UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE AND ENGINEERING
FINAL EXAMINATION, APRIL 2001
First year
GLG185S—EARTH SYSTEMS ENGINEERING
Exam Type: A
Examiner—R. N. Pysklywec

Duration: 2.5 hours
No Aids Allowed

Part A—answer **10** out of 12 questions; each question worth **2** marks = 20
Part B—answer **3** out of 5 questions; each question worth **10** marks = 30
50 total

Read each question carefully and answer concisely and completely. Use clear handwriting and include drawn diagrams and point form as appropriate.

Please begin each answer on a new page and mark the questions you have done on the front of your examination book.

Part A—answer 10 out of 12

A.1 Explain what the significance of carbonaceous chondrules is.

A.2 Describe an event of mass extinction that occurred in Earth's past, explaining how and when it happened, and the consequences.

A.3 Give two examples of economically valuable non-silicate minerals and provide several reasons why non-silicates are more significant in supplying mineral resources than silicate minerals.

A.4 Explain what a pluton is and describe three different types. Comment on the type of rock that forms in a pluton.

A.5 What is orogenesis and how does it occur?

A.6 What is the most earthquake prone region of Canada and why?

A.7 Explain what a laterite is, how it develops, and what its economic significance is.

A.8 Explain how the process of downslope soil creep can occur. What is an *approximate* rate and what are some consequences of the creep?

A.9 Sketch a diagram (with brief accompanying labels/comments) to illustrate the following:
--drawdown, aquitard, piezometric surface, confined aquifer

A.10 Make several sketches to illustrate the general velocity distribution within a meandering river. Define what a placer deposit is, and where/why it forms.

A.11 Explain what a disseminated mineral deposit is and how it forms. What mineral resource is commonly derived from these deposits?

A.12 Describe how a nuclear fusion reaction produces energy. What reaction, in particular (i.e., indicate the elements), are researchers trying to harness as a new energy source?

Part B—answer 3 out of 5

B.1 Sketch a profile of the interior of the Earth from the surface to the centre of the planet, marking the major internal divisions and approximate depths. Provide reasonably comprehensive descriptions of the rheology and/or composition of these regions, as well as a discussion of the behaviour (kinematic/dynamical) in each. List evidence (both direct and indirect) that supports the interpretations.

B.2 Explain in detail how earthquakes relate to plate tectonics. Explain using arguments based on simple material rheology why the vast majority of earthquakes occur in the outermost 60 km of the Earth.

Give a specific example of a seismically active region and explain what type of plate tectonic motion is responsible for the earthquake activity. List four types of acoustic waves generated by an earthquake, and sketch the style of particle motion associated with each.

You have a prized sample of peridotite (mass=3.248 kg) perched precariously on a pedestal in your house which is located in this seismically active region. An earthquake occurs nearby, inducing seismic waves with particle accelerations (only occurring in the horizontal direction) reaching 2.45 m/s^2. What coefficient of static friction between the pedestal and rock sample is required to prevent the peridotite from slipping and falling to the floor (assuming it doesn't fall by tipping)?

B.3 Define what a constitutive relation is.

Give a constitutive relation for a linear viscous (Newtonian) body, defining all terms (including units). What region(s) of the Earth can be described as viscous over timescales of (i) seconds, (ii) millions of years and explain how you know?

Give a constitutive relation for a linear elastic body, defining all terms (including units). What region(s) of the Earth can be described as viscous over timescales of seconds and explain how you know?

Derive an expression for a visco-elastic body in which the accumulated strain is the superposition of linear elastic and linear viscous strain (i.e,. a Maxwell body). What region of the Earth can *generally* be described as visco-elastic? What geological/geophysical evidence supports this claim? Prove mathematically that if one applies a rapid strain to the visco-elastic medium, the material behaves elastically (i.e., immediate elastic response, subsequent viscous response).

B.4 The phrase "economic mineral deposits" describes a wide range of economically valuable resources from the Earth. List four of the main types of economic mineral deposits and give at least two specific examples of each of these (including the chemical formula for each).

The Sudbury complex is an important mineral resource in Ontario. What are the major mineral groups that are mined in the region? Explain in general terms the nature of the ore body (e.g., basic structure, composition) and how it may have formed.

Assuming the ore body is localized, nearly vertical and situated at depth, the optimal method for extraction is an underground mine. Sketch a basic diagram of the mine labeling a (i) drift, (ii) stope, (iii) orepass, (iv) shaft, and (v) headframe.

B.5 Nuclear power represents an important means for producing electricity in Ontario. Explain what nuclear reaction takes place to produce energy and describe (generally) how this energy is converted to electricity. Where in Canada is most of the nuclear fuel mined and in what type of rock?

The method produces very small amounts of pollution, but dealing with the high-level nuclear waste (i.e., spent fuel bundles) is a problem. List several criteria that must be considered for storing the nuclear waste in the long-term, and provide an estimate of how long this "long-term" storage must be so before the material is non-hazardous.

What is the disposal method favoured by AECL (Atomic Energy Canada Ltd.) and the government of Canada? Describe the general outline of the plan and discuss in particular the geological and geotechnical aspects of the plan that must be considered. Assuming you agree with this concept for waste storage, explain where in Canada (or otherwise) you would locate the disposal site, discussing why this would be the optimal site, as well as any problems there might be.