr ago affect life on Earth?

Results

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Fall, 2006-Summer, 2007				
Program Area	ND Passing Score	Total Test Takers	Average Score	Percent Passing
Earth Science- 20571	149	0		

c. Results of other content knowledge assessment (s).

No candidates are enrolled in the program.

Student Work Samples

None. No candidates are enrolled in the program.

13010.2, 13020.2, 13035.2, 13045.2, 13047.2, 13050.2 NATURE OF SCIENCE

The program requires study of the history and philosophy of science as well as the interrelationships among the sciences. The program uses varied performance assessments of candidate's understanding and ability to apply that knowledge.

List course number, title and description and any accompanying activities or experiences in which students engage to meet the standard.

<u>Note:</u> Syllabi for Geology courses accompany this document. Where syllabi were furnished by multiple instructors (e.g., in instances of multiple sections with different teachers), all the furnished syllabi are included.

Students have the opportunity to meet the Standard by completing homework exercises, completing laboratory exercises, responding to examination and quiz questions, and writing a scientific paper.

<u>Geol 101/101L</u>. Introduction to Geology/Lab. 4 credits. Introduction to the dynamics of Earth—volcanoes, earthquakes, plate tectonics, streams, groundwater, glaciers, waves, wind, and landslides, with emphasis on the environmental applications of these processes. Introduction to the tools of the geologist—minerals, rocks, maps, and aerial photographs. An introductory laboratory complements Geol 101, and includes field trip(s).

<u>Geol 102/102L</u>. Earth Through Time/Lab. 4 credits. The tracing of changes in Earth and life through time, with emphasis on the record from North America. An introductory laboratory complements Geol 102.

<u>Geol 318</u>. Mineralogy. 3 credits. Prerequisite: Geol 101 or GeoE 203, and Chem 121 or consent of instructor. Survey of the origin, distribution and uses of rock-forming minerals. Introduction to mineral structures, crystal chemistry, and crystallography. Laboratory identification of common minerals in hand sample and petrographic thin section. Introduction to the use of the polarizing microscope. Includes field trip.

<u>Geol 411</u>. Sedimentology and Stratigraphy. 5 credits. Prerequisite: Geol 320. Origin, transportation, deposition, and diagenesis of sediments; principles and applications of stratigraphy. Includes field trip and laboratory.

<u>Geol 415</u>. Introduction to Paleontology. 4 credits. Prerequisite: Geol 102. Recommended: Biol 150, 151. The principles of paleontology/paleobiology are presented using fossils to document the evolutionary, stratigraphic, and paleoecologic history of animal and plant life on Earth. Includes field trip and laboratory.

<u>Geol 420</u>. The Evolving Earth. 3 credits. Prerequisite: Senior standing in Geology. A synthesis of the physical, biological, and chemical changes on Earth through time set within geologic systems and unifying concepts.

Assessments

- a. Earth Science Praxis II Exam-no test takers within the last 3 years
- b. Included below are numerous examples, taken from multiple levels in the curriculum, illustrating coverage of the history and philosophy of science as well as the interrelationships among the sciences. Please note that interrelationships among the sciences are treated profusely among the examples we provided for the *interdisciplinary nature of Earth science* (see the preceding Standard); we provide some additional examples here. Also, the history and philosophy of science are further addressed in many of our responses to the "Inquiry" standard (below); we give a smaller set of examples here. In addressing the Nature of Science, we examine some fundamental assumptions of science and of geological science in particular, limitations on how (or where?) we "look" for answers, the importance of testing tentative explanations, and "self-correction" in science. We also consider people whose ideas had a profound impact on thinking in geological science, whether or not those ideas proved adequate in the fullness of time. Indeed, almost any falsifiable scientific idea can fairly be regarded as a *useful* contribution to science-even "wrong" ideas inspire thought and lead to investigations whose findings ultimately broaden and deepen our understanding of the natural world.

Geol 101/L. Introduction to Geology/Introduction to Geology Laboratory

- 1. Briefly describe Aristotle's influence on the science of geology.
- 2. All science relies on the fundamental assumption that:
 a) the natural world operates in a consistent and predictable manner
 b) religious and scientific thought are incompatible
 c) Earth had no beginning and will have no end
 d) given enough time, anything can happen
 e) the universe is billions of years old
- 3. Many natural scientists resist efforts (by school boards, etc.) to bring Ascientific creationism@ and "intelligent design theory" into the science curriculum because:
 a) they are trying to get even with people who don=t want evolution to be taught

b) these theories haven=t yet been researched as thoroughly as the other theories

c) it would be too confusing to the students if they had to learn two competing theories

d) science doesn=t call on supernatural explanations, so it wouldn=t be science

e) there just isn=t time to do everything

- 4. To interpret Earth history, geologists rely on one of James Hutton=s contributions, a fundamental premise stating that Athe physical and chemical laws operating today also operated in the past.@ This is sometimes summarized as Athe present is the key to the past.@ This idea is known as:

 a) Succession
 b) Historical Interpretation
 c) Scientific Deduction
 - c) Scientific Deduction
- 5. The main problem(s) with Wegener's Continental Drift idea was/were that:
 a) it provided no workable mechanism for the continents to move
 b) it could not explain the jigsaw-puzzle fit of South America and Africa
 c) it could not explain the existence of similar fossils on several continents
 d) it could not explain why there would be ancient glacial deposits in areas that are now covered by tropical forests
 e) all of the above.
- 6. What is the difference between the meaning of the term "theory" in science and its general meaning to the public?

Geol 102: Earth Through Time/Earth Through Time Lab

- 1. How does a scientific explanation become elevated to the status of "theory"?
 - a) It is submitted to a vote of the United Nations
 - b) The President's science advisor renders a judgement
 - c) By informal consensus of scientists working in the same scientific field
 - d) By an act of Congress
 - e) Adoption by the National Academy of Sciences
- 2. The original work on the Cambrian System was criticized because:

a) the rocks are highly deformed and hence difficult to trace accurately to other locations;

b) it showed older strata lying above younger strata;

c) it was discovered that the geologic maps appeared to violate Walther's Law;

d) the fossils were not described adequately;

e) its founder used outdated methods and neglected to consider the effects of evolution.

Geol 318: Mineralogy

- 1. What was the contribution of James Dwight Dana to the problem of mineral classification?
- 2. Over the years there have been several key discoveries that have allowed the science of mineralogy to advance. Just 200 years ago, we did not understand the nature of mineral structures, why some minerals have crystals of one shape and why others have different shapes, or how elements bond to produce crystals. Today we know all those things. What were the key discoveries, and who made them, the led us to the "modern" mineralogy we understand today?
- 3. Linus Pauling arguably contributed more to the field of mineralogy than any other single person. Explain why some people believe this? Do you? Argue with your self and then reach a conclusion.

Geol 411: Sedimentology and Stratigraphy

1. An igneous rock has the following mineral composition:

Quartz 20% K-feldspar 32% Plagioclase 31% Biotite 5% Hornblende 5% Magnetite 3% Ilmenite 1% Other 3%

What mineral assemblages would you expect to find in material derived from this rock which is: A) very slightly weathered; B) partially weathered; and C) extremely weathered? Assume a temperate climate. What specific weathering processes are involved?

2. Briefly describe "Walther's Law". What is the significance of this "law"? Include an example.

Geol 415: Paleontology

- 1. Name two topics Conrad Gesner contributed to paleontological reasoning or paleontological methods as a science.
- 2. What was the contribution of one of the following gentlemen to geological or paleontological reasoning (be specific) (extra 2 points for a second gentleman)? Steno, Smith, Hooke, Vallisnieri, Scheuchzer.
- 3. a) Name and b) explain one contribution made by Cuvier still relevant to paleontological studies today.

- 4. Provide a statement on the contribution of one of the following individuals or groups in regards to a scientific concept discussed in class:
 A) Greeks and the species concept; B) Lamarck; C) Nominalists;
 D) H. DeVries; E) W. Smith; F) H. Smith; G) Mendel; H) S. Stanley;
 I) N. Eldridge; J) E. Mayr; or K) G.G. Simpson.
- 5. Describe in some detail (say four main points) what a geologist does in naming a new formation (the process begins with field work).
- 6. Provide a reasonable explanation for why organisms that are derived from different phylogenies might evolve similar morphologies through time.
- 7. What difference does it make to the potential formation of a new species whether or not an isolating mechanism isA) prezygotic orB) postzygotic?
- 8. What do the equivalent concept names "evolutionary synthesis," "modern synthesis," or "neo-Darwinism" represent?
- 9. What is the importance of mutations to the evolution of life?
- 10. Describe how allopatric speciation works. (There should be three components to your answer.) A), B), C)
- 11. Explain the difference between how the models ofA) punctutated equilibrium andB) phyletic gradualismmight explain evolutionary patterns seen in the fossil record.
- 12. What is binomial nomenclature? Give a proper example.
- 13. What do red beds and banded-iron formations have in common?
- 14. What are the major sources of free oxygen in Earth's atmosphere?
- 15. How are sources of oxygen important in the development of life in the Precambrian?
- 16. What is the significance of cyanobacteria to the terra-forming of Precambrian Earth? (Indicate two biological and two physical consequences.)
- 17. What is the difference between indirect and direct evidence for the origin of life on Earth?
- 18. What is the significance of possessing a coelom?

- 19. In the geologic record, how might we be able to tell if a soft-bodied organism had a coelom or not?
- 20. Therapsids are known as mammal-like reptiles. Why? Two reasons would be good.
- 21. Write briefly but meaningfully on the significance on the geological/paleontological contribution of one of the following individuals:A) Walcott; B) Dawson; C) Lyell.

Geol 420: Evolving Earth

- 1. Why is testability critical to scientific progress?
- 2. Briefly discuss the "RNA World" hypothesis.
- 3. In 1896, Svante Arrhenius calculated that emissions from human industry might someday bring a global warming. In 1939, G.S. Callendar argued that the level of both carbon dioxide and temperature had been rising. In the 1950s, most climate scientists rejected the suggestion that CO₂ could cause global warming largely because they thought that any CO₂ produced would be absorbed by the oceans and terrestrial biosphere. What did Roger Revelle and Charles Keeling do that changed people's minds?
- 4. A common argument against human caused global warming is that the rise in temperature observed in ice cores actually precedes the rise in CO₂. Is this argument persuasive or is it flawed. How so?
- 5. What geologic evidence indicates the presence of a substantial greenhouse warming of the early Earth?

Results

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Fall, 2006-Summer, 2007				
Program Area	ND Passing Score	Total Test Takers	Average Score	Percent Passing
Earth Science- 20571	149	0		

d. Results of other content knowledge assessment (s).

No candidates are enrolled in the program.

Student Work Samples

None. No candidates are enrolled in the program.

13010.3, 13020.3, 13035.3, 13045.3, 13047.3, 13050.3 INQUIRY

The program requires study of the processes of science common to all scientific fields. The program uses varied performance assessments of candidate's understanding and ability to apply that knowledge.

List course number, title and description and any accompanying activities or experiences in which students engage to meet the standard.

<u>Geol 101/101L</u>. Introduction to Geology/Lab. 4 credits. Introduction to the dynamics of Earth—volcanoes, earthquakes, plate tectonics, streams, groundwater, glaciers, waves, wind, and landslides, with emphasis on the environmental applications of these processes. Introduction to the tools of the geologist—minerals, rocks, maps, and aerial photographs. An introductory laboratory complements Geol 101, and includes field trip(s).

<u>Geol 102/102L</u>. Earth Through Time/Lab. 4 credits. The tracing of changes in Earth and life through time, with emphasis on the record from North America. An introductory laboratory complements Geol 102.

<u>Geol 318.</u> **Mineralogy.** 3 credits. Prerequisite: Geol 101 or GeoE 203, and Chem 121 or consent of instructor. Survey of the origin, distribution and uses of rock-forming minerals. Introduction to mineral structures, crystal chemistry, and crystallography. Laboratory identification of common minerals in hand sample and petrographic thin section. Introduction to the use of the polarizing microscope. Includes field trip.

<u>Geol 321</u>. Geochemistry. 3 credits. Prerequisite: Geol 318, Chem 122 and Math 166, or consent of instructor. Application of the principles of chemistry to geologic and hydrogeologic problems. Origin and distribution of the chemical elements. Introduction to radiochemistry, isotopic geochronology, and stable-isotope geochemistry.

<u>Geol 411</u>. Sedimentology and Stratigraphy. 5 credits. Prerequisite: Geol 320. Origin, transportation, deposition, and diagenesis of sediments; principles and applications of stratigraphy. Includes field trip and laboratory.

<u>Geol 415</u>. Introduction to Paleontology. 4 credits. Prerequisite: Geol 102. Recommended: Biol 150, 151. The principles of paleontology/paleobiology are presented using fossils to document the evolutionary, stratigraphic, and paleoecologic history of animal and plant life on Earth. Includes field trip and laboratory.

<u>Geol 487</u>. Research I. 1 credit. Prerequisite: Senior standing in departmental major. Identification and proposal of research project. Includes literature review, feasibility review, and formal project identification and written proposal. Selection of faculty research adviser within first month of semester.

Geol 488. **Research II.** 2 credits. Prerequisite: Geol 487. Execution of research plan developed in Geol 487.

<u>Geol 494</u>. Senior Thesis. 1 credit. Prerequisite or corequisite: Geol 488. Written results of research conducted in Geol 488. The thesis document should conform to the format guidelines of a major English-language journal in which the thesis could be published.

Assessments

- a. Earth Science Praxis II Exam-no test takers within the last 3 years
- b. Included below are numerous examples, taken from multiple levels in the curriculum, illustrating coverage of the processes of science common to all scientific fields. Scientific inquiry begins with observation, and here we document a few of the observations we ask students to make even at elementary levels in the curriculum. We ask students to draw conclusions that flow logically from their observations or from example scenarios. We show that scientific explanations proposing to account for a phenomenon, or group of presumably related phenomena, can appeal only to causes in the natural world. Students are expected to comprehend and to conduct hypothesis testing. We also stress that scientific conclusions are always tentative, and we deal with examples in which explanations proved wrong. Students engage deeply with this Standard as they conduct research and report its results in satisfaction of our curricular requirements to write a senior thesis.

Geol 101/L: Introduction to Geology/Introduction to Geology Lab

- The current "best" scientific explanation to account for a natural phenomenon or a set of presumably related natural phenomena is regarded as a:

 a) paradigm
 b) theory
 c) bestiality
 c) hypothesis
- 2. Refer to the picture below. Recall that, in class, these specimens were passed around and you were asked to write down <u>descriptive</u> observations somewhere in your notebook. You were asked to particularly note differences between the specimens. It's time now to "think like a geologist" and make an interpretation based on your observations.



Recall that science proceeds initially from observations. Observations then lead to questions. Those questions then lead to hypotheses (which are tentative answers to those questions). Eventually, with further study, solid answers to the questions may be determined.

So, by looking at the specimen on the left, you should automatically raise the question: "Why does it have that particular difference from the other specimen?". (Now, that "particular" difference I'm referring to is <u>not</u> a difference in color, nor is it a difference in the size of constituent clasts.) I'm doing a little "steering" here. Your assignment now is to...

"Give the geologic history of the rock on the left." (Succinctly walk the reader through steps that finally answer the question about the "particular" look of that rock.) Some of you might choose to start your story with a mountain canyon. In your discussion of the historic steps, use good geologic terminology that you've been exposed to during this course.

The grading of your "rock history" will be based on how well you incorporate the necessary geologic steps and necessary flow of logic to explain that rock to a reader. Enjoy!

- 3. Explain the origin of the Hawaiian Islands and explain the <u>measurable</u> evidence that tells us of that origin.
- 4. Explain how a geologist would think about the relative age between a granite and the marble immediately adjacent to it.
- 5. How did scientists finally conclude that sea-floor spreading was true? That is, what is the "smoking gun" evidence that ended debate?
- 6. Lab 1 Minerals: 1) note which specimens have crystal faces; which have cleavage faces; which have fracture surfaces. 2) select 6 with cleavage and describe the cleavage of each. 3) assess the relative hardness of your specimens. 4) divide your specimens into two groups according to whether they have metallic, or nonmetallic luster. 5) determine which of your minerals exhibits a streak color. Now that you've gathered observational facts about your specimens, you're ready to use the following determinative tables to narrow down and finally determine the identities of your samples.
- 7. Lab 2 Igneous Rocks: Activity 1) Identification of texture and composition. Activity 2) Identification of igneous rock specimens.
- 8. Lab 3 Sedimentary Rocks: Activity 1) Identify characteristics of sedimentary rocks, including texture and mineral composition. Activity 2) Identify sedimentary rock samples.

- 9. Lab 4 Metamorphic Rocks: Activity 1) Identify metamorphic textures. Activity 2) Identify metamorphic rock specimens.
- 10. Lab 5 Geologic Time: Activity 1) Determine relative ages of features. Activity 2) Determining the sequence of events. Activity 3) Using the geologic time scale. Activity 4) Deciphering the rock record. Examples of putting knowledge together to draw scientific conclusions in this lab include: Activity 2G) Reconstruct the geologic history of this site (taken from a roadcut in the middle of North America). What happened first, second, etc.? Tell the tale; make it a story.

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Activity 2H) Place the events in this diagram in the proper oirder, from first to last. Be sure to include even non-labeled events.



- Lab 7 Streams: Activity 1 and 2) understanding stream profiles and base level changes. Activity 3) Geologic interpretation of map features. Activity
 4) Interpreting subsurface conditions based on surface processes and features.
- 12. Lab 9 Glaciers and Glacial Landforms: Activity 4D) using what you've learned, give a geologic interpretation of the landform shown in the center of these images.



 Lab 11 Crustal Structures: Activity 1) extrapolating to/from the surface/subsurface. Add missing information of block diagrams. Activity 2) complete a structure section and use results to estimate tunnel drilling budget. Activity 3) complete missing sides of block models.

Geol 102/L: Earth Through Time/Earth Through Time Lab

- 1. All science is based on the fundamental assumption that:
 - a) the universe is billions of years old
 - b) given enough time, anything can happen
 - c) Earth had no beginning and will have no end
 - d) religious and scientific thought are incompatible
 - e) the natural world operates in a consistent and predictable manner
- 2. Many natural scientists resist efforts (by school boards, etc.) to insert Ascientific creationism@ and "intelligent design theory" into the science curriculum because:

a) they are trying to get even with people who don=t want evolution to be taught

b) these ideas haven=t yet been researched as thoroughly as the other theoriesc) it would be too confusing to the students if they had to learn two competing theories

d) science doesn=t call on supernatural explanations, so it wouldn=t be science

e) there just isn=t time to do everything

3. A serious problem with the Continental Drift idea was that:

a) it provided no workable mechanism for the continents to move
b) it could not explain the jigsaw-puzzle fit of South America and Africa
c) it could not explain the existence of similar fossils on several continents
d) it could not explain why there would be ancient glacial deposits in areas that are now covered by tropical forests

e) all of these

4. If a sedimentary rock in North America is Cambrian, it means that it:a) originally formed in Wales, and later became attached to North America

b) formed at the same time as certain Welch rocks that are included in the Cambrian Systemc) has a radiometric age of 438 million years or more

- 5. Demonstrate critical thinking skills (a GER goal) by thoroughly explaining <u>why</u> the distribution of *Glossopteris* either *supports* or *challenges* the idea that the continents were once connected. Convince the reader that other potential explanations for Glossopteris' distribution are inadequate, and that yours is
 - the most reasonable. Organize your thoughts before setting pencil to paper. Write legibly if you want any credit at all.

Geol 318: Mineralogy

1. What is the scientific method? Describe how Roentgen, Curie, Pauling and others discovered the nature and value X-radiation for studying minerals. Compare what they did with the scientific method. Did they follow the method?

Geol 321: Geochemistry

1. The average eustatic rise of sea level between the Wisconsinan glacial maximum and the present was 120 meters. Assume that the surface area of the oceans remained constant over this period (this assumption introduces only a small error).

(a) What fraction (or percentage) of the present ocean volume was "tied up" as continental ice during the Wisconsinan maximum? Show all of your work and cite the source(s) of additional data you need to perform the calculation. (b) What fraction (or percentage) of the present ocean volume would have to be transferred to the continental ice sheets to produce a glacial-age ocean with δ^{18} O of +1 1 (i.e., 1 1 *more* than at present) if the average δ^{18} O of the ice (SMOW scale) were:

i) -10 1; ii) -20 1; iii) -30 1; iv) -40 1. Show all of your work.

(c) During the Wisconsinan maximum, seawater is thought to have had $\delta^{18}O = +1$ 1. Based on your answers to (a) and (b) above, what was the probable average $\delta^{18}O$ of glacial ice during the Wisconsinan maximum?

2. A sample of biotite and a sample of muscovite from a hand sample of a certain pluton gave the following results:

Mineral	wt% K ₂ O	⁴⁰ Ar* moles/g	
Biotite	7.90	6.996 x 10 ⁻¹⁰	
Muscovite	10.72	13.66 x 10 ⁻¹⁰	

Determine dates for each and offer a plausible explanation for why they are different. You can assume that the true crystallization ages of the biotite and muscovite are identical.

3. A small pluton in northeastern Washington contains biotite and hornblende with analyses as follows:

Mineral	wt% K ₂ O	⁴⁰ Ar* moles/g	
Biotite	8.71	12.83 x 10 ⁻¹⁰	
Hornblende	1.44	4.348 x 10 ⁻¹⁰	

Calculate dates for both minerals, explain why they are different, and then speculate about the *age* of this pluton assuming that it may have been reheated during a later phase of intrusive activity in this area.

Geol 411: Sedimentology and Stratigraphy

- 1. It is maintained by many stratigraphers that every bedding plane is an unconformity which represents more time than the preserved sediments around it, even in the absence of any evidence of erosion. Briefly discuss this viewpoint. What evidence exists to support or refute that view?
- 2. Most of the subsurface stratigraphic units of the Williston Basin have type sections or areas in outcrop in the states or provinces surrounding North Dakota. How would you go about demonstrating the equivalence of a subsurface unit with its (supposedly) correlative type section? What are the strengths and weaknesses of your method?

Geol 415: Paleontology:

- 1. How do we infer the origin of the amniotes?
- 2. In the geologic record, how might we be able to tell if a soft-bodied organism had a coelom or not?

3. Each student will submit a short paper and 15-minute presentation on a topic of their choice (with my approval).

The Process. The term writing assignment will be submitted as if to a journal for publication. This means you hope to get your manuscript published. I am your publisher, editor, and reviewer. If you submit a manuscript that does not meet the guidelines, it can be rejected for rewrite for resubmission. If accepted, the manuscript will be edited for style, grammar, and content. It can be accepted provisionally, with revision, or as is, with no revision necessary. You may accept the grade you receive on the first review or resubmit with

editor's suggestions for an improved grade "for publication" and a possible better grade. The purpose of the following-up on revisions is to learn how to improve your writing skills, accept a critique, and understand the professional review process.

General. The term paper will focus on a particular group of fossil organisms through a selected duration of geologic time. The overall purpose of the project is for the student to learn how to integrate, through literature study, the various facets of the fossil record of a specific group of organisms. Depending on the subject and/or interest of the student, the paper should include a review of a taxon's:

1) Morphology (distinguishing characteristics); 2) Paleoecology (utility in paleoenvironmental reconstruction); 3) Evolutionary trends (change in morphology of selected taxa through time, pattern of evolution); 4) Biostratigraphy (utility for interpreting geologic time); and/or 5) Paleobiogeography (geographic distribution through slices of geologic time and its historical significance; e.g., migration, local extinction, etc.).

Requirements. The text will be doubled spaced, with one inch margins on all sides. The paper will have a brief abstract (200 words), with an I. Introduction; II. Basic knowledge; III. Discussion; and IV. Conclusion sections (you may retitle these headers as appropriate). The suggested length of the paper is 5 pages, excluding references and illustrations. All references must be author cited (no anonymous Web citations). Additional style information will be provided. The references will be in a GSA format.

Presentations. Each student will give a PowerPoint presentation on their talk to be critiqued by the class. This informal opportunity to speak provides the student the opportunity to practice communication skills, both in presenting research and answering questions based on knowledge derived from course work and research. The presentation will be a maximum of 15 minutes in duration. Students will be subjected to classmate and my questions for as long as they last. (Examples of titles of talks include "Sphaeriidae" (Mollusca, Bivalvia), "Anomalocaris" (Invertebrates), "Euryperids" (Arthropods), "Smilodon" (Vertebrates), "Conodonts" (Vertebrates), "Mammoths" (Vertebrates), "Origin of Birds and Flight" (Vertebrates).

Geol 487: Research I

1. Selection of an appropriate and feasible research topic.

Let's mutually decide on a research topic no later than six weeks into the semester! Please turn in a one page typewritten description of the project at

that time.

"*Feasibility review*" I think means describing what methods you plan to use, along giving some assurance that the methods you choose will work.

No later than two weeks before the last day of classes, please turn in a completed draft of your research proposal. This should be about 5-10 typewritten double-spaced pages, include figures, maps, tables, etc., and have the following parts:

Title - brief and to the point

Introduction - What is the problem you will address or question you plan to answer? Why is it important? Why should others care? What are your multiple-working hypotheses (see Chamberlin, 1890)?

Previous Research - What is our state of knowledge on this problem, both indirect and direct? Describe the work that others have carried out that relates to the problem you plan to address. Briefly summarize the gap in knowledge that you will explore.

Methods - Provide an overview of the methods you plan to employ and then go into each step in detail. Provide a time line - when will each part of the work you plan be completed? Are there contingency plans? What will happen if the methods do not work as well as you hope? How much will it cost and how will it be paid for?

Anticipated Results - What answers do you expect? How will the results be presented (text, figures, tables, appendices, etc.)?

List of References - Make sure that all references cited in the text are included and none others. Pay strict attention to citation style; I would recommend using the style required by the *Journal of Hydrology*.

I will try to return comments on your draft proposal no more than one week later. The final draft, with all comments and problems satisfactorily addressed, must be turned in no later than the last day of classes.

Geol 488: Research II

1. Execution of the research proposed in Research I.

Be sure to begin early! Plan to turn in all your results in an organized format no later than two weeks before the last day of classes. It should be essentially the methods and results section of your thesis (see below).

Geol 494: Senior Thesis

1. Preparation of a scientific paper documenting the work undertaken in Research II and the interpretation of results of that work.

No later than two weeks before the last day of classes, please turn in a completed draft of your senior thesis. Note that much of it can be adapted from your proposal. The final paper should be about 8-15 typewritten double-spaced pages and include figures, maps, tables, etc. Here is an outline of the essential parts:

Title - brief and to the point

Abstract - A 250 word or less summary of your thesis. It should include a sentence or two on each part that follows.

Introduction - What is the problem you will address or question you plan to answer? Why is it important? Why should others care? What are your multiple-working hypotheses (see Chamberlain, 1890)?

Previous Research - What is our state of knowledge on this problem, both indirect and direct? Describe the work that others have carried out that relates to the problem you plan to address. Briefly summarize the gap in knowledge that you will explore.

Methods - Provide an overview of the methods you used and then go into each step in detail. Provide sufficient detail to allow someone else to replicate your work.

Results - What answers do you find? How do the results address the question or hypothesis you present? Present the results clearly and concisely using text, figures, tables, and appendices.

Discussion - How do your results relate to the work that others have done? Explain the answer to the question you posed.

Conclusions - Summarize your findings.

List of References - Make sure that all references cited in the text are included and none others. Pay strict attention to citation style; I would recommend using the style required by the *Journal of Hydrology*.

I will try to return comments on your draft thesis no more than one week later. The final draft, with all comments and problems satisfactorily addressed, must be turned in no later than the last day of classes. A copy should go to the library, too.

Results

Fall, 2006-Summer, 2007				
Program Area	ND Passing Score	Total Test Takers	Average Score	Percent Passing
Earth Science- 20571	149	0		

c. Praxis II results for Earth Science

d. Results of other content knowledge assessment (s).

No candidates are enrolled in the program.

Student Work Samples

None. No candidates are enrolled in the program.

13010.4, 13020.4, 13035.4, 13045.4, 13047.4, 13050.4 CONTEXT OF SCIENCE

The program requires the study of the effect of social and technological context on the study of science and on the application and valuing of scientific knowledge. The program prepares candidates to relate science to the daily lives and interests of students and to a larger framework of human endeavor and understanding. The program provides the candidate with an understanding of the relationship of science to industry, business, government, and multicultural aspects of a variety of communities. The program uses varied performance assessments of

List course number, title and description and any accompanying activities or experiences in which students engage to meet the standard.

<u>Geol 101/101L</u>. Introduction to Geology/Lab. 4 credits. Introduction to the dynamics of Earth—volcanoes, earthquakes, plate tectonics, streams, groundwater, glaciers, waves, wind, and landslides, with emphasis on the environmental applications of these processes. Introduction to the tools of the geologist—minerals, rocks, maps, and aerial photographs. An introductory laboratory complements Geol 101, and includes field trip(s).

<u>Geol 102/102L</u>. Earth Through Time/Lab. 4 credits. The tracing of changes in Earth and life through time, with emphasis on the record from North America. An introductory laboratory complements Geol 102.

<u>Geol 330</u>. Structural Geology. 3 credits. Prerequisites: Geol 318, Geol 320, and Math 105. Mechanics of rock deformation, analysis of rock structures, preparation and interpretation of geologic maps and cross sections showing structural and tectonic features. Includes laboratory.

<u>Geol 414</u>. Applied Geophysics. 3 credits. Prerequisites: Geol 101, Math 265, Phys 212 or 252. Principles of various geophysical methods and their application to geologic problems.

<u>GeoE 417</u>. Hydrogeology. 3 credits. Prerequisite: Math 166 or consent of instructor. Physical and chemical aspects of groundwater movement, supply, and contamination.

Assessments

- a. Earth Science Praxis II Exam- no test takers within the last 3 years
- b. Included below are numerous examples, taken from multiple levels in the curriculum, illustrating the context of geological science within society. Examples include a geologic evaluation of the suitability of a proposed disposal site for high-level nuclear waste, formulation of a plan to develop the groundwater resources of a community, identification of the uses of certain geologic materials in consumer products, origins of ores having industrial and commercial importance, exploration for natural resources, the increasing exploitation of groundwater resources (especially in agriculture), and the origin and inventory of the "fossil fuels" oil and coal (upon which all industrial societies are heavily dependent). The value of our science to society is further elaborated through the study of geologic hazards, especially earthquakes and volcanic eruptions. We ask students to learn where these risks are greatest and to explain why. We hope this knowledge will inform political processes (such as the updating of municipal zoning requirements), as well as personal choices. We examine fluvial (river) processes and hazards with a similar societal goal. Much of what we know about seismic and volcanic hazards has been illuminated through technology. In some instances, technological advances have fortuitously allowed us to explore Earth in greater detail, but it is also true that a "need" to understand more about Earth has driven technological experimentation and development. The Great San Francisco Earthquake of 1906 is said to have ushered in the modern era of seismic research; a great American city lay in ruins, many people were killed. Why did this happen? Society was interested in what science could offer. Hypotheses were developed. Seismographs were deployed around the world. Eventually, the study of seismograms would reveal new details of Earth's internal structure and document strong tendencies for quakes to be most prevalent in narrow belts that snake around the planet. Volcanoes also tend to be concentrated in belts, and many volcanic and earthquake belts correspond quite closely to one another. Eventually, technological advances affecting a variety of disciplines (seismology, volcanology, the study of remanent magnetism, radiometric dating) allowed for the accumulation of overwhelming evidence that "plate tectonics" links and explains many of the dynamic (and sometimes catastrophic) processes we experience at Earth's surface.

We also intend for a knowledge of geology to enrich the daily lives of our students. Earth is beautiful and awe-inspiring. Comprehending that the rock you are standing on formed 15,000 feet beneath Earth's surface 120 million years ago (and understanding how we know those things), or that another rock was part of a massive sand dune complex being shaped by the wind 200 million years ago, or that a group of rock layers now exposed deep in the gorge of the Grand Canyon are a *de facto* physical record of the progressive inundation of nearly all of North America by *seawater* some 500 million years ago—these and similar realizations add immensely to the possibilities of finding joy and intellectual satisfaction in life. Hence, we ask students to demonstrate familiarity with the geology and geologic history of particularly spectacular places they may be most likely to visit, and to understand the dominant geologic features and processes of major geologic "provinces" in the nation.

Geol 101/L: Introduction to Geology/Introduction to Geology Lab

- 1. The acid-neutralizing ingredient in Tums and other conventional antacids is: a) gypsum; b) quartz; c) halite; d) pyrite; e) calcite.
- 2. The mineral used to make drywall ("sheetrock", "wallboard") and plaster is: a) calcite; b) halite; c) quartz; d) biotite; e) gypsum.
- 3. The cities of Seattle and Portland are most threatened by:
 a) stratovolcanoes; b) shield volcanoes; c) cinder cones; d) domes or plugs;
 e) batholiths
- The type of volcano that has caused the most destruction to cities is the:
 a) stratovolcano; b) dome or plug; c) cinder cone; d) shield volcano; e) none of these
- 5. Aluminum is refined from this mineral found in tropical soils: a) borax; b) quartz; c) limestones; d) iron oxides; e) bauxite.
- 6. Most of Earth's <u>liquid fresh water</u> is:
 a) flowing beneath glaciers; b) in Lake Superior; c) seawater;
 d) groundwater; e) river water.
- 7. When a new dam is placed on a graded river, the portion of the river immediately *upstream* of the dam responds by:
 a) straightening its channel; b) meandering; c) depositing its load;
 d) increasing its competence; e) increasing its gradient.
- Assuming all building lots are at the same elevation, the <u>worst</u> place to build a house is probably the lot labeled [illustration omitted from ESPB report]:
 a) F; b) G; c) H; d) I; e) J.
- 9. Piers or groins disturb the beach primarily by:
 - a) increasing the angle of wave refraction
 - b) interfering with longshore drift
 - c) decreasing the angle of wave refraction
 - d) lowering local wave base
 - e) raising local sea level

10. As water is withdrawn from a well, the water table near the well drops and forms a(n)

a) travertine deposit; b) artesian system; c) dowser; d) contamination zone; e) cone of depression.

11. According to people using M. King Hubbert's methods, which statement best describes the future of oil availability in the world?a) we will have all we want for about 30-35 years, but then it will suddenly

run out b) it will remain plantiful for at least several decades, and probably for

b) it will remain plentiful for at least several decades, and probably for centuries

c) it can remain plentiful for several decades, but only if the Arctic National Wildlife Refuge is drilled soon

d) each year from now on, more and more oil will be available as new exploration and development technologies are used

e) each year from now on, there will be less and less oil available

- 12. Petroleum comes mainly from partly decomposed:a) dinosaurs b) forest trees and plants c) fish d) microscopic plants and animals e) shells, bones and teeth
- 13. The U.S. uses about ____% of all the oil pumped out of the ground in the world each year.
 a) 56% b) 35% c) 25% d) 18% e) 4.5%
- 14. In recent years, about 2/3 (two-thirds) of the oil used by the U.S. each year is imported.a) true b) false
- 15. There are numerous earthquakes and andesite volcanoes in Japan and in the Aleutian Islands because these areas are on:
 - a) crumbling plates
 - b) convergent plate boundaries
 - c) divergent plate boundaries
 - d) transform plate boundaries
 - e) hot spots
- 16. There are numerous earthquakes in southern and central California because this area lies on a:
 - a) subduction zone
 - b) divergent boundary
 - c) transform boundary
 - d) crumbling plate
 - e) continent.

- 17. Refer to the geologic map above [omitted from ESPB report]. Which of these two letters marks what is probably the better place to drill for oil?a) A b) B
- 18. Generally speaking, it is best to build a house on soft sediments since those dampen (reduce the size of) seismic waves.a) true b) false
- 19. One way we know Earth's outer core is liquid is that:a) P waves are not received by seismographs in a large zone on the side of Earth opposite an earthquake

b) S waves are not received by seismographs in a large zone on the side of Earth opposite an earthquake

c) surface waves are not received by seismographs in a large zone on the side of Earth opposite an earthquake

d) P waves can only travel through liquids

e) the P waves and the S waves get closer together after moving through the core.

20. The distance between a seismograph and the source of an earthquake can be determined from:

a) calculation of the earthquake's magnitude

- b) the intensity of the quake as recorded on the seismograph
- c) the height of the p waves
- d) the height of the s waves
- e) the arrival times of the p and s waves
- 21. The epicenter of an earthquake can be determined if:

a) the quake is recorded by the Richter Memorial Seismograph in Washington, D.C.

b) three seismographs detect the p waves

c) P waves, S waves, and L waves from the quake are recorded by seismographs at two different locations

d) P waves and S waves from the quake are recorded by seismographs at three different locations

e) S waves and L waves from the quake are recorded by seismographs at four different locations

Geol 102/L: Earth Through Time/Earth Through Time Lab.

- 1. The U.S. mountain chain known as the Cascade Range is:
 - a) a volcanic arc located above a subduction zone

b) a new divergent plate boundary, where igneous material will eventually split the continent apart

c) prone to earthquakes originating on transform faults

d) an accretionary wedge of tectonic melange

e) choices (b) and (c) only

- 2. Refer to the picture that will be shown during the exam [omitted from ESPB report]. The sedimentary structures visible in this mudstone indicate that the sediment could have been deposited:
 - a) in a glacial lake
 - b) on the deep sea floor, following a submarine landslide
 - c) on the banks of a river
 - d) on a sand dune
 - e) beneath a glacier.
- 3. The Tapeats Sandstone, Bright Angel Shale, and Muav limestone:
 - a) are flysch and molasse of the Caledonian Orogeny
 - b) are flysch and molasse of the Allegheny Orogeny
 - c) record the earliest and largest glaciation to strike Laurentia in the Paleozoic
 - d) record regression of the Sauk Sea in the Silurian
 - e) record transgression of the Sauk Sea in the Cambrian
- 4. Much of the high grade coal from the eastern U.S. formed in cyclothems during the:a) Devonian; b) Mississippian; c) Pennsylvanian; d) Permian; e) Ordovician.
- 5. The White Cliffs of Dover on the English Channel are made of sediment deposited in the _____ Period.
 a) Silurian; b) Eocene; c) Calcareous; d) Cretaceous; e) Oolitic.
- 6. Granites now exposed in Yosemite National Park in the Sierra Nevada date from the:a) Permian; b) Jurassic; c) Tertiary; d) Absaroka; e) Calcareous
- 7. As a result of subduction of the Juan de Fuca plate beneath North America, volcanism continues in the:
 a) Atlantic Coastal Plain b) Great Plains c) Appalachian Mountains
 d) Cascade Range e) Hawaiian Islands
- 8. An area of North America that may be slowly rifting apart is the:
 a) Black Hills b) Cascade Range c) Basin and Range d) Grand Canyon
 e) Mississippi Embayment
- 9. The Columbia River basalts as well as the volcanic rocks of the Snake River Plain and the Yellowstone area:
 - a) were all formed on the Colorado Plateau
 - b) formed as a result of the Laramide Orogeny

c) may have formed as North America drifted over a plume of magma rising from the mantle

d) record the early stages of a process in which North America will probably ultimately rift aparte) may have formed in a volcanic island arc

Geol 330: Structural Geology

Thermal and Structural Analysis of Disposal of High-Level Nuclear Waste

This project is designed to encourage scientific inquiry into problems associated with disposal of high-level nuclear waste. In the following pages, a number of questions are posed and the means to seek answers to most of the questions are provided in specific software packages. You are encouraged to question the validity of the approach, to pose new questions, to seek alternate answers, and to suggest solutions to additional problems that may be indicated during the project.

Problem Statement

The US Department of Energy (DOE) proposes to store high-level nuclear waste (HLW) underground so that it will be isolated from the biosphere for a minimum of 10 ka. The HLW is to be stored in containers in an excavated cavern in either Precambrian granite in west central Minnesota or a salt dome in Louisiana at depths between 350 m and 800 m.

Discussion

Above 350 m, rock permeability's are high enough to permit significant fluid flow in joints and other fractures. Below 800 m, rock pressures are high enough to cause rock bursts in the excavated cavern and rock bursts can destroy the containers.

Problem Questions

1. What are the pressures of the rocks and fluids in the rocks at the proposed depths?

- 2. If the HLW containers leak, can fluids flow from the cavern to the surface?
- 3. Can fluids flow laterally? What do we need to consider?
- 4. Will the cavern ever fill with water?
- 5. If the cavern fills, is it a problem if the containers remain intact?
- 6. How could one insure that the containers remain intact?

Software:

EXCEL spreadsheet with calculations for Darcy velocity, pressure vs. depth, and thermal stress.

ARC – Finite difference heat flow model - calculates, displays, and creates data files for temperature change due to heat generation in the HLW.

Problem Steps

1. Use **HLW.xls** to determine the lithostatic and hydrostatic pressures at 350 m and 800m.

Lithostatic pressure (granite)	350 m	800 m
Endosado pressure (grante)		
Lithostatic pressure (salt)		
Hydrostatic pressure		

2. A stream flowing through the area has cut a valley with a relief of 20 m. Due to geomorphologic and structural considerations, the HLW site is located beneath a hill that is 200 m distant from the stream. Will water flow from the cavern to the stream?

Use **HLW.xls** to determine pressure differences below the hill and the stream. Do we do this for both rocks and water?

3. dP

Use program **HLW.xls** to calculate flow velocities based on the distance and pressure differences. (Assume the permeability of granite is 10^{-16} m² and the permeability of salt is 10^{-12} m²).

4. Velocity from hill to stream at 350 m depth _____ and 800 m depth _____

5. Will water flow into the excavated cavern? Calculate the pressure difference between the rock wall and the excavated cavern and recalculate velocities for water flow into the cavern. Initially use 0.1 m for the distance. Note that as water flows from the rock walls the hydrostatic pressure drops thus increasing the horizontal gradient.

6. Will the pressure differences we have calculated cause the rock to fracture? The tensile stress required to fracture granite is approximately 14 MPA, but the compressive stress is 150 MPa. Consider the **Poisson effect** as a clue to the answer for this question.

7. Heating by the radioactive waste will increase the temperature in the cavern. We need to determine how much time is required to attain boiling temperatures in the cavern and then calculate thermal stress between the cavern and the surrounding rocks. Run program **PrjWinHeat** or **ARC** to make this determination. Instructions on how to run the programs will be given in class, but a capsule for each follows:

PrjWinHeat – Click on **File**, select **input data**, select **text file**, select **hlwa** Click on Check and pull down the slide bar to see if the last line reads, "Read file successfully." Click on close. Click on Tools, select **run model**. Use the step option to monitor maximum temperature and elapsed time. Save the model as a grid file for **SURFER**[®] by clicking on the save option and giving the file a name. The .grd extension will be added by the program. Open **SURFER**[®] to view and display the results.

ARC – Click on **ARC** and follow the menu. Do not save the final model, but give the **SURFER**[©] grid file a .grd extension.

Hold a group discussion of the results; then prepare individual written analysis of the results with recommendations for action.

Geol 414: Applied Geophysics

1. Can you detect the following using geophysical techniques? How?

Buried tunnels Old streets in Underground Atlanta Missile Silos Faults Stream beds Salt domes Anticlines

GeoE 417: Hydrogeology

1. Aquifer Development Project

Below are the proposed teams for the engineering project:

West Team East Team

In making these teams I have tried to split up disciplines and promote diversity. One of the requirements for accreditation of the geological engineering program (and ALL other accredited engineering programs in the country, for that matter) is that our students must demonstrate an ability to function on multi-disciplinary teams (point d of the Mission of the Geological Engineering Program). Therefore, I want to keeps the teams as multidisciplinary (and as diverse) as possible. However, if you have a major problem with the team you are on, please contact me as soon as possible.

By Wednesday, November 7, 2007, do the following tasks: 1. Break up into your teams.

- 2. Share phone numbers and e-mail addresses with your teammates.
- 3. Select a team representative that I can contact if I need to get a hold of your team. Include his/her phone number.
- 4. List three one-hour time periods during the week that your team can meet with me (Meetings with me will usually last less than 15 minutes.). Give the best time first and the worst time last.
- 5. Read the Mission of the Geological Engineering Program. In this project I try to include as many of the objectives and outcomes listed in our mission statement.

Project Description

Your team is to make a numerical model of the Pleasant Lake aquifer in the vicinity of Sand Lake and estimate the amount of water, if any, that drains from the lake via the "intermediate aquifer" shown on Figures 2 and 16. You are to simulate "steady-state" conditions of permitted pumping before the new Rugby well field was permitted. Figures 35–37 (Pusc and Cline, 2002, pages 72–74) show various modeling result for the aquifer under these conditions. Assume these modeling results and the physical data provided in the Rugby report (Pusc and Cline, 2002) are accurate unless you can verify that they are wrong. See, for example, my discussion on the length of the shoreline for Sand Lake in the subsection on Hydrogeologic Information below. Your model should use constant-head boundaries when a lake or wetland is present at a boundary. Otherwise, you may use a mix of constant-head and no-flow boundaries; however, your model must use both types of boundary conditions Your model should incorporate the physical data in the Rugby report wherever possible. However, do not add complexity if it does not contribute to the quality of the model. This quote is attributed to Albert Einstein (1879-1955): "Everything should be made as simple as possible, but not simpler." This is good advice for a modeler. During the final week of classes each team will present its model. I may ask another graduate student to help assess your models.

Geographic Information

Geographic locations will be based on the federal system of rectangular surveys of public land. The first three digits (columns 1-3) identify the township north of an established baseline and the second three digits (columns 4-6) identify the range west of the Fifth Principal Meridian. The last two digits (columns 7-8) identify the section within the designated township and range in which the site is located. The letters A, B, C, and D designate, respectively, the northeast, northwest, southwest, and southeast quarter section (160 acres), quarter-quarter section (40 acres), and the quarter-quarter-quarter section (10 acres). For an illustrative example of this system, go to http://www.swc.state.nd.us, click on "Map and Data Resources" in the left menu column, and click "Ground/Surface Water." In the "Ground and Surface Water Query" after "Location" click "[info]."

Hydrogeologic Information

See the report by Pusc and Cline (2002). Assume the physical data given and the model results are accurate unless you can verify otherwise. For example, note the information on Sand Lake on pages 22 and 149 (Figure 94). The area is 71 acres, yet the shoreline is given as 0.85 miles. Verify that it is impossible to encircle an area this large with a shoreline this short. What is a more reasonable estimate for the shoreline length?

Tasks

Below are some tasks that need to be done for your project:

1. Name your company.

2. Everyone should review the Rugby report and then meet as a team to review it. Discuss how each person should make a numerical model of the area around Sand Lake and give guidance, as appropriate. Meet again and decide how to refine the models to determine a realistic range of how much water, if any, leaves Sand Lake through the intermediate aquifer. With your level of modeling sophistication you need to chose a horizontal elevation for the base of your model. Assume your base is impermeable. Based on the physical data, what is a reasonable estimate for the depth of the aquifer in the vicinity of Sand Lake?

3. The simulations will be done by Excel using the iteration option. You can either set your model up first and then go to the iteration option or you can allow the iteration option to be in process as you set up the model. If you choose the latter, select all of the cells that will be in your model, go to "Tools" on the menu bar, select "Options," then select "Calculation," and click the Iteration box. Initially, you should have only a iterations (~10) and a low accuracy (~ 0.1 ft). Once you have entered the appropriate values and equations in the model, then you should to back and change the iterations to 32,000 and the accuracy to 1E-10 ft. The computer will do the iterations for you. Check your model for errors!

4. The basic flow equation to be solved is (Eq 4.46 in Fetter).

$$\frac{\partial}{\partial x}\left(h\frac{\partial h}{\partial x}\right) + \frac{\partial}{\partial y}\left(h\frac{\partial h}{\partial y}\right) = 0$$
...(1)

We know h is a function of x and y. We also know that

$$\frac{\partial h^2}{\partial x} = 2h \frac{\partial h}{\partial x}$$
 and $\frac{\partial h^2}{\partial y} = 2h \frac{\partial h}{\partial y}$

Making these substitutions into Eq. (1) yields

$$\frac{\partial^2 h^2}{\partial x^2} + \frac{\partial^2 h^2}{\partial y^2} = 0$$
....(2)

Making the substitution u = h2 yields the two-dimensional Laplace equation (Eq. 4.43 in Fetter). If we also include recharge, w (many authors use R), Eq. (2) becomes

$$\frac{\partial^2 h^2}{\partial x^2} + \frac{\partial^2 h^2}{\partial y^2} = -\frac{2w}{K}$$
...(3)

Which is Eq. (4.67) in Fetter. Use the following relationships to change Eq. (3) into the finite difference equation that must be solved for the interior cells in your model. Let $\Delta x = \Delta y$.

$$\frac{\partial^2 u}{\partial x^2} \approx \frac{u_{i-1,j} - 2u_{i,j} + u_{i+1,j}}{\left(\Delta x\right)^2} \text{ and } \frac{\partial^2 u}{\partial y^2} \approx \frac{u_{i,j-1,j} - 2u_{i,j} + u_{i,j+1,j}}{\left(\Delta y\right)^2}$$

Make sure you have the correct finite difference formula before you proceed. Start simply and add complexity later (differing K and w values). First get the general flow directions correct.

5. Once your model has converged on a solution, you need to plot the equipotential lines. To do this, take the square root of the u field and select the resulting h field. Then, select "Chart," and then "Surface." Finally, click of the y-axis of the plot and select "reverse order" so the plot is in the same orientation as the figures in Pusc and Cline (2002). Your results should be similar to those on Figure 35 (page 72). However, the contour interval on Figure 35 is 2 ft and is too coarse to allow you to draw an accurate flow net around Sand Lake. Choose the contouring parameters that you think best display your results.

6. Draw a flow net with the equipotential lines. Remember, inflow – outflow = change in storage. In = groundwater in + precipitation; out = groundwater out + evapotranspiration. Use the Dupuit equation (4.59) to estimate the amount of flow in your flow tubes. This equation is for discharge in the entire flow tube; however, it is likely that the aquifer is deeper than Sand Lake. How can you proportion the amount of groundwater flowing into Sand Lake and the amount flowing beneath Sand Lake but still in the main portion of the Pleasant Lake aquifer (PLA) (and possibly being lost from the PLA to the intermediate aquifer)?

7. Compare the different models developed by your teammates. How can you check if the models make physical sense? This will be key issue on "selling" you product to the "clients." See chapter 13 in Fetter on model calibration.

8. Decide on a final set of models to shown the range of possible discharge from Sand Lake to the intermediate aquifer.

9. Prepare you presentation.

Presentation

The teams will present their models on either December 5th or 7th. Each of the two teams will have 10-15 minutes to present their results. Assume that your team is a consulting company asked to make an initial model of the groundwater flow around Sand Lake. The best company would then get a contract to continue the modeling to find where pumping wells could be added in the aquifer. The potential "clients" you need to impress are myself and some graduate students. Everyone on the team should participate in the presentation. Almost all of the figures in the Rugby report are in color. I have color pdf files of them, if you need them. You may also borrow the original figures if you would like to make color copies. The color pdf files are reduced to fit on an 8.5" x 11" page. Figures like Figure 5-6 are reduced at different scales, which limits their usefulness for comparison purposes.

Report

All numbers and calculations used in your design must be recorded in a report that will be due at the time of your presentation. Students and the instructor must be able to follow your work. Poster, hardcopies of PowerPoint presentations, calculations, etc. will be made available in the Geology Library for students to peruse. It is vital that your work is easy to follow. The EXCEL spreadsheets of your model will also be made available to everyone.

Grade

Your grade will be based on how well you performed the above tasks and how effectively you communicated them to the "clients." This is a team project; however, I will be checking weekly to determine the effort contributed by each team member. You will also be asked to provide a list of things you did, things your teammates did, and your effort as a percent of the total team effort.

Below is a breakdown of the project components.

- I. Hydrogeological Model Components (total = 68)
 - A. Proper finite difference formula for Eq. (3) and appropriate Δx (4)
 - B. Determination of boundaries of simulation (length, width, depth) (8)
 - C. Determination of flow parameters (w and K) (8)
 - D. Proper boundary conditions (constant-head, no-flow) (8)
 - E. Proper consideration of Sand Lake (size, location, depth, shape) (6)
 - F. Proper flow net (8)
 - G. Alternative solutions (everyone must do a model simulation) (8)
 - H. Model calibration to determine range of discharge from Sand Lake to intermediate aquifer (18)
- II. Presentation of models (total = 32)
 - A. Clarity of report (16)
 - B. Oral presentation EVERYONE MUST PARTICIPATE (16)

Final Exam

On the final exam each student will be asked the following question worth 10 points: "Which of the engineering teams did the best job in designing and presenting their model? Explain the basis for your answer in a short paragraph."

Project Goal

The goal of this project is to teach students in geological engineering and other engineering and scientific disciplines some of the fundamentals of engineering design from a hydrogeological perspective. Engineering design "is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic
sciences and mathematics and engineering sciences are applied to convert resources optimally to meet a stated objective. Among the fundamental elements of design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing, and evaluation. The engineering design component of a curriculum must include most of the following features: development of student creativity, use of open-ended problems, development and use of modern design theory and methodology, formulation of design problem statements and specifications, consideration of alternative solutions, feasibility considerations, production processes, concurrent engineering design, and detailed system descriptions. Further, it is essential to include a variety of realistic constraints, such as economic factors, safety, reliability, aesthetics, ethics, and social impact." In our problem you are designing a groundwater model, based on physical data, to estimate the range of how much water is leaving Sand Lake through the intermediate aquifer in the Pleasant Lake groundwater system.

Slight deviations from some of the guidelines above may be implemented, but only after they are approved by the instructor.

Time is short. Don't get bogged down in trivial details; your boss believes that time is money. There is no single right answer for this project. Use good engineering judgment based on sound science and be creative in applying it!

*This comprehensive and intellectually challenging exercise demands integration of prior learning at a high cognitive level; the analysis, synthesis and prioritization of voluminous data and interpretations from multiple subdisciplines; selection of site-appropriate parameters for use in sophisticated computer simulations, and—ultimately—arrival at a justified mathematical description (a model) of groundwater flow in a complex aquifer system. The groundwater model is a provisional explanation, analogous to a hypothesis. Interpretations derived from the model can then guide strategies for future exploitation of the groundwater resource. Aesthetics, ethics, and social impact are explicitly considered. The exercise is a prime example of the context of science with respect to business, industry, government, society, and the environment.

Results

c. Praxis II results for Earth Science Fall, 2006-Summer, 2007

Program Area	ND Passing Score	Total Test Takers	Average Score	Percent Passing
Earth Science-	149	0		
20571				

d. Results of other content knowledge assessment (s).

No candidates are enrolled in the program.

Student Work Samples

None. No candidates are enrolled in the program.

13010.5, 13020.5, 13035.5, 13045.5, 13047.5, 13050.5 SKILLS OF TEACHING

The program requires the candidate to demonstrate proficiency in methods of teaching science. The program uses varied performance assessments of the candidate's understanding and ability to apply that knowledge.

List course number, title and description and any accompanying activities or experiences in which students engage to meet the standard.

<u>T&L 400 Methods and Materials- Science</u>: Through a partnership with departments in the College of Arts and Sciences and the College of Business, candidates may seek secondary licensure in several areas. Requirements may vary depending upon the field of study, so candidates are advised to keep in close and regular contact with academic advisers from both Teaching and Learning and their academic discipline. Secondary education degrees are offered in science and social studies.

A copy of the syllabus from T&L 400, Science Teaching Methods is included that requires students to prepare and present demonstrations, assessments, and lesson plans. Students spend time in class observing various styles of presentation for labs, demonstrations, and assessment. Then they develop and present their own lessons, demonstrations, assessments, and grading (using rubrics and gradepower.com (a free website developed by Dr. Helgeson for teachers to use in grading student progress). The syllabus includes a variety of activities by which students learn how to promote the development and use of a variety of science skills, e.g., measurement, observation, inference, data analysis, data presentation, etc.

Assessments

- a. Course Grades
- b. Student Teaching Evaluations

Results

a. Course Grades

Fall 06 & Fall 0	7	Methods and M	Iaterials - Scienc	e	
T&L 400	А	В	С	D	F
N=12	12/100%				

b. Student Teaching Evaluation: No Earth Science candidates in the program in the last 3 years.

13010.6, 13020.6, 13035.6, 13045.6, 13047.6, 13050.6 CURRICULUM

The program provides candidates with information necessary to identify, evaluate, and apply a coherent, focused science curriculum that is consistent with state and national standards for science education and appropriate for addressing the needs, abilities and interests of students. The program uses varied performance assessments of candidate's understanding and ability to apply that knowledge.

List course number, title and description and any accompanying activities or experiences in which students engage to meet the standard.

<u>T&L 400 Methods and Materials- Science:</u> Through a partnership with departments in the College of Arts and Sciences and the College of Business, candidates may seek secondary licensure in several areas. Requirements may vary depending upon the field of study, so candidates are advised to keep in close and regular contact with academic advisers from both Teaching and Learning and their academic discipline. Secondary education degrees are offered in science and social studies.

Students conduct experiments and activities from three major curriculum projects: Project WET, Project Learning Tree, and SEPUP (Science Education for Public Understanding Program. All these curriculum projects are recognized at the national level as exemplary science education programs and all address the National Science Education Standards. Students are required to become members of the National Science Educators Association (NSTA), for which they receive a quarterly newspaper that addresses recent legislation, new curriculum, content and material evaluation of new books and science supplies. In addition students receive information about regional and national science education conferences.

Assessments

- a. Course Grades
- b. Student Teaching Evaluations

Results

a. Cour	se Grades				
Fall 06 & Fall 0	7	Methods and M	laterials - Scienc	e	
T&L 400	А	В	С	D	F
N=12	12/100%				

b. Student Teaching Evaluation: No Earth Science candidates currently in the program in the last 3 years.

13010.7, 13020.7, 13035.7, 13045.7, 13047.7, 13050.7 ASSESSMENT

The program prepares candidates to use a variety of performance assessment strategies to evaluate the intellectual, social, and personal development of the learner in all aspects of science. Where in your program do candidates have the opportunity to address/meet this standard? T&L 400 Secondary Science Methods syllabus attached that shows the requirement to develop assessments of student content knowledge, skills, and problem solving strategies.

List course number, title and description and any accompanying activities or experiences in which students engage to meet the standard.

<u>T&L 400 Methods and Materials- Science:</u> Through a partnership with departments in the College of Arts and Sciences and the College of Business, candidates may seek secondary licensure in several areas. Requirements may vary depending upon the field of study, so candidates are advised to keep in close and regular contact with academic advisers from both Teaching and Learning and their academic discipline. Secondary education degrees are offered in science and social studies.

T&L 400 Secondary Science Methods syllabus attached that shows the requirement to develop assessments of student content knowledge, skills, and problem solving strategies. Students prepare Multiple Choice exam questions, Open ended exam questions with accompanying rubrics, and Performance Based Assessment and Rubrics. The course includes extensive discussion of National and State testing for teachers and high school and middle school students.

Assessments

- a. Course Grades
- b. Student Teaching Evaluations

Students are also evaluated by their in-class discussion and performance related to this standard. The professor teaching the course spends a significant amount of time on the problem of relating the type of assessment to the activities in class and to the style of teaching a lesson. In addition students learn how to assign and defend weighted grades using the website gradepower.com. In that web site they learn how to communicate with students about grades, weight and give grades, and student teachers engage in extensive discussion on the philosophies and ideologies related to grades, evaluation, and assessment.

u. 00ui	be officies				
Fall 06 & Fall 0	7	Methods and M	Iaterials - Scienc	e	
T&L 400	А	В	С	D	F
N=12	12/100%				

Results

a. Course Grades

b. Student Teaching Evaluation: No Earth Science candidates in the program in the last 3 years.

13010.8, 13020.8, 13035.8, 13045.8, 13047.8, 13050.8 ENVIRONMENT FOR LEARNING

The program prepares candidates to design and manage safe and supportive learning environments in the classroom, laboratory, and field. The program reflects high expectations for the success of all students. The program uses varied performance assessments of candidate's understanding and ability to apply that knowledge.

List course number, title and description and any accompanying activities or experiences in which students engage to meet the standard.

<u>T&L 400 Methods and Materials- Science</u>: Through a partnership with departments in the College of Arts and Sciences and the College of Business, candidates may seek secondary licensure in several areas. Requirements may vary depending upon the field of study, so candidates are advised to keep in close and regular contact with academic advisers from both Teaching and Learning and their academic discipline. Secondary education degrees are offered in science and social studies.

<u>T&L 401 School Science Safety - Science</u>: Prepares students to plan for and communicate about a wide variety of classroom and laboratory safety issues. Health and safety issues are examined for the classroom teacher and the students in all science courses, including electrical safety, biological safety, chemical use, storage and disposal, legal issues, liability reduction and cost control are also addressed in detail.

T&L 400 Secondary Science Teaching Methods and T&L 401 School Science Safety address these standards. Syllabi show that students develop observational lists that help them to clarify in their own minds what an ideal laboratory/science environment should be. With regard to safety in the science room students are required to carry out evaluations of classroom in existing schools, assess ventilation within the classroom, assess storage and disposal procedures for chemicals, and to understand the safety requirements in Chemistry, Biology, Physics, Environmental studies, and on field trips. They learn extensively about the law and teacher responsibility in maintaining a safe learning environment.

Students must pass examinations in Safety related to the areas Chemical, Biological, and Physics science safety as part of this course.

Assessments

- a. Course Grades
 - 1. T&L 400
 - 2. T&L 401
- b. Student Teaching Evaluations
- c. Safety Exam Results

Results

A.1 Course Grades

Fall 06 & Fall 07Methods and Materials - Science					
T&L	А	В	С	D	F
400					

N=12	12/100%							
A.2 Cou	A.2 Course Grades							
Fall 07	Fall 07 School Safety - Science							
T&L	Α	В	С	D	F			
400								
N=5	5/100%							

b. Student Teaching Evaluation: No Earth Science candidates in the program in the last 3 years.

13010.9, 13020.9, 13035.9, 13045.9, 13047.9, 13050.9 PROFESSIONAL PRACTICE

The program prepares candidates to participate in the professional community, improving practice through their personal actions, education, and development. The program uses varied performance assessments of candidate's understanding and ability to apply that knowledge.

List course number, title and description and any accompanying activities or experiences in which students engage to meet the standard.

<u>T&L 400 Methods and Materials- Science</u>: Through a partnership with departments in the College of Arts and Sciences and the College of Business, candidates may seek secondary licensure in several areas. Requirements may vary depending upon the field of study, so candidates are advised to keep in close and regular contact with academic advisers from both Teaching and Learning and their academic discipline. Secondary education degrees are offered in science and social studies.

Students enrolled in T&L 400 are required to become members of the National Science Teachers Association in order to receive either the journal "Science Scope" or "The Science Teacher" and the NSTA quarterly newspaper, and have access to professional conference information. Students in T&L 400 discuss NSTA journal articles and NSTA newspaper articles that included recent legislation and trends in science education, and these are all discussed in class at great length. The membership in NSTA is in lieu of a textbook for the class as the documents that come with membership provide in-depth reviews of current trends and legislation related to science education. In addition students carry out extensive discussion of their Field Experience (T&L 486) and complete an evaluation of the Laboratory Safety in their schools and make a list of observations in their assigned Field Experience school laboratories and materials (books and equipment) and curriculum.

Assessments

- a. Course Grades
- b. Student Teaching Evaluations

Results

a. Course Grades

u. Course Orades	
Fall 06 & Fall 07	Methods and Materials - Science

T&L 400	А	В	С	D	F
N=12	12/100%				

b. Student Teaching Evaluation: No Earth Science candidates in the program in the last 3 years.

13010.10, 13020.10, 13035.10, 13045.10, 13047.10, 13050.10 TECHNOLOGY

The program requires the study of current, appropriate instructional technologies. The program uses varied performance assessments of candidates' understanding and abilities to apply that knowledge.

List course number, title and description and any accompanying activities or experiences in which students engage to meet the standard.

<u>T&L 400 Methods and Materials- Science</u>: Through a partnership with departments in the College of Arts and Sciences and the College of Business, candidates may seek secondary licensure in several areas. Requirements may vary depending upon the field of study, so candidates are advised to keep in close and regular contact with academic advisers from both Teaching and Learning and their academic discipline. Secondary education degrees are offered in science and social studies.

Students learn about and use current Vernier and Texas Instruments Computer Based Laboratory technology to gather real time data in experiments. They learn to use Global Positioning Systems and ARCVIEW Geographic Information Systems Software to track sampling sites in data gathering. They learn to use i-movie to film student performance in classroom and testing for the purpose of analysis of student science skills. They learn to use standard laboratory equipment for a variety of tasks including demonstrations, performance tests, and science skill evaluation. They use video cameras to record and analyze assessment procedures.

Assessments

a. Course Grades

Results

a. Course Grades

]	Fall 06 & Fall 0	7	Methods and M	Iaterials - Scienc	e	
	T&L	А	В	С	D	F
	400					
	N=12	12/100%				

Student Work Samples

Samples of Student designed Performance Based Examination is included in the form of an i-movie on CDs available in the Hard Copy exhibits.

13010.11

Candidate assessment data are regularly and systematically collected, compiled, aggregated, summarized, and analyzed to improve candidate performance, program quality, and program operations. The program disaggregates candidate assessment data when candidates are in alternate route, off-campus, and distance learning programs.

Teaching & Learning Undergraduate Assessment Plan

Data Collection. Data are collected at transition points throughout the program to assess candidate performance, program quality and program operations. The Teaching and Learning Undergraduate Assessment Committee (UGAC) develops an annual schedule for the purposes of data collection. T&L undergraduate faculty who assess critical tasks, staff in the Office of Advising and Admissions and staff in the Office of Field Experience are responsible for submitting data presented in the table below. The UGAC monitors the collection process and follows up in a timely manner when data is missing. N/A.

Data Analysis and Reporting. The UGAC is responsible for submitting an annual report to the undergraduate faculty in the Department of Teaching and Learning, the Chair of Teaching and Learning and the Associate Dean for Teacher Education (NCATE Coordinator) based upon a detailed analysis of data collected over the course of the previous year. The Assessment Committee facilitates an annual Assessment Retreat. Faculty discuss the report at the departmental and individual program level and develop a written plan of action designed to address areas of weakness. Should no areas of weakness be found, a written record of faculty discussion leading to this conclusion is created. In between assessment retreats, the UGAC monitors progress in the implementation of the action plan(s). In subsequent retreats, the action plans are revisited and revised in light of the new round of data analysis.

Initial Program Undergraduate	s Upon Admission to Teacher Education	B	efore Entering Student Teaching		Before Program Completion	After Completion
 Elementary ECE/Elementa Elementary/Mi 	 GPA PPST Score Letter of Application Disposition 	•	Critical Tasks (Child Study, Multicultura I Teaching, Lesson Plan, Beliefs and Practices Statement) Praxis II Tests Dispositions	•	Critical Tasks (Mid- term Evaluation, Final Evaluation Dispositions	Assessments:Graduate SurveysPrincipal Surveys

Unit Assessment System for the Elementary Education Program

Please describe the program changes that have occurred as a result of your data analysis process for the last three years. If you have just initiated this assessment system, please indicate what you have done to date.

II. Multicultural/Native American /Diversity Standard

The program requires the study of multicultural education including Native American studies and strategies for teaching and assessing diverse learners.

This response is prepared for all programs approved by ESPB. If you are reviewing an undergraduate or initial program only, please read the sections of this response headed *Initial Programs*. For Advanced or Professional Programs, please read the sections of this response headed *Advanced Programs*. Syllabi, vita and cited electronic work samples referred to in the report may be found in the folder labeled "MC-Diversity Standard."

MULTICULTURAL EDUCATION/NATIVE AMERICAN STUDY

Initial Programs

Opportunity to Address/Meet Standard

T&L 433: Multicultural Education: All candidates in the Teacher Education Program at the University of North Dakota are required to complete this course (There is also a correspondence course with the same prefix and title which is offered to those who are in non-UND programs. Rarely, an exception is made for a candidate in the program who is unable to take the on-campus course.)

Course Description

This class takes an anthropological view of multicultural education. It will help students better understand students in culturally diverse classrooms as well as prepare them to teach about cultural diversity. This class examines several cultures but is particularly interested in American Indians of North Dakota. Those original groups include: Lakota, Dakota, and Nakota, Chippewa, and the three affiliated tribes: Mandan, Hidatsa, and Arikara (see attached sample syllabus <u>TL</u> <u>433</u>).

Assessments/Results

1. Critical Task: Multicultural Teaching is submitted and assessed in LiveText, an on-line data management system. This Critical Task is a research paper based upon an issue in multicultural education. The paper includes a lesson plan which is assessed to determine candidates' ability to apply what they have learned related to diversity. The task was piloted in the spring of 2007 and assessed formally for the first time in the fall of 2007.

Initial Programs Critical Task Assessment Results for Multi-Cultural Teaching

Fall 2007 N=90

		Fulfills	Exceeds
Teaching & Learning Standards	Does Not Meet	Expectations	Expectations
1.2 Teacher candidate uses tools of inquiry			
to develop content knowledge.	13%	56%	30%
1.3 Teacher candidate selects content to			
encourage diverse perspectives.	13%	53%	33%

6.2 Teacher candidate uses language to			
promote learning (e.g., use questioning			
skills, discussion techniques, delivery style,			
nonverbal cues).	14%	56%	29%
6.3 Teacher candidate uses media and			
technology as effective learning and			
communication tools.	13%	36%	30%
6.6 Teacher candidate's communication			
skills facilitate partnerships with students,			
families and colleagues.	15%	52%	32%
6.6 Teacher candidate's communication skills facilitate partnerships with students, families and colleagues.	15%	52%	32%

- Standards 1.3 and 6.6 especially target candidates knowledge and dispositions related to diversity. As indicate in the table 84%-86% of candidates meet or exceed expectations in these categories.
 - 2. Mid-Term Showcase: Candidates work in pairs to create a showcase of a culture that includes engaging hands on learning activities.

Fall 2007Multicultural Ed						
TL433: Section 1: Midterm Showcase Scores	А	В	С	D	F	
N = 30	# 30 100%	0%	0%	0%	0%	

3. Native American Reservation Field Trip: The class participates in a field trip, to an

American Indian reservation school K-12. Each candidate is expected to write a 3-5 page paper reflecting on the field experience. At a minimum, the student should provide answers to the following questions after the field experience: (a) What does education and learning experiences mean to these students; (b) Is the educational system ensuring that the diverse needs of those students are met?

The field trip reflection assessment rubric covers three areas:

(a) Focus (i.e. relevant, specific and clear response to the above questions....10 points);(b) Perspective (i.e. the student reflects on the field trip from a diverse/multiple perspective...10 points);

(c) Language/Grammar (i.e., the students uses appropriate diversity terminology/ language as well as correct grammar...5 points).

TL 433 Section 1:Fall 2007	А	В	С	D
Field Trip Reflection Scores (N=30)	#26 87%	#4 13%	#0	#0

Student Work Samples

1. For candidate work related to the critical task (#1 above), please click on the any of the documents below:

- <u>Sample 1</u> Does Not Meet Expectations
- <u>Sample 2</u> Meets Expectations

• <u>Sample 3</u> Exceeds Expectations

2. A variety of student work samples related to the showcase will be available in the hard copy exhibit room.

Advanced Programs Opportunity to Address/Meet Standard

EFR 506: Multicultural Education: Candidates who have not taken T&L 433 as

undergraduates are encouraged to take this course. As described in the catalog the course is a "review of the conceptual, historical, and theoretical aspects of multicultural education. A major goal will be to provide educators with the processes for incorporating multicultural education into their own education environments to meet the needs of their culturally diverse students and to increase the cultural awareness and sensitivity of all students. North Dakota/Native American issues are primary elements of this course" (pg.249). (Also, see attached sample syllabi: <u>EFR 5061; EFR5062</u>.

Assessments/Results:

Course Grades					
Sections 1-4: SU, 2007					
Course EFR 506: Multicultural Education	А	В	С	D	F
N=28	# 26	#1	#0	#0	#1
	93%	3.5%	%	%	3.5%

As indicated by the majority of A's and B's in the chart above, candidates taking this course met or exceeded course goals.

STRATEGIES FOR TEACHING AND ASSESSING DIVERSE LEARNERS
Initial Programs

Opportunity to Address/Meet Standard

T&L 315: Education of Exceptional Students: All candidates in our Early Childhood Education, Elementary Education and Middle Level programs are required to take this course(see attached syllabus <u>T&L 315</u>).

Course Description: "An orientation course, especially for classroom teachers, stressing the identification, characteristics and educational problems of exceptional children" (college catalog p.184).

TEAM Methods: Candidates in Elementary Education, Early Childhood Education and Middle Level Education take a series of methods related courses that require them to demonstrate an ability to accommodate instruction for students with special needs. Initially, candidates are presented with a case of a virtual student. They view a video and review an IEP and create a lesson plan with accommodations for this student (see IEP of Nathan). Next, candidates complete a 60-hour field experience. They select a lesson for assessment that includes accommodations for one or more students in their field experience setting. **Integration of Special Needs**: The secondary education program has developed an integrated approach to guide candidates' knowledge about and skill in teaching diverse learners (see <u>Integration of Special Needs within the Secondary Education Program</u> document).

Assessments/Results

Course Orades					
Fall 06 - Spring 07					
Course TL 315: Education of Exceptional Students	Α	В	С	D	F
N=197	#148	#34	#7	#4	#4
	75%	18%	3%	2%	2%

Over 93% of candidates from spring 2006 to fall of 2007 met or exceeded expectations related to the content of TL315 as demonstrated by the percent of A's and B's awarded.

TEAM Methods: Candidates development and implement a lesson plan and during the 60 hour field experience tied to the methods semester that is submitted and assessed in LiveText, an on-line data management system. INTASC Standard 3 and Program Standard 3.1 are assessed to determine candidates' abilities to accommodate all learners needs. Results from fall 2006-spring 2007 are presented in the table below:

Standard: 3.2 TAAL INTASC 3 Teacher candidate plans and adapts instruction for individual needs	Not Met	Met	Exceeds
Fall 2006	6.4%	70.2%	23.4%
Spring 2007	13.8%	74.2%	12%

During the 2006-2007 academic year 87.2%-94.6% of candidates met or exceeded the standard related to adapting instruction. The faculty reviewed data in May of 2007 and were disappointed in the lower results in the spring semester. It was at this point that the case of Nathan was developed for implementation in the fall of 2007. We hope to see improvements during the 07-08 academic year.

Integration of Special Needs: Candidates development and implement a lesson plan and during the 60 hour field experience tied to the methods semester that is submitted and assessed in LiveText, an on-line data management system. INTASC Standard 3 and Program Standard 3.1 are assessed to determine candidates' abilities to accommodate all learners needs. The Lesson Plan for secondary programs is submitted and scored only in the fall since this is when the methods courses are offered. At the time of this report, no results are available. Results for fall 2007 will be available in the spring of 2008.

Student Teaching Evaluations: Mid-term and final evaluations during the student teaching semester provide additional evidence that candidates in all of our programs address the needs of diverse learners in their classrooms. Cooperating Teachers and University Supervisors complete these evaluations at mid and end term during the student

teaching semester. The results for candidates' in the area of exceptionalities in the fall 2006 and spring 2007 are presented in the table below:

INTASC Standard 3: Teacher candidate plans and adapts instruction for individual needs								
	Mid Term N = 86			Final N =86				
Fall 06- Spring 07	Deficient	Developing	Proficient	Not Observed	Deficient	Developing	Proficient	Not Observed
All Programs	0%	30%	58%	12%	0%	10%	75%	15%

As noted in the evaluations 85%-88% of candidates during student teaching are able to adequately address this standard. In addition, 20% of candidates moved from the developing to proficient category by the end of the their student teaching assignment.

Advanced Programs

Opportunity to Address/Meet Standard

EFR 506: Multicultural Education: Candidates who have not taken T&L 433 as undergraduates are encouraged to take this course. The emphasis of the course may vary dependent upon the semester. For example, in the summer of 2007 one section of EFR 506 emphasized issues in special education within the context of the multicultural framework (see syllabus <u>EFR 506</u>).

Assessment /Analysis

Course Grades

Course Grudes					
Course	А	В	С	D	F
EFR 506: Multicultural Education: Sec3: SU, 2007	#12	#1	#	#	#1
N=14	86%	7%	0%	0%	7%

As indicated by the majority of A's and B's in the chart above, candidates taking this course met or exceeded course goals.

Other important diversity aspects are part of the curriculum in the required courses of <u>EFR</u> <u>500</u>: Philosophical Foundations of Education, <u>TL 540</u>: Philosophies and Theories of Curriculum, and <u>TL 542</u>: Models of Teaching. In addition, the candidate is required to take an additional three credits of foundations. Typically, they are advised to take <u>EFR 505</u>: Social Foundations of Education or <u>EFR 507</u> Gender and Education; in either of these latter two courses, candidates study multicultural education, diversity education, and socioeconomic aspects related to access, equality, and equity.

TL 590 ST: Children's Literature in the Classroom. In this course, candidates in the reading specialist and elementary education advanced programs read multicultural literature and critique literature used in classrooms to determine its resonance with all students. Further, students complete projects which explore Native American Literature. The syllabus for <u>TL590ST</u> states the following goal:

• Expand your knowledge of the wealth of literature available for diverse children in classrooms (NBPTS #2)

The goal is met through reading and discussing articles and children's literature and by assignments. Sample readings and assignments are provided to illustrate candidate experiences.

Sample articles on diverse learners (cultural, racial, gender, socioeconomic)

- Enteneman, J., Murnen, T. J., & Hendricks, C. (2005). Victims, bullies, and bystanders in K-3 literature. *The Reading Teacher*, *59*, pp. 352-364.
- Livingston, N. & Kurkjian, C. (2005). Circles and celebrations: Learning about other cultures through literature. *The Reading Teacher*, *58*, pp. 696-703.
- Louie, B. L. Guiding princiles for teaching multicultural literature. *The Reading Teacher*, *59*, pp. 438-448.
- Wason-Ellam, L. (1997). "If only I was like Barbie." Language Arts, 74(6), pp. 430-437.
- Yenika-Agbaw, V. (1997). Taking children's literature seriously: Reading for pleasure and social change. *Language Arts*, 74(6), pp. 446-453.

Multicultural and gender-based literature assigned for the course and read by candidates:

- Curtis, C. P. (1995). The Watsons Go To Birmingham. Yearling. ISBN: 0440414121
- DiCamillo, K. (2000). Because of Winn-Dixie. Scholastic. ISBN: 043925051X
- Erdrich, L. (1999). The Birchbark House. Scholastic. ISBN: 0439203406
- Munsch, R. (1980). The Paper Bag Princess. Annick Press. ISBN: 0920236162
- Ryan, P. M. (2000). Esperanza Rising. Scholastic.

Artifacts supplied to illustrate multicultural course experiences are listed here and supplied for perusal.

- PowerPoint by candidate—<u>Contemporary Native Americans and Literature</u>
- Character Comparison between Esperanza in *Esperanza Rising* and Opal in *Because of Winn-Dixie*
- Key Discussant Grade Report on *Birchbark House* with bibliography of Native America book resources and teaching ideas
- <u>Multicultural Book Analysis</u>

TL 590 ST: Writing in the Elementary School Classroom. In part this course is designed to increase candidates' ability to effectively teach diverse children to write, respecting development, culture, gender, and individuality. Though meeting a goal such as this is integrated throughout the semester, specific course readings and activities are devoted to the goal. Readings on gender and writing, specifically paying attention to boys, and culturally conscious writing instruction is also addressed. Multicultural and gender-based readings include the following:

- Dworin, J. E. (2006). The family stories project: Using funds of knowledge for writing. *The Reading Teacher*, *59*(6), 510-520.
- Dyson, A. H. (1998). Fold processes and media creatures: Reflections on popular culture for educators. *The Reading Teacher*, *51*(5). 392-402.
- Fletcher, R. (2006). Boy writers: Reclaiming their voices. (Chapter 10). Portland, ME: Stenhouse Publishers.
- Fu, D. & Shelton, N.R. (2007). Including students with special needs in a writing workshop. *Language Arts*, 84(4), 325-336.

- Newkirk, T. (2000). Misreading masculinity: Speculations on the great gender gap in writing. *Language Arts*, 77(4), 294-300.
- Rubin, R. & Carlan, V. G. (2005). Using writing to understand bilingual children's literacy development. *The Reading Teacher*, *58*(8), 728-739.

One artifact supplied to illustrate linguistic/cultural study of writers is a whole class effort to identify ways to support ELLs in the writing classroom. Candidates reviewed numerous books and articles, identified resources, and gleaned specific practical ideas for supporting young writers. The series of charts that evolved from that activity are supplied as an example of the type of learning event that is integrated in the course to learn about supporting multicultural learners in writing.

Programs for Other School Professionals

In addition to the instruction and assessment in the above programs, the following coursework in Educational Leadership and School Counseling attend to multicultural and diversity issues.

Educational Leadership:

Opportunity to Address/Meet Standard: Courses

EDL 514: Personnel, Supervision, and Staff Development: Various in-depth discussions regarding diversity occur (e.g., Native American and the BIA system). EDL 516 Policy and Educational Finance: Candidates conduct research on various schools, locations, and issues. An example of a research project may be an exploration of the funding for a Native American school.

<u>EDL 519</u>: The Principalship: Principals from various schools (including Indian Reservations) discuss the complexity of education and how it affects students, teachers, and communities.

<u>EDL 501</u>: Leadership, Planning, and Organizational Behavior: Studies include shaping school culture, addressing individual and group needs, setting goals and priorities according to the context of the community.

EDL 511: Personal Communications and Ethics: Discussions are held on how culture, age, and socioeconomics influences education.

Assessments Include:

Exams Research Papers Portfolios

<u>School Counseling:</u> Opportunity to Address/Meet Standard: Courses

<u>Coun 518</u>: Group Theory and Process: Addresses the principles and practices of support, task, psycho-educational, and therapeutic groups with various populations in a multicultural context. Includes study of professional issues relevant to group processes, involves participation and leading group experiences.

<u>Coun 531</u>: Psychology of Women, Gender, and Development: This course presents current research and trends in developmental theory, particularly theories pertaining to psychological development of women and men. Issues such as abuse, ageism, depression, eating disorders, emotional experience and expression, heterosexism, feminism, and multiculturalism will be examined as related to the practice of psychology. Learning methods include writing, music, film, group discussion and creative projects.

<u>Coun 532</u>: Multicultural Counseling: "This course offers an introduction to counseling theories and interventions appropriate for American ethnic and non-ethnic minority clients. The values suppositions of various cultural groups will be examined"(college catalog p. 24).

Assessments Include:

Papers Exams Presentations Counselor Preparation Comprehensive Examination (CPCE) Student Internship Evaluation Forms



CURRICULUM EXHIBIT FORM BASIC PROGRAM



EDUCATION STANDARDS AND PRACTICES BOARD

SFN 14381 (05-06)

Composition Course		
9 credits Total		
	71-73 Total	34-36 Total
	11-13 IUlai	3 4 -30 i Ulai

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