Topic 9

Glacial Processes and Landforms

Alpine & Continental Glaciers
Glacial Mass Balance
Glacial Ice Formation
Glacial Movement & Erosion
Erosional and Depositional Landforms
The Pleistocene Epoch
Geomorphology of SW Manitoba

KEY LEARNING CONCEPTS

Chapter 17

1

What is a Glacier?

- Mass of snow and ice:
  - existing throughout the year
  - evidence of movement
- Grows:
- Shrinks:
- Moves:

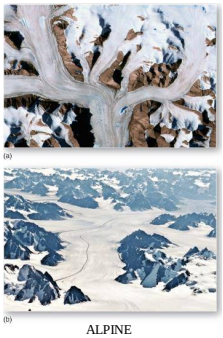
2

Types of Glaciers

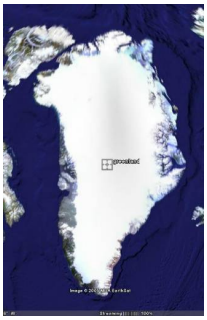
- Two basic types:
- **Alpine** and **Continental**
  - Differ in terms of:
    1.
    2.
    3.
    4.

3

Rivers and Sheets of Ice



ALPINE



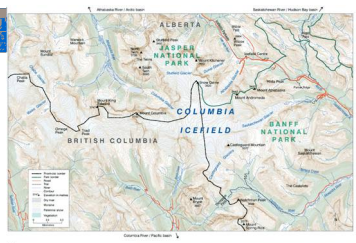
CONTINENTAL

Glacial Ice in Canada

FIGURE 17.2 Glacial ice in Canada. Regions of glacial ice in Canada can be described as Coastal, Arctic, and Rocky Mountain. [Map courtesy of *Canadian Geographic*.]

Alpine Glaciers

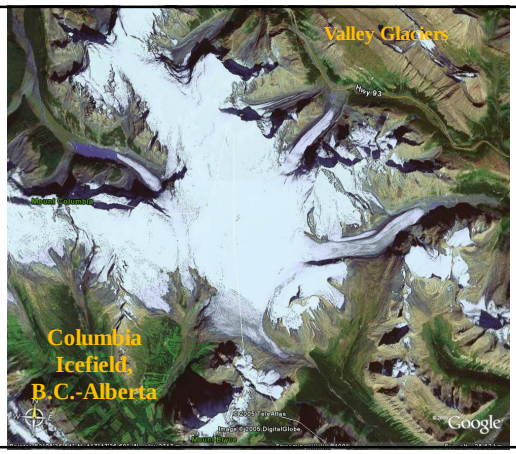
- Located in mountainous regions
- Form at elevation above the snowline
- <u>Movement is:</u>



(a)

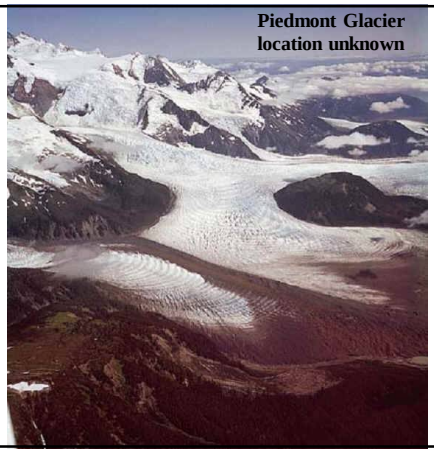
(b)

FIGURE 17.3 The Columbia Icefield. (a) This is the accumulation area for several valley glaciers that flow into three different oceans—the Columbia River that flows into the Pacific, the Athabasca River that flows into the Arctic, and the North Saskatchewan and Saskatchewan rivers that flow into Hudson Bay and the Atlantic Ocean. (b) The Athabasca Glacier is a popular tourist destination where a snowcoach takes visitors onto the ice surface along an ice road, visible in the middle ground of the photo. [(a) Map courtesy of *Canadian Geographic*; (b) iStockphoto/Thinkstock.]


Valley Glaciers
Hwy 93
Mount Columbia
Columbia
Icefield,
B.C.-Alberta
Google


Cirque Glacier


Cirque Basin



Continental Glaciers

- Large continuous mass of glacial ice, regardless of location, is referred to as a **continental glacier**
- Come in different sizes:
- Largest - **ice sheet** (>50,000 km^2)
- Smaller - **ice cap** (<50,000 km^2)
- If mountain tops are visible called **ice field**
- Movement controlled by:

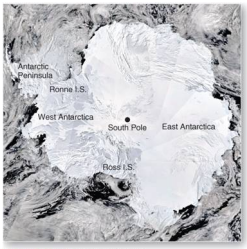


FIGURE 17.5 Antarctic Ice Sheet. A composite of *Aqua* MODIS images from January 2009 portrays the Antarctic continent—containing 92% of Earth's glacial ice. Reference the map of Antarctica in Figure 17.32c. [*Aqua* MODIS image, NASA/GSFC.]

Ice Sheets, Caps, and Fields

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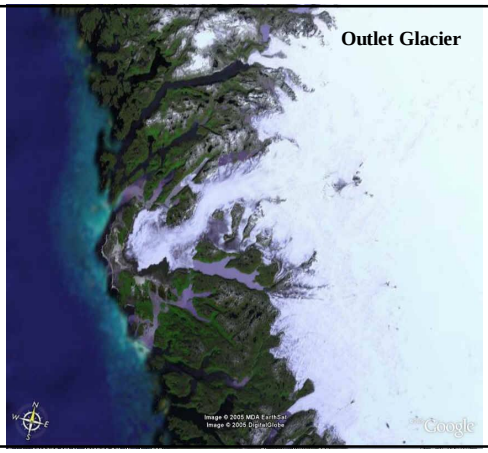

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Glacial Ice Formation

- Accumulation of snow and ice, thick layers
- Weight → increased pressure at depth
- Pressure melting point at depth is reduced

Snow → Gr. Snow → Firn → Imp.GIce → Tr. GIce

Behaves as a plastic under pressure - flows

- Process takes from a few yrs to thousands of yrs

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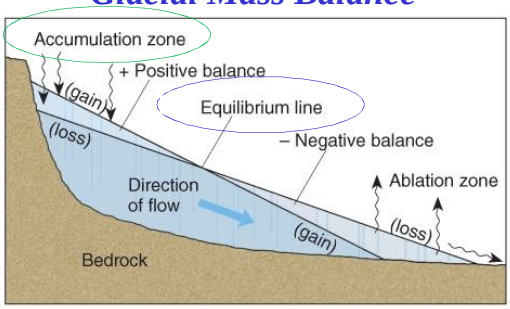
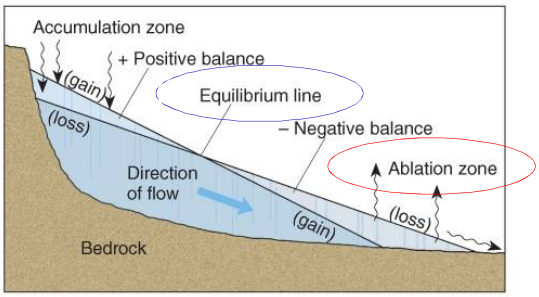
Glacial Mass Balance

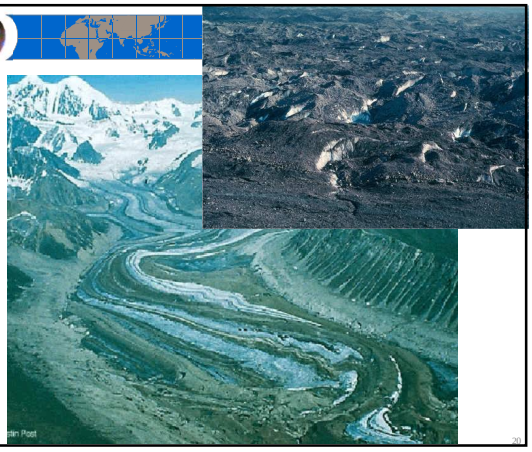


Accumulation = Precip. (all forms), snow avalanches

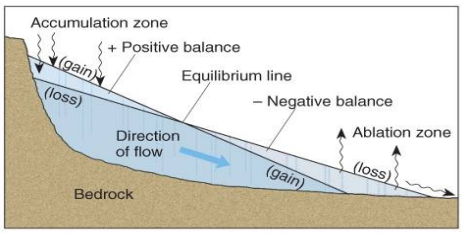
Glacial Mass Balance



Ablation = snowmelt, sublimation, deflation, and calving



Glacial Advance or Retreat?



Glaciers advance/grow when:
Precip. ↑ and/or temperatures ↓
Causing ↑ accumulation and/or ↓ ablation
Equilibrium line shifts towards terminus;
the glacier advances

Glaciers retreat/shrink when:
Precip. ↓ and/or temperatures ↑
Causing ↓ accumulation and/or ↑ ablation
Equilibrium line shifts towards accumulation zone;
the glacier retreats

Advance or Retreat?

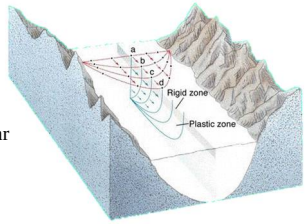
Movement of glacial ice is NOT necessarily coincident with advance or retreat of the terminus.

Ice may be moving even when the terminus is stationary, advancing, or retreating

Glacial Movement

Rate of movement depends on:
1. Rate of _____
2. Slope of _____
3. Slope of _____
4. Temperature of _____
5. Presence of _____ at base

Rate varies - metres/day to cm/year
Faster near _____, along _____
Slowest near _____and _____
due to _____



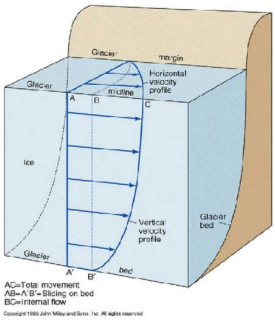
Glacial Movement

Three mechanisms of movement:

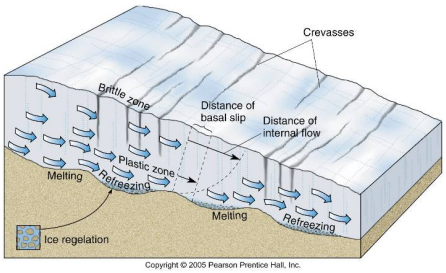
1) Basal Sliding

2) Plastic Flow

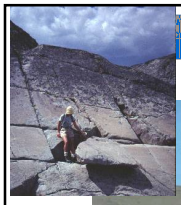
3) Shearing

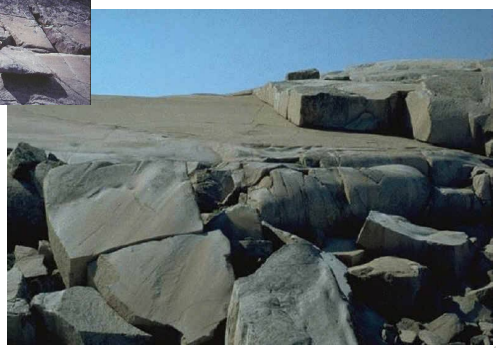


Ice Regelation and Plucking



Due to pressure changes at base of glacier





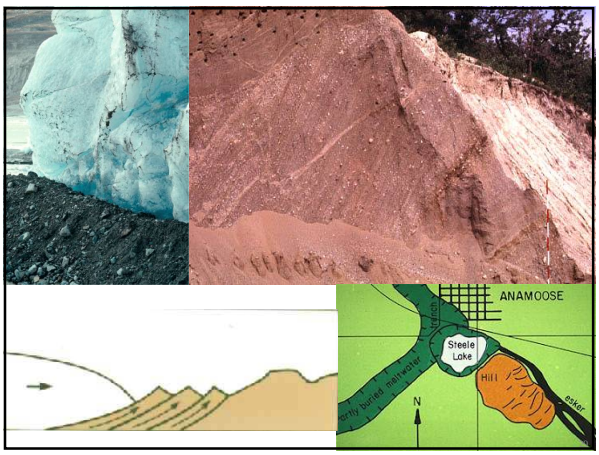
Glacial Erosion

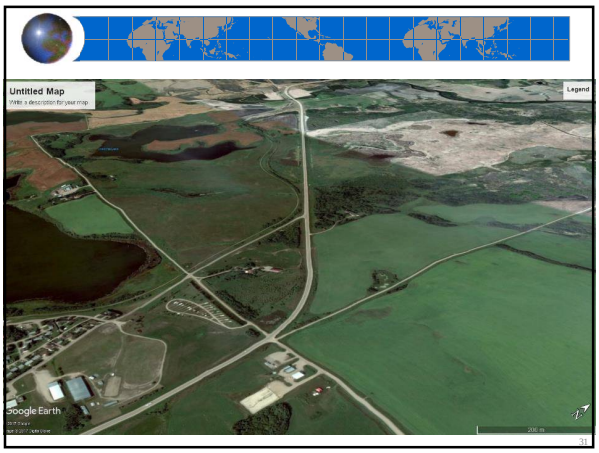
Three processes account for the majority of glacial erosion:

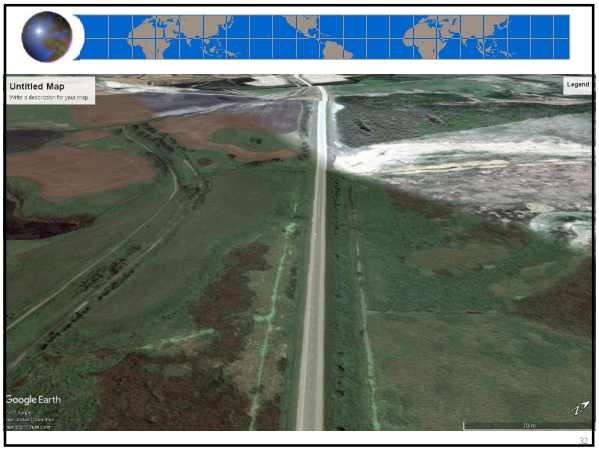
1) Plucking
   w/ ice regelation

2) Abrasion
   polishing, scouring, striations, grooves

3) Bulldozing
   glaciotectonic features


ANAMOOSE
Steele
Lake
Hill
N
esker





Erosional Landforms Created by Alpine Glaciation

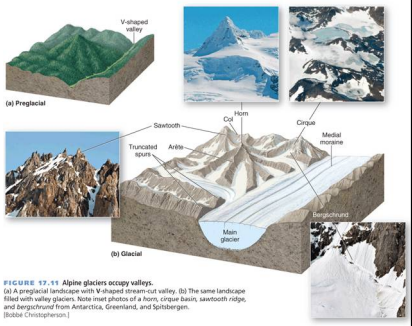


FIGURE 17.11 Alpine glaciers occupy valleys. (a) A preglacial landscape with V-shaped stream-cut valley. (b) The same landscape filled with valley glaciers. Note inset photos of a *horn*, *cirque basin*, *sawtooth ridge*, and *bergschrund* from Antarctica, Greenland, and Spitsbergen. [Bobbé Christopherson.]

Glaciation typically removes soil and regolith, eroding down to bedrock

Postglacial Alpine Landscape & Resulting Erosional Landforms

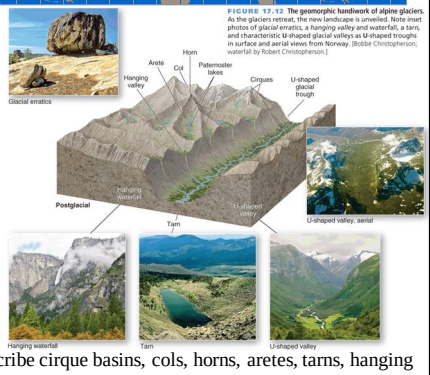


FIGURE 17.12 The geomorphic handiwork of alpine glaciers. As the glaciers retreat, the new landscape is unveiled. Note inset photos of glacial erratics, a hanging valley and waterfall, a tarn, and characteristic U-shaped glacial valleys as U-shaped troughs in surface and aerial views from Norway. [Bobbé Christopherson; waterfall: by Robert Christopherson.]

Identify and describe cirque basins, cols, horns, aretes, tarns, hanging and u-shaped valleys, paternoster lakes, fjords

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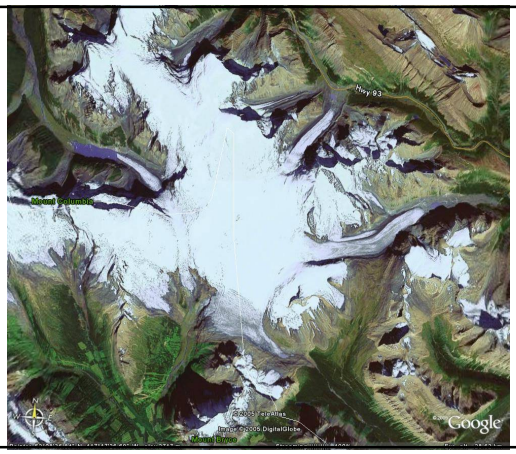
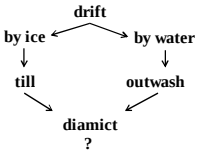


Depositional Landforms Created by Alpine or Continental Glaciation



Depositional Landforms Created by Alpine or Continental Glaciation

- **Moraines**
  - Accumulations of till (unsorted material)
  - **Terminal** or **end moraines**; advance = ablation
  - Sequence of end moraines referred to as **washboard** or **recessional moraines**
  - Lateral vs. Medial Moraines (alpine)

Animation –Terminal and Recessional Moraines

Depositional Landforms Created by Alpine or Continental Glaciation

- Glaciofluvial deposits (sorted material)
  - Glaciers develop extensive drainage systems in the ablation zone
  - on = _____
  - within = _____
  - and beneath = _____
  - Sediment laden runoff deposits an _____ _____ in a process analogous to the development of a delta or alluvial fan

Animation – Outwash

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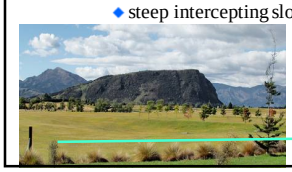
Depositional Landforms Created by Continental Glaciation

- Ablation of stagnant ice; = till plain
- Deposition of glaciofluvial seds; = inverted topography after ice melts
  - Subglacial fluvial deposits result in long sinuous ridges called _____
  - Supraglacial lake deposits result in hills called _____
  - Blocks of clean ice result in subsidence and depressions called _____

Erosional and Depositional Landforms Created by Continental Glaciation

- Two general types of streamlined features:
  - **Roche Moutonnee –** _____
    - gentle intercepting slope, steep leeward slope
  - **Drumlins -** _____
    - steep intercepting slope, gentle leeward slope



Deposition by Continental Glaciers

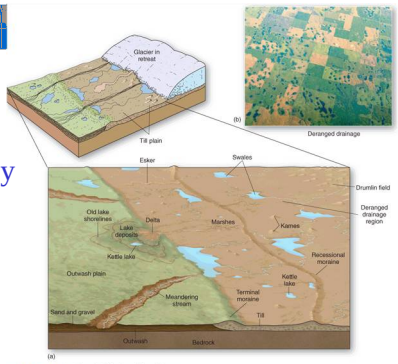


FIGURE 17.17 Continental glacier depositional features. (a) Common depositional landforms produced by glaciers, note the esker, drumlin field, recessional moraine, kames, kettle lake, till, and outwash plain of stratified drift. (b) Deranged drainage tells us continental glaciers advanced and retreated across the prairies of central Saskatchewan, Canada. [Bobbe Christopherson.]

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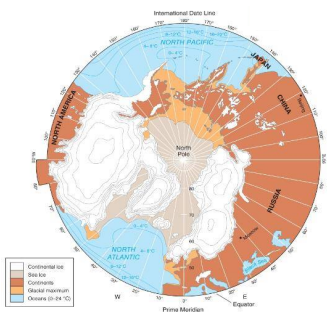
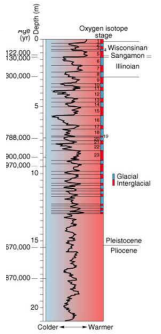
Pleistocene Glaciation





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Mechanisms of Climate Fluctuation

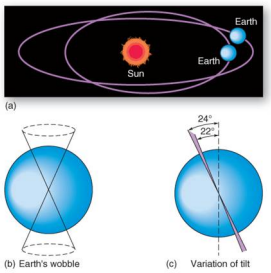

FIGURE 17.31 Astronomical factors that may affect broad climatic cycles.
(a) Earth's elliptical orbit varies widely during a 100 000-year cycle, stretching out to an extreme ellipse. (b) Earth's 26 000-year axial wobble. (c) Variation in Earth's axial tilt has a 41 000-year cycle.

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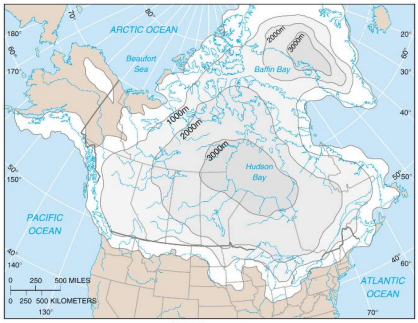
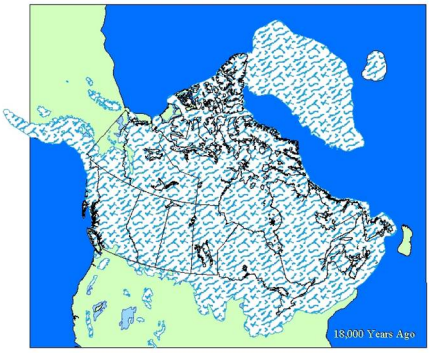
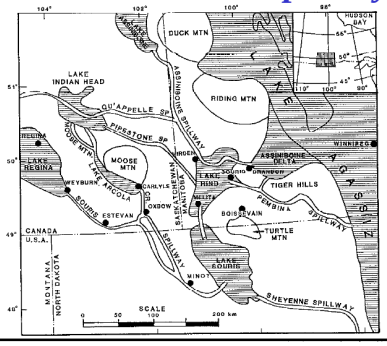
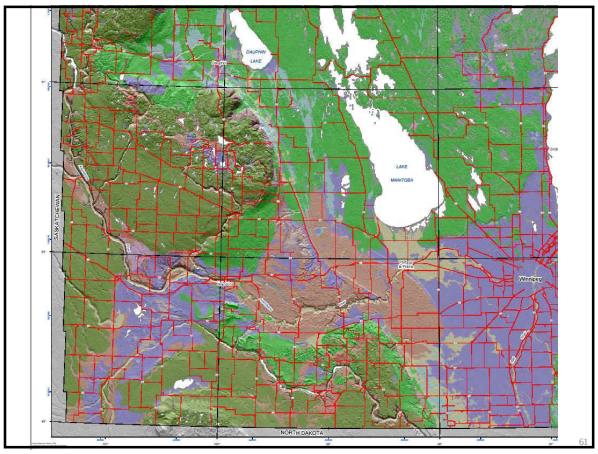


18,000 years ago



Glacial Lakes and Spillways




OKAPIWIN LAKE
LAKE MANITOBA
SASKATCHEWAN
Winnipeg
NORTH DAKOTA