Glaciers and Ice Sheets

• Cryosphere
  – The perennially frozen part of the hydrosphere

• Components of the cryosphere
  – Glaciers
    • A semi-permanent or perennially frozen body of ice,
    • Consists largely of re-crystallized snow
    • Moves under the pull of gravity
      – Temperate glaciers
      – Polar glacier
      – Ice sheets
      – Ice shelves, ice bergs

GLACIER TYPES AND FEATURES

What are glaciers?

• Masses of ice that are thick enough to flow under their own weight.
Glaciers and Ice Sheets

• How glaciers form
  – Snow that survives for more than a year gradually becomes denser until it is no longer penetrable by air and becomes glacier ice.
  – Further changes happen as the glacial ice is buried deeper (increasing pressure)

Glacial Ice

• Glacial Ice is snow that has been recrystallized and densified (spec. gravity = 0.9). It is commonly banded because of formation of layers at different times. It is blue in color because it reflects blue wavelengths and absorbs others.

What kinds of glaciers are there?

• Ice Sheets-dome shape, >50,000 km²
• Ice Caps-dome shape, <50,000 km²
• Ice Fields
• Valley Glaciers
• Cirque Glaciers
• Tidewater Glaciers and Ice Shelves
• Small Glaciers
Ice Sheets- Dome shaped masses of ice that are greater than 50,000 km² in area.

The Laurentide Ice Sheet
Ice Caps - Dome shaped masses of ice less than 50,000 km² in area

Eyjafjallajökull-Iceland

Outlet (valley) glacier from ice cap. Notice moraine, proglacial lake, outwash plain.

Top of an ice dome from the air
Piedmont lobe of an Icelandic ice cap

Ice Fields – Non dome-shaped masses of ice of large areal extent in mountainous areas. Mountain peaks project above them.

Climbers ascending to top of ice field.
Valley Glaciers—Long narrow glaciers that flow down hill in troughs cut into bedrock

Athabasca Glacier—Note moraines.

Ruth Glacier—Alaska
Alaska

Chamonix
Icelandic glacier in previously formed glacial trough

Solheimajökull, Iceland, 1971

Solheimajökull Glacier, 1992
Cirque Glaciers

- Small glacier that forms in a bowl-shaped depression called a cirque.

Cirque was formed by a glacier during the last ice age.

Grinnell Glacier-Glacier National Park
Tidewater Glaciers and Ice Shelves: Glaciers that terminate in water

- Tidewater glaciers: grounded at the end of the glacier; does not form an ice shelf

Harvard and Yale Glaciers - Prince William Sound

- Tidewater glaciers: grounded at the end of the glacier; does not form an ice shelf

Yale Glacier - Prince William Sound
Edge of an ice shelf. The height of the edge is 30 m and the shelf extends several hundred meters below sea level.
Larsen Ice Shelf, 2002. Shelf is undergoing catastrophic collapse due to global warming.

Tabular ice bergs

Breakup of ice shelf margin to form tabular ice bergs
Glaciers and Ice Sheets

- How glaciers grow and shrink
  - A glacier is measured using the amount of snow (winter) and the amount of melting (summer).
  - The difference between accumulation and ablation is a measure of the glacier’s mass balance.
Glacier Mass Balance (budget)

- Accumulation area
- Ablation area
- Equilibrium line

VISUALIZING

Glaciers and Ice Sheets

- How glaciers move
  - Glaciers move because of the pull of gravity
  - Ice in the central part of the glacier moves faster than the sides, and the uppermost moves faster than the lower layers
Glaciers and Ice Sheets

2 types of movement
• Internal deformation (creep)
• Basal sliding

Internal flow
– Ice moves in a glacier through a combination of ductile deformation at depth and brittle deformation at the surface
– Crevasse
  • A deep gaping fissure in the upper surface of a glacier

Basal sliding
– Ice at the bottom of a glacier slides across its bed (the rock or sediment which the glacier rests on)
– The glacial landscape
  • Glacier acts like a file, sled, and plow
• Glacial erosion
  - Abrasion
    • Glacial striations
  - Plucking (quarrying); removal of large blocks
  - Large scale erosion
    • Glacial troughs (deep valleys with a U-shaped profile)
    • Cirques

Arete: thin ridge between 2 cirques

Troughs and fjords

Geiranger fjord, Norway
Glacial abrasion: striations

Striations, polish, Maine

Plucking
Plucking: large blocks removed as glacier moves over

**Glaciers and Ice Sheets**

- **Glacial deposition**
  - **Till**
    - A mixture of crushed rock, clay, sand, pebbles, cobbles, and boulders deposited by a glacier
  - **Moraine**
    - A ridge or pile of debris that has been, or is being, transported by a glacier
    - Generally formed in the middle of the glacier (medial), at the sides (lateral), or at the end of the glacier (terminal)

Michigan impacted by three lobes of the LIS

Glacial deposits 3-180 meters thick

Overlie sedimentary rocks of Michigan Basin
Basal till-South Haven

Glacial moraines in SW Michigan
Glaciers and Ice Sheets

Glacial landforms
- Esker
  - Ridge deposited by a river flowing in a tunnel at the base of a glacier
- Drumlin
  - Streamlined hill formed by squeezing of soft sediment at the base of the ice

Dahlen esker; eastern North Dakota
Road cut through esker; southern Manitoba

Glaciers and Ice Sheets

- Periglacial landforms
  - Tundra
  - Permafrost
    - Ground that is perennially below the freezing point of water
  - Ice wedges
  - Patterned ground
    - Produced by freeze-thaw cycle
Active Ice wedge (USGS)

Ice wedge cast

Relict ice wedge polygons-Wisconsin. Indicative of past permafrost conditions.