Intro to Earth Sciences I
Lecture Topics for Midterm Exam
with Brief Notes
Summer 2014

The major topic areas that we have covered are:
Origin of the Universe, the Elements, and the Earth and Solar System
Minerals and Igneous, Sedimentary, and Metamorphic Rocks
Rock Hazards and Environmental Health
Geologic Structures (especially faults)
Earthquakes Seismology and Earthquake Risks
The Earth's Interior
Geosynclines and Continental Drift

origins
- Big Bang theory for the formation of the universe
  evidence: the redshift, cosmic microwave background radiation
  what formed? only H & He according to theoretical considerations
- stellar evolution (birth, main stage, death)
  death of large stars (supernovas) and the formation of the elements beyond H & He
- Solar Nebula Theory of how Earth formed
  solar nebula included material formed in a supernova
- differences between terrestrial planets and gas giants and the apparent reason why
- the asteroid belt and meteorites found on Earth (what they tell us)
- origin of the Moon
- Earth layering: iron (mostly) core & rocky silicate mantle (and crust); how/why
- origin of the hydrosphere & atmosphere

atoms and minerals
calcite (calcium carbonate), quartz, feldspars, muscovite and biotite mica, amphiboles (hornblende), pyroxenes (augite), olivine
- the eight most abundant chemical elements in the crust (especially the two most abundant, O & Si)
- protons, neutrons, electrons and how they compose atoms
- the difference between atoms, elements, ions (cations), compounds, minerals, and rocks
- silicon (the element), silica (compound of silicon + oxygen), silicates (minerals containing silica)
- silicate minerals
  relative silica content vs. metal cation content (esp. Fe & Mg)
  felsic vs. mafic

igneous rocks
granite, rhyolite, diorite, andesite, gabbro, basalt
- melt: magma, lava
- melting/crystallization temperature of felsic (low) vs. mafic (hi) minerals
- solid-liquid-gas phases of matter and phase change melting/crystallization

temperature = avg. kinetic energy
physical (molecular) difference between solid and liquid (and gas) phases

- Igneous Texture: coarse-grained, fine-grained, porphyritic, glassy
  and mode of emplacement: plutonic (intrusive), vs. volcanic (extrusive)
- Color/Composition: felsic, intermediate, mafic, ultramafic
- classification of igneous rocks (texture and color/composition)

igneous bodies: volcanoes and igneous intrusions

- lava viscosity & temperature/composition; viscosity vs. volcano slope
- dissolved gases (CO2 & water vapor), viscosity, and explosive eruptions
- pyroclastic material (bombs, ash, lapili), angle of repose
- shield volcanoes, cinder cones, stratovolcanoes (composite cones), calderas
- what type and viscosity of lava is associated with each
- aa & pahoehoe lava
- intrusive bodies: stocks, batholiths, dikes, sills

sedimentary rocks

conglomerate, sandstone, shale, limestone, coal
the 5 steps in the formation of sedimentary rocks

1. weathering of pre-existing rocks produces sediments
2. transport
3. deposition
4. compaction
5. cementation

1. weathering

mechanical:
stream abrasion, sand blasting, frost wedging
chemical:
formation of carbonic acid:most natural surface waters slightly acidic
hydrolysis: silicate minerals in acid solution alter to clays + soluble ions
dissolution of some minerals (like calcite)
weathering products: gravel, sand, silt, clay, dissolved ions

2. transport: via streams, wind, glaciers, waves

the faster the stream velocity, the larger the sedimentary particles that may be transported
sorting and rounding

3. deposition (e.g., when stream velocity drops)

sediments are deposited in horizontal layers (cross-bedding not withstanding)
oldest layers are on the bottom, younger toward the top

4. compaction
5. cementation:

crusts of minerals precipitated from ions dissolved in water into voids between sedimentary particles
common cements: silica, calcite (fizzes), hematite (red)
classification of sedimentary rocks
clastic: conglomerate, sandstone, shale
biogenic (biochemical): limestone, coal

chemical precipitates: halite
the importance of sedimentary rocks
fossil evidence for past life
record of past climate and environment: marine vs. terrestrial, stream deposits, desert deposits, glacial deposits
fossil fuels:
e.g., coal: high organic matter, oxygen-poor conditions (like saturated swamp soil), organic matter preserved (not decayed)
also oil & natural gas: organic matter preserved in sed. strata; matures into oil & gas

metamorphic rocks
slate, schist, gneiss, quartzite, marble
conditions for metamorphism
pressure and heat (not so much heat to melt the rocks)
fluids (including water and carbon dioxide stored in rocks)
regional metamorphism (our main interest)
elevated pressure and temperature caused by deep burial cause by tectonic collisions and mountain building
(other types include contact, hydrothermal, and cataclastic metamorphism)
protolith --> meta rx (characteristics of meta rocks compared to their protolith)
examples:
foliated (w/ slaty cleavage, schistosity, gneissic banding: know the characteristics of each)
shale --> slate
shale --> schist
granite --> gneiss
non-foliated
sandstone --> quartzite
limestone --> marble

be able to draw simple sketches (magnified views) showing features of igneous, sedimentary, and metamorphic rocks

rock hazards and environmental health
durability of rocks
tendency to split into sheets/layers, porosity, resistance to chemical weathering
tilt of sheets/layers/foliation relative to road cuts, reservoirs, etc. and landslides
asbestos (especially crocidolite-blue asbestos)
cardiovascular health and water hardness (dissolved ions: Ca, Mg, Fe, Mn, etc.)
arsenic as a natural hazard - dissolves when iron dissolves under reducing conditions
selenium (and other salts) concentration by evaporation from irrigated fields
radon
formed as a daughter product in the decay chain of uranium
can leek into basements in areas underlain by “uranium-rich” bedrock & sediments
increases the risk of lung cancer, especially for smokers

structural geology
folds, metamorphic foliation, joints, faults
- compression, tension, shearing stress
- initial elastic response to stress (non-permanent deformation)
- brittle vs. ductile response to stress (permament deformation)
- folds
    - anticlines and synclines
    - fold axis
    - plunging folds
    - erosion in tilted strata: valley and ridge topography
    - (erosion in flat-lying strata: cliff and bench topography)
- foliation
    - axial planar cleavage
- joint sets
    - controls surface weathering and topography
- faults: hanging wall and footwall blocks
- the 3 categories (4 types) of faults and the stress environments in which they are found
    - normal faults (extension) (example: basin and range province)
        - crustal thinning and lengthening
        - horst & graben (uplifted ranges and downdropped basins)
        - half-grabens (Newark Basin & East African Rift)
    - thrust & reverse faults (compression)
        - crustal thickening and shortening
        - mountain belts, collisions (e.g., modern Himalayas, ancient Appalachians)
    - strike-slip faults (shearing)
        - San Andreas Fault, offset streams
        - restraining and releasing bends
- orientation of faults, folds, and foliation relative to the applied (tectonic) forces
- topography related to underlying structure
    - basin and range topography
    - valley and ridge topography resulting from differential weathering of folded strata

be able to draw simple maps and profiles of faults and folds, etc.

earthquakes
- elastic strain buildup -> rupture (slippage) on faults -> seismic waves propagate outward through Earth
- body waves: P waves, S waves
- surface waves: Love waves, Rayleigh waves
- epicenter and focus (hypocenter)
- basic principal of seismometers (inertial mass that remains stationary as the crust moves)
- determining distance from earthquake by S-P interval
- earthquake location via triangulation (S-P interval from three seismic stations)
- information needed to determine an earthquake's magnitude
    - peak amplitude of ground motion at recording station
    - S-P interval (to determine distance)

- the Richter magnitude scale of earthquake strength: logarithmic scale (powers of 10)
- what the moment magnitude scale measures as compared to the Richter scale
- Modified Mercalli scale of earthquake intensity
- first motion studies to determine type of fault in an earthquake
- type of plate boundary where worst (greatest magnitude) earthquakes tend to occur
    convergent plate boundaries where an oceanic plate subducts (sinks) beneath another
- local bedrock geology and earthquake damage risk (esp. solid bedrock vs. unconsolidated sediments and saturated muds)
- earthquake "prediction"
    probabilities of EQs of given magnitude in certain number of years
    EQ sequence (e.g., Parkfield, Istanbul)
    seismic gaps (e.g., Alaska)
    but earthquake prediction?
- earthquake early warning systems

be able to draw simple sketches to illustrate methods in seismology (triangulation, first motion studies, magnitude determination)

earth's interior

- wavefronts and ray paths
- Moho: what it is (crust-mantle boundary) and how it was discovered
- characteristics of continental crust, oceanic crust, and mantle rock
- the average thickness and the predominant igneous rock types (felsic, mafic, etc.) found in ocean crust and in continental crust
-the core-mantle boundary (Gutenberg seismic discont.) - P and S wave shadow zones
- the mantle: low velocity zone (LVZ) - the asthenosphere (evidence for it; its characteristics)
- the lithosphere: all the crust and mantle above the asthenosphere
~~- 660 km seismic discontinuity - uppper-lower mantle - transformation of olivine-spinel-perovskite~~
- major subdivisions of the earth from core to surface and the materials that make them up: inner core, outer core, mantle, crust
- evidence for interior composition:
  crust: we walk on it;
  mantle: xenoliths carried up in volcanoes, seismic velocity
  core: must be high density material common in the solar system,
    and account for seismic velocity and fluctuating magnetic field
- mechanisms for cooling the earth:
    conduction? No, b/c rock is a good insulator, poor conductor
    convection? Yes, b/c rock in the mantle is ductile

be able to draw profiles of the Earth's interior and describe the major layers and boundaries

be able to draw simple sketches to show how the Moho and Core-Mantle Boundary were discovered

isostasy

- the crust ‘floats’ on the more dense (solid but ductile) mantle
- mountains (thick continental crust) have deep sub-crustal roots

(just as 9/10 of an iceberg lies beneath the ocean surface)
- as orogenic belts erode, the crust rises

historical development of continental drift and plate tectonics
- geosynclines (based on the observed relationship between mountain belts and thick sedimentary sequences)
- continental drift: Wegener and DuToit
  - jigsaw puzzle fit of the continents
  - truncated geologic features:
    - matching geologic formations on opposite sides of the Atlantic
  - far-flung fossils: same species in presently geographically isolated locations
  - paleoclimate indicators: glacial deposits on the southern continents, same time as tropical coals in the northern continents