Glaciers and Glaciation

Chapter 16

Glaciers

- A glacier is a large, permanent (non-seasonal) mass of ice that is formed on land and moves under the force of gravity.
- Glaciers may form anywhere that snow accumulation exceeds seasonal melt.

Types of Glaciers

- **Alpine glaciers** form in the mountains.
  - A valley glacier is one that occupies a valley,
  - An ice cap is a mass of ice that occupies a high mountain area and flows outward in several directions.
- **Continental glaciers** (ice sheets) may cover large sections of continents as in Greenland and Antarctica.

East Greenland

Glacier Dynamics

- A typical valley glacier will add snow at its head and lose to melt at its foot.
- The snow line is the line below which the annual snow cover is lost in summer.
- The region above the snowline is the zone of accumulation; the region below the zone of wastage (melting, sublimation, calving).
- If it gains more than it loses, its terminus will advance.
- If it loses more than it gains, it will retreat.
Properties of Ice

- Ice has a density of 0.96 g/cm³. (It floats.)
- Ice is a weak solid and will not hold a vertical cliff higher than 40m (130ft).
- Ice will flow under its own weight.
- Pressure can cause local melting.

Crevasses, Seracs, and Ogives

- A crevasse is a fracture in the glacier surface.
  - Crevasses form where the surface is in tension.
  - Crevasses are rarely more than about 40 m deep.
  - A bergschrund is a crevasse at the head (top) of a glacier.
- A serac is a large, irregular block of ice formed by intersecting crevasses
- An ogive is a compressional wave in the glacier surface.
**Moraines**

- A moraine is a deposit of unsorted (silt- to boulder-size) material (till) left by a glacier.
  - Lateral moraines are left at the sides of glaciers
  - Medial moraines are left in the centers.
  - Terminal moraines are left at the ends.

**Mountain Glacial Landforms**

- Glacial valleys have a characteristic U-shape.
- A hanging valley is the valley of a tributary glacier.
- A cirque is a steep-walled bowl-shaped valley at the head of a glacier.
- An arête is a narrow ridge between two cirques.
- A horn is a peak at the intersection of arêtes.
- A fjord is a glacial valley that opens to the sea.

**Lateral Moraines**
Mountain Glacial Landforms:

Arête

Mountain Glacial Landforms:

Horn

Mountain Glacial Landforms:

Nunatak

Mountain Glacial Landforms:

Cirque

Mountain Glacial Landforms:

Fjord

Kangerluqsuaq

E. Greenland

Ice Ages

- The last 1.8 million years of geologic time (Pleistocene) are the Ice Ages.
- The last major ice advance in North America peaked about 18,000 years ago.
- Climate warmed abruptly at 14,500 years ago.
- It cooled again and then warmed abruptly (~6°C) at about 11,500 to near current levels.
- The last remnants of the North American Ice sheets melted away less than 7000 years ago.
**Previous Ice Ages**

- Permian (300 million years)
- Neo-Proterozoic (570 million years)
- Archaean-Proterozoic boundary?

**Causes of Ice Ages**

- **Milankovich Cycles**
  - Eccentricity of orbit (100,000 y cycle).
  - Tilt of rotation axis (41,000 y cycle).
  - Precession of rotation axis (23,000 y cycle).
- $CO_2$ variation.
- Continental drift and polar continents.
- Ocean Circulation patterns

**Eccentricity**

- Low eccentricity
- High eccentricity

**Tilt**

- Tilt 41,000 years
- Axis of rotation
  - $21.5^\circ$ to $24.5^\circ$

**Precession**

- Precession 23,000 years
- Spinning top
  - Wobble of axis
  - Axis of rotation
  - Axis of rotation of top
**Past Climate History**

- **$^{18}$O/$^{16}$O Variation in Ice Cores**
  - Oxygen isotopes are fractionated by evaporation and precipitation.
  - The vapor prefers the lighter isotope.
  - Cold global temperatures deplete $^{18}$O in ice and enrich it in ocean water.
  - Isotope variation can be measured in ice cores and in ocean sediments.
- **$CO_2$ variation can be measured in gas bubbles in ice.**
- **Both methods provide evidence of large variation in global temperatures.**

**Water ($H_2O$)**

- $^1H$, $^2H$
- $^{16}O$, $^{17}O$, $^{18}O$
- $^{18}(H_2O)$
- $^{19}(H_2O)$
- $^{20}(H_2O)$
- $^{21}(H_2O)$
- $^{22}(H_2O)$

- Light water evaporates more quickly

**$CO_2$ Variation**

- Carbon dioxide is a greenhouse gas.
  - It transmits visible and UV radiation
  - It blocks IR radiation.
- $CO_2$ variation correlates with global temperature.
Glacial Terms

- Glacier
- Alpine Glacier
- Ice Cap
- Ice Sheet
- Horn
- Arête
- Cirque
- Fjord
- Snow Line
- Sublimation
- Calving
- Crevasse
- Bergschrund
- Serac
- Ogive
- Till
- Drumlin
- Esker
- Kettle
- Hanging Valley
- Moraine
  - Terminal
  - Lateral
  - Medial