The Moving Crust

- ## The Earth
- Layers of the earth
  - Lithosphere
    - the solid outermost shell of a rocky planet
    - On the Earth, the lithosphere includes the crust (both oceanic and continental) and the uppermost layer of the mantle
  - Asthenosphere
    - Located below the lithosphere and above the outer core
    - The region which the plate tectonics “float” on top of
    - It is semi liquid (partially molten) and flows

- A look at each layer
  - <u>Crust</u>
    - Divided into two parts
    - Mainly composed of silicon and aluminium
    - Continental Crust
      - Thicker and less dense
      - composed of sodium potassium and aluminium silicate rocks.
      - Composed of older rock than the oceanic crust
    - Oceanic Crust
      - Thin and dense
      - composed of dense iron magnesium silicate rocks and underlie the ocean basins.
      - Composed of newer rock than the continental crust

  - <u>Mantle</u>
    - roughly between 30 and 2,900 km below the surface,
    - Divided into the Upper and Lower mantle
    - occupies about 70% of Earth's volume
    - Typical mantle rocks have a higher portion of iron and magnesium, a higher magnesium to iron ratio, and a smaller portion of silicon and aluminium than the crust.
    - temperatures range between 100°C at the upper boundary to over 4,000°C at the boundary with the core
    - The crust “floats” on the mantle

  - Outer core
    - Liquid
    - Because the earth spins, the outer core rotates around the inner core and causes the earth’s magnetism (it works similar to a dynamo)
    - mainly consists of iron, some nickel and about 10% sulphur and oxygen
    - The temperature is approximately 4000-5000ºC

- Inner core
  - Solid because the pressure is so great that it can not melt
  - mainly consists of iron, nickel and some lighter elements
  - The temperature is approximately 5000-6000 º C

Pangea

- What is it?
  - At one point in time the continents were joined as one land mass called pangea
  - Over millions of years they slowly “drifted” apart

- What is it?
  - Over time pangea separated into Gondwanda and Laurasia

Continental Drift Theory

- The theory
- That the continents moved over thousands of years
- Wegener’s evidence
- The continents fit together like a puzzle (ex. Africa and South America)
- Similar fossils of the same age were found across continents
- Similarities in geological features were found across continents
- This suggests that the shores of these continents were once joined
- During the existence of Pangea it was covered with many glaciers that spread Permo-Carboniferous rocks over all the continents
- Gondwanda had glaciers that moved from the equator south scaring the earth in that direction
- Today, the scaring on the southern continents that made up Gondwanda, points in the wrong direction to correspond to the glacial movement

- **Evidence recap**
- Continents fit together like a puzzle
- Fossils of the same age and species match across continents
- Geological features match across continents
- The striations (grooves in rock and land) in the land points in the wrong direction in the southern continents

- What causes continental movement?

- Sea floor spreading
  - is the process in which the ocean floor is extended when two plates move apart.
  - As the plates move apart, the rocks break and form a crack between the plates
  - Earthquakes occur along the plate boundary. Magma rises through the cracks and seeps out onto the ocean floor like a long, thin, undersea volcanoes.

What causes continental movement?

- As magma meets the water, it cools and solidifies, adding to the edges of the plates
- Magma piles up along the crack and a long chain of mountains forms
- This chain is called an **oceanic ridge**.

What causes continental movement?

- Because new crust is being formed and added to the ocean floor the size these plates gradually extends and increases
- As one edge of the plate gets bigger the other side maybe getting small at a subduction zone
- **sea-floor spreading** is basically **volcanic**, but it is a slow and regular process, without the explosive outbursts of the volcanoes on land.

How do we know this is happening?

- Convection Currents
  - convection help move the plate tectonics
  - The plates “ride” on the currents like a boat on water

How do we know this is happening?

- Sea floor magnetization
  - When new rock is formed at the oceanic ridges it does not have any polarity until it is exposed to the surface of the earth
  - Researches have found out that over years the earth’s polarity changes and therefore the polarity of new rock formed may not be the same as the last

What causes continental movement?

- This diagram shows how the magnetic field changed over the years giving the sea floor a reversed polarity sometimes

Plate Tectonic Theory

- Surpassed the continental drift theory
- Unified many characteristics from sea floor spreading and the continental drift theory
- Said that :
  - there are ten major and many minor plates
  - the plates found in the lithosphere float on the asthenosphere and move by convection currents and sea floor spreading
  - These plates move in relation to one another at one of three types of plate boundaries: convergent, divergent and transform
  - Earthquakes, volcanoes and mountain-building, and oceanic trench formation occur along plate boundaries.

Types of plate movements

- Divergent
  - Almost all of the earth's new crust is formed at divergent plates
  - plate edges move away from each other
  - This continuous process builds a chain of volcanoes and rift valleys called an **oceanic ridge**

- Convergent
  - when plates move towards each other
  - We need to know that oceanic crust is dense and continental crust is buoyant and less dense

  - When 2 plates collide three different things can happen:
    - **Continental vs. oceanic**
    - **Oceanic vs. oceanic**
    - **Continental vs. continental**
  - **Continental crust vs. oceanic crust**
    - **The dense oceanic plate sinks under the buoyant continental plate**
    - **The dense, leading edge of the oceanic plate actually *pulls* the rest of the plate into the flowing asthenosphere and a subduction zone is born!**
    - **Where the two plates intersect, a deep trench forms**

Types of Plate movements(cont.)

- **Continental crust vs. oceanic crust (cont.)**
  - The oceanic plate melts under extreme heat and pressure
  - Scientist aren't sure how far down the oceanic plate sinks until it completely melts

- **Oceanic crust vs. oceanic crust**
  - Density is the key again
  - The older the oceanic crust is the denser that it is therefore the older oceanic crust will sink
  - The rest is the same as if it were colliding with a continental crust

- **Continental vs. continental plate convergence**
  - Ex. Himalayan Mountains
  - both plates are too buoyant to sink
  - here is where the highest mountain grow
  - here faults are created and many things can happen
  - pressure is very great at these points

- Transform
  - At transform plate boundaries plates grind past each other side by side
  - This type of boundary separates the North American plate from the Pacific plate along the San Andreas fault, a famous transform plate boundary that's responsible for many of California's earthquakes.

Volcanoes

- Volcano

-three types

1. Cinder – steep and ash
2. shield – gentle slope and lava
3. composite – in between – alternating layers of ash and lava

Why Some Volcanoes Erupt

- Some volcanoes, like Mount St. Helens, tend to be explosive when they erupt, whereas others, like Hawaii's Kilauea, tend to be effusive (loosely flowing) and nonexplosive. How explosive an eruption is depends on the magma's chemical composition and gas content, which in turn affect the magma's stickiness, or **viscosity**. All magma contains gases that escape as the magma travels to the Earth's surface. If magma is fluid (as is Kilauea's), gases can escape relatively rapidly. As a result, lava flows instead of exploding during an eruption. If magma is viscous (as is Mount St. Helens), the gases cannot escape easily; pressure builds inside the magma until the gases sometimes escape violently.

Viscosity

- If we ran water and syrup down a piece of cardboard on a slant we would find out that the water moves faster and therefore has a lower viscosity than syrup

• Earthquakes

- An **earthquake** is the shaking of the ground caused by an abrupt shift of rock along a fracture in the Earth, called a **fault**. Within seconds, an earthquake releases stress that has slowly accumulated within the rock, sometimes over hundreds of years. ...

• Types of Rocks

- Sedimentary
  - ➢ Are formed due to erosion
  - ➢ You can see layers
  - ➢ They are many rocks compacted together
  - ➢ Compaction and cementation

- Metamorphic Rock

➢ Rock that has been physically altered by heat and/or pressure.

- Igneous Rock

➢ Rock formed when molten (melted) materials harden

➢ either below the surface as intrusive rocks or on the surface as extrusive rocks

- Intrusive
  - – the magma cools slowly, and as a result these rocks are coarse grained

- Extrusive
  - – Because lava cools and crystallizes rapidly, it is fine grained

• The Rock Cycle

Using Rocks to learn about the past

- The law of Superposition
  - – In its plainest form, that is: *layers are arranged in a time sequence, with the oldest on the bottom and the youngest on the top, unless later processes disturb this arrangement.*

Potash

A) General Information

- Potash is a general term covering several types of potassium salts, of which the most important is potassium chloride
- Roughly 95 per cent of world potash production goes into fertilizer,
- the other five per cent is used in commercial and industrial products - everything from soap to television tubes.

B) Saskatchewan Potash

- Saskatchewan Potash production since 1962
- the largest potash producer in the world
- and accounts for about 25 per cent of world potash production
- annual sales for Saskatchewan potash has totalled some $1 billion per year.
- Only about five per cent of the potash produced in Saskatchewan is consumed in Canada
- About two-thirds of the exports go to the U.S.
- Sask also supplies Pacific Rim offshore markets: China, Japan, Malaysia, Korea and Indonesia.

C) How it was formed in Sask

- The potash deposits formed over 350 million years ago as a result of the final stage of evaporative concentration of sea water in a middle Devonian sea.
- This sea extended from the southern Northwest Territories south-eastward through Alberta, southern Saskatchewan, and into Manitoba and North Dakota.
- Saskatchewan has the majority of the resulting potash deposits as this stage of evaporation occurred mainly in this province.

Fossils

- Fossils are the remains, moulds, or traces of organisms that died a long time ago and were preserved in (usually) sedimentary rocks such as sandstones, siltstones, shales or limestones.

Two kinds of fossils

- There are two main types of fossils: **body fossils** and **trace fossils**.
- **Body fossils** include any part of the actual animal or plant. Things like bones, teeth, shells, and leaves are considered body fossils.

B) Trace fossils give us proof of animal life from the past. Trace fossils include things like foot prints, burrows, and fossilized fesses.

Fossils How are they formed?

- When land animals or plants died, the soft parts usually decomposed or were eaten by scavengers. However, if the hard parts (bones, shells, wood) are quickly covered by water, sand, or even volcanic ash, they might be preserved. Teeth are the hardest parts of an animal and are most likely to be preserved.

Dating Fossils

- There are two methods by which we can estimate the age of rocks and the fossils contained in them:
- Relative Dating is based on the study of rock layers and the order of appearance of the fossils contained in them. In other words “the law of superposition.”
- Absolute (Radiometric) Dating is based on the rate of decay of radioactive elements in rocks.

Cast and Mold

- Mold
  - forms when something is pressed into soft mud and removed by decomposition or pulled out, leaving an impression of the object
- Cast
  - is a 3-D example of an object of the past created when a mold fills up with sediment like mud, sand or volcanic ash.