Week 2 Notes – Environmental Geology

Earth Structure

The inside of the earth cannot be directly observed, but earthquake wave studies (like an ultrasound shows a baby) have given us a well validated model/theory of earths internal structure and composition.

Earths radius is about 6400 kilometers or about 3970 miles

(1 km = 0.62 miles so 6400 km x 0.62 miles/km = 3970 miles)

Earth is made up of 4 main layers:

Inner core solid, made of nickel and iron and has a diameter of about 1200 km

Outer core liquid made of nickel and iron and has a diameter of about 2200 km

Mantle is the thickest of the three layers, is made of silicon, oxygen aluminum and iron minerals. Has a diameter of about 3000 km

“Crust” is relatively thin (100 + km thick) outer layer. It is the only part of earth that can be observed directly. It is made of a variety of elements and rocks.

Deepest well drilled by Russians – KOLA – 12,262 meters – 40,230 feet

Deepest oil well in Utah 17,000 feet in Uintah Basin

Earths Outer Layers and Plate Tectonics

1**) Lithosphere** – upper “thin” (100 km or 60 miles) layer where rock is hard and brittle. Includes crust.

Lithosphere broken into about fifteen pieces called **PLATES**. Most earthquakes, mountains and volcanoes occur near the edges or boundaries of these plates.

2) **Asthenosphere** – The lithosphere slides or moves on the Asthenosphere, where rock is hot and under pressure. In the Asthenosphere, rock behaves like “silly putty” and does not melt completely.

**TECTONICS** is a general term used to describe earthquakes, volcanoes and mountain building.

**Plate Tectonics** is a model or theory that describes the slow and steady movement of the plates. Movement of the plates is the main cause of most earthquakes, volcanoes and other “tectonic events.”

Earthquakes, mountains and volcanoes occur near plate boundaries or edges, where the plates interact.

Plate Tectonics – Lines of Evidence

Paleoclimate indicators and deposits – Wegner applied the principle of uniformitarianism:

Why do we find corals and other fossils and rocks that originate only in tropical climates in Utah, Canada and other northern latitudes?;

Why do we find coal in Antartica when today coal forms in swamps like those that occur in the SE USA?;

Why do we find glacial/ice deposits in the hot tropics?

Why are mountain ranges and sedimentary basins on opposite continents made up of similar rocks?

Why do the mountains and basins have similar structures and geometries?

Distribution of Fossils

Paleomagnetism

Earth Composition – Rocks and Minerals

Earths outer layer or “crust” is the focus of our class. The crust is made of three types of rocks:

1) igneous

2) metamorphic

3) sedimentary

Rocks are defined as: Aggregates of minerals or in other words “rocks are made of minerals.”

* Rocks are made of minerals and minerals are made of combinations of elements/atoms.
* Minerals are defined as “naturally occurring inorganic solids.”
* The most common minerals in the crust are the **silicates**.

Other common minerals, NaCl – Salt, FeS – pyrite, CaCO3 Limestone,

There are hundreds of minerals, but only a relatively few minerals, called the rock forming minerals, make up most rocks.

Weathering and Erosion

Some minerals and rocks are more stable than others. This means some rocks are stronger than others for use as building materials.

Weathering - the disintegration and decomposition of rock at or near the surface of the earth.  It affects the rocks in place and no transport is involved.  This distinguishes weathering from erosion.

* Igneous and metamorphic minerals and rocks form at high temperatures, and under high pressure conditions.
* When exposed at the surface the minerals are no longer at equilibrium. For minerals, this is done through weathering.

Physical Weathering – Ice Wedging

Chemical Weathering – Dissolving, Oxidation and Hydrolysis

* ***Carbonic acid*** forms when carbon dioxide CO2 in the atmosphere combines with rain water H2O to form carbonic acid H2O + CO2 -> H2CO3

Differential weathering – some rocks more resistant to erosion than others. Mudrocks/Shale may form a slope and limestones may form a cliff.

Erosion is wearing away of rock and the movement of the sediment. Sediment can be moved or transported by ice (glaciers), wind (sand dunes), water (streams, currents or waves) and by gravity.

Environments in which rocks form

1. **Igneous** rocks form from melted rock or magma under conditions of high heat inside the earth. Most magma stays under the surface under pressure. When magma does find a fracture in the earth it sometimes comes to the surface and forms a volcano. When magma at the surface it is called lava.
2. **Sedimentary** rocks form on or near earths surface under conditions of low pressure and temperature. Sedimentary rocks are made of pieces of preexisting rock, are chemically precipitated or are made from the shells or activities of organisms.
3. **Metamorphic** rocks form under conditions of high heat and pressure deep inside the earth, but the rocks do not melt. Under high pressure the rocks re-crystallize or re-form in the solid state.

If igneous and metamorphic rocks form miles deep inside the earth, why do we see them at 9000 plus feet elevation in the Wasatch Mountains in Davis and Weber Counties?

Basic Principles of Geology

**James Hutton** – “Father of modern Geology” late 1700s and early 1800s. Before Hutton, Noahs flood was “the” answer

**Relative Dating** geological principles that allow us to organize the rocks and events.

Uniformitariansim –

1) We can interpret what we see in the rock record (understand earth history) by observing current geologic processes ("the present is the key to past").  In other words, we assume earth process (laws of nature) have remained the same over time.

2) Constant geologic processes operate slowly in terms of a human life, but add up to big changes over long time periods.

3) Application of uniformitarianism implies a VERY old earth.

* **Superposition** – in any sequence of undeformed sedimentary rock layers or layered igneous rocks (lava flows) older rocks underlie younger rock layers.
* **Cross Cutting Relations** – If a rock layer or fault cuts across another rock layer, the rock layer or fault that cuts across is younger.
* **Inclusions** – If one rock is included inside another rock, it must be older than the rock in which it is included. Example – SLC Conference Center
* **Unconformity** – a surface of erosion or non-deposition separating younger from older rocks. Applies to all three types of rocks. Hutton at Siccar Point in England.
* **Fossil** – Lithified hard parts of remains of animals and plants. Fossils are used to determine the ages of rocks and tell us about environments; Green River Formation (50 million years old).
* **Fossil Succession/Evolution** – The fossil record shows evolutionary changes in plant and animal life. Each period includes particular fossils (Dinosaurs 245-65 million years ago). Evolution means descent from a common ancestor. Evolution DOES NOT propose “man came from apes.” Since certain fossils occur at certain points in the rock record, the fossils are like markers in time. The majority of animals and plants that have lived on earth are now extinct.

Fossils of “modern humans” occur in rocks and sediments at the very top of the rock record (earliest about 200,000 yrs from Ethiopia).

Geological Structures

Due to forces at plate boundaries, the rocks in earths crust are folded and faulted (broken). Gravity also has a significant role.

* Faults and folds fit in a category called **geological structures**.
* Specific forces at each plate boundary.

These forces include:

1) push together, compression

2) pull apart, extension, and

3) twisting or shearing

These forces are referred to as stress.

* + extend (divergent plate boundary),
  + compress (convergent plate boundary),
  + twist (transform plate boundary).

Stress = Force/Area

Force from a shoe 0.5 square inches

130lbs/0.5 sq inches = 260 lbs/sq in

Geologic forces are enormous

**Strain** – measureable change in length or shape or a rotation caused by Stress.

Rocks at surface are elastic and brittle

Rocks at depth are plastic and ductile

Rock strength – total stress a rock can take before it fails or break

Because earth is complex and made up of a variety of rocks, structures and forces, difficult to model or estimate the stress

Two main types of geological structures:

1) Faults (**faulting causes EQs!)**

2) Folds

Three main types of geological forces:

1) Extension – pull apart

2) Compression – push together

3) Shear or Twist – side by side

**Normal faults** such as the **Wasatch** are created by extensional forces. **Faulting causes EQs!**

**Thrust faults** result from compression and have mostly vertical displacement. **Faulting causes EQs!**

Shearing or twisting that causes a mostly horizontal displacement. San Andreas is a famous example of a transform or **strike slip type-like fault**. **Faulting causes EQs!**

* The structure of the earth is determined by measuring the orientations and extent of rock layers and using the measurements to make a geological map.
* Cross sections are also used to show/model the geologic structure in the subsurface.
* **Geologic mapping is usually the first step in any geology study, and is the MAIN TOOL OF A GEOLOGIST.**

Strength of Rocks

* Rock Strength refers to how easily a rock breaks.
* RS depends on the composition, texture and bedding or layering of the rock.
* Rocks are not homogenous and isotopic
* Safety Factor – do not load a rock to break point. Load to a percent of break point.
* Fracturing weakens the rock. It will break along any fractures. Also allows for increased weathering.

Hydrologic System

* Distribution of water on the earth. Air flow..
* Sun is the energy source
  + Greenhouse effect, Ave Temp 60F
* Subsystems
  + Glaciers
  + Wind - Eolian
  + Streams
  + Oceans
  + Rivers
  + Groundwater
  + Massive Human impacts

**Carbon Cycle**

* Carbon in the atmosphere exists in two main forms: carbon dioxide or CO2 and methane of CH4. Both gases absorb and retain heat in the atmosphere and cause a greenhouse effect, which keeps earths atmosphere at about 57 F.
* Carbon dioxide leave the atmosphere by photosynthesis.
* Carbon dioxide also dissolves directly from the atmosphere into oceans, lakes, etc.) as well as dissolving in precipitation as raindrops fall through the atmosphere.
* Human activity has significantly increased the amount of carbon in the atmosphere, mainly in the form of carbon dioxide, both by modifying ecosystems' ability to extract carbon dioxide (deforestation) from the atmosphere and by burning fossil fuels and manufacturing concrete

Nitrogen Cycle

* Nitrogen is necessary for all known forms of life on Earth (DNA, amino acids and proteins). Plants/chlorophyll also uses nitrogen.
* Nitrogen gas (N2) is the largest constituent of the atmosphere, but this form is relatively nonreactive and unusable by plants.
* Chemical processing by bacteria is needed to convert gaseous nitrogen into compounds such as nitrate or ammonia which can be used by plants.
* The abundance or scarcity of this "fixed" nitrogen frequently limits plant growth in both managed and wild environments. The nitrogen cycle, like the carbon cycle, is an important part of every ecosystem.