Answer Key

First Hour Exam **Name:**_____________________________________

Please answer five of the six questions. If you answer all six questions only the first five will count towards your score. Make sure you explain your answers.

Just as a reminder: Check here if you attended the special seminar talk on soils. ☐

1. Scientific Reasoning and Method

a) Outline the steps of the scientific method. (2 points)
b) Give an example of how scientists use the scientific method in their work. (2 points)
c) Considering that Wegener's theory of Continental Drift was incorrect in several aspects, how would you judge the scientific quality of Wegener's hypothesis? (3 points)
d) What does the theory of Uniformitarianism state and how would you test it? (3 points)

a) Scientific Method:

Starts out with recognizing a **problem** and forming one (or more) **working hypotheses**; these hypotheses should make predictions which can be tested by observations, calculations, simulations etc. they can either be found true or rejected. rejected hypotheses may be modified, improved, tested again etc. a hypothesis backed up by observational evidence can become a theory and later (after much more testing) may be called a law.

b) Example:

I was looking for a concrete example not just a rehash of the outline above. Plenty examples are possible, here is one we dealt with in class:

Wegener noticed the peculiar shape of continents and hypothesized that continents once formed one big super continent. He went out to find supporting evidence that would back up his hypothesis of *Continental Drift*. The testing phase went on for several decades and stalled because there were some unexplained parts to his theory (e.g. driving mechanism) and some parts were obviously incorrect. His hypothesis was modified over the years and, backed up by additional evidence, is now accepted as *Plate Tectonics*.

c) Scientific Quality of Wegener's Hypothesis

Even with his hypothesis flawed in several areas it can still be considered good science. the main argument is that the Continental Drift hypothesis makes a series of testable predictions. In other words it can be shown to be right or wrong. Creationism, for example, is considered a poor scientific theory, because it rests on the assumption that God made the earth and makes no testable predictions. Since God can do whatever he (or she) wants without being bound by any laws of physics/chemistry etc. there is really no way to decide whether the hypothesis is correct.

d) Uniformitarianism states that the processes that formed and shaped the earth did not change significantly over the history of the earth. To test it one can observe geologic processes that form rocks today and compare the outcome with older rocks that formed millions/billions of years ago. Lab experiment could also be used to test the hypothesis, e.g., the heating or melting of rocks in the laboratory to make new metamorphic and igneous rocks. Finally, even computer simulations that rest on well accepted physical and chemical principles can be used to verify the theory.

As an aside, today we don't subscribe to a strict uniformitarianistic theory any longer but realize that the rates of processes can change. We also realize that catastrophes can and do happen, e.g. volcanic eruptions, meteorite impacts... However, the underlying laws of nature remain unchanged.

2. Continental Drift and Plate Tectonics

a) List Wegener's evidence for his hypothesis of Continental Drift. (2.5 points)

b) Why was Continental Drift not accepted by the general Scientific community for several decades, and which additional geological observations convinced earth scientists that continents are actually moving? (3 points)

c) What are the similarities and differences between the Continental Drift and Plate Tectonic theories? (2 points)

d) Give an example of a geologic feature (other than the list of arguments given above) that can be explained by Plate Tectonics. (2.5 points)

a) Shape of continents, terrestrial fossil distributions, stratigraphic units across oceans, extent of glaciations, extent of mountain ranges across oceans, climate zones

b) (Now) obvious errors in his hypothesis and observational data set, the lack of a plausible driving mechanism, the lack of a reasonable constraint for the age of the Earth, competing theories (land-bridges) and personal reasons (e.g., W. was not part of the geologic crowd) all contributed to the rejection of Continental drift.
New evidence included bathymetric data of the oceans, the discovery of magnetic stripe patterns symmetric to mid-ocean ridges, and a better understanding of the age structure of the oceans.

c) Both hypotheses state that continents move, but Continental Drift invokes a different driving mechanism and states that continental crust forces its way through oceanic crust. Plate Tectonics states mantle convection as one mechanism of plate movement, it divides the Earth's surface into a series of rigid plates which move with respect to each other. new oceanic crust is formed at divergent plate margins and pushes older crust, including continents aside. So continents move with the oceanic rocks rather than through them.

d)
- andesitic volcanoes at subduction zones, where wet partial melting of the subducting crust creates a reservoir of magma
- seamount chains that were created as the oceanic plate moves over a stationary hotspot
- mountain ranges that are created at the collision zones between continents

(and plenty more)

3. Minerals and Rocks

a) Which of the following three substances are minerals and why? (3 points)
obsidian, olivine, granite

b) List the physical and chemical differences of the three major magma types. (3 points)

c) What types of magma are generated over subduction zones and what types of volcanoes do you find in subduction zones? (2 points)

d) Describe and identify the rock specimen. (2 points)
My specimen has the following label: ________________________

a) obsidian: not a mineral, lacks well defined chemical composition and crystal structure
olivine: fulfills all the criteria for a mineral
granite is a type of rock made from several minerals

b) basaltic: low silica content, low viscosity, high in Fe and Mg, dark color
rhyolithic: high silica content, low Fe and Mg, high viscosity, light color
andesitic: intermediate between the two endmembers

c) Stratovolcanoes such as Mount St. Helens erupt mostly **andesitic** and **basaltic** magma. However, **rhyolithic** magma is created as well and forms large plutonic bodies of igneous rocks at depth , such as the Sierra Nevada

d) SHU 02-A
fine grained, gray to tan, layered, breaks easily, dull, reddish brown surface weathering, sedimentary rock, small grain size makes it a **shale**
CAS 02-A
light colored rock, containing feldspar and quartz and swirls of a black flaky mineral (biotite) preferred orientation of the biotite doe to differential stress during formation, therefore a metamorphic rock, **gneiss**
BUC 02-A
red sedimentary rock, often visible grains, varying grainsize from silt to gravel, muscovite flakes visible in many samples, depending on sample: **arcose**, **sandstone** or **conglomerate**

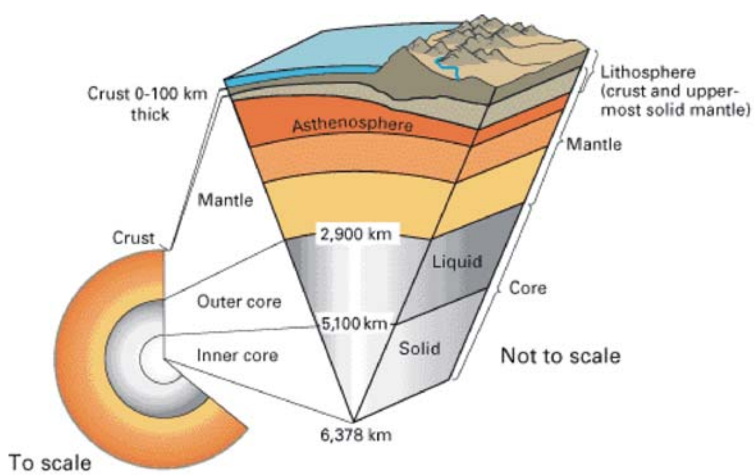
4. The Interior of the Earth

a) How and why do pressure and temperature change with depth? (2 points)
b) Which techniques can we use to find out about the interior of the earth? (3 points)
c) Draw a cross section of the Earth, label its principal layers and list their physical and chemical properties. (5 points)

a) Both, p and T increase with depth. p increases because of increasing weight of overburden as rocks get buried deeper, T increases because rocks are good insulators and are heated by radioactive decay.

b) Seismology (study of earthquake waves) can tell you about depth to various internal layers and whether they are solid, liquid or near melting point.
Gravity observations can tell you density of rocks
Shape of earth tells you about the cohesiveness and strength of rocks
Volcanoes can provide samples from deep inside Earth
Meteorites provide information about chemical composition...

c)



crust: rocky, rigid, basaltic and granitic composition
mantle: solid, plastic, ultramafic rocks
outer core: Fe-Ni alloy, liquid
inner core: Fe-Ni allow, solid

lithosphere: rigid (crust + upper mantle)
asthenosphere: plastic, deformable, near melting point of most rocks

5. Weathering and Sedimentary Rocks

a) Which weathering processes are likely to affect rocks in Connecticut? (2 points)

b) List the following three minerals in order of increasing resistance to weathering. Show your reasoning: Muscovite, Quartz, Feldspar (3 points)

c) Which criteria do geologists use to name sedimentary rocks? (1 point)

d) How does sediment transport affect the physical and chemical properties of sediment? (4 points)

a) CT is wet, supports plenty of plant growth and cold enough to freeze once in a while. So you can have a combination of physical weathering (frost wedging) and chemical weathering (dissolution, leaching) due to the abundance of water and plants.

b)
muscovite: perfect cleavage, complex chemical formula, plenty ions to leach out of crystal structure
feldspar: cleavage, stronger crystal bonds, but more complex chemical structure than quartz
quartz: no cleavage, strong crystal bonds, simple chemical makeup

c)
grainsize (e.g. shale, siltstone, sandstone, conglomerate)
mineralogy (e.g., limestone, chert, arcose)

d)
decreases: grainsize, angularity
increases: sorting, roundness
biases towards weathering resistant minerals

6. Metamorphic Rocks

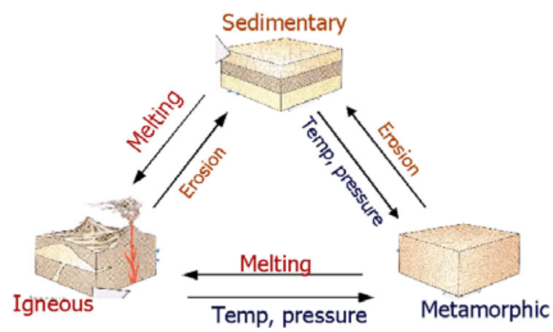
a) Describe the rock cycle, which rocks can form the basis for metamorphic rocks? (2 points)

b) How can geologists determine the pressure and temperature history of a metamorphic rock? (3 points)

c) Describe a plate tectonic setting that can lead to high temperature / low pressure conditions. (3 points)

d) Explain the influence of water on the formation of metamorphic rocks. (2 points)

a)



b) by determining the stability field of metamorphic minerals (range of p,T) in the laboratory and looking for these minerals in metamorphic rocks. Polymorhs are especially useful because they share the same chemistry yet different crystal structure, so their occurrence or absence is not by changes in rock chemistry.

c) local heating of rocks by igneous intrusions, e.g. under volcanoes in subduction zone, hotspot volcanoes, submairine eruptions in mid-ocean ridges or lava deposits in rift valleys

d) water increases the mobility of ions in solid rocks and speeds up the rate of crystal formation leading to larger crystals.