Module 20
Glacial System

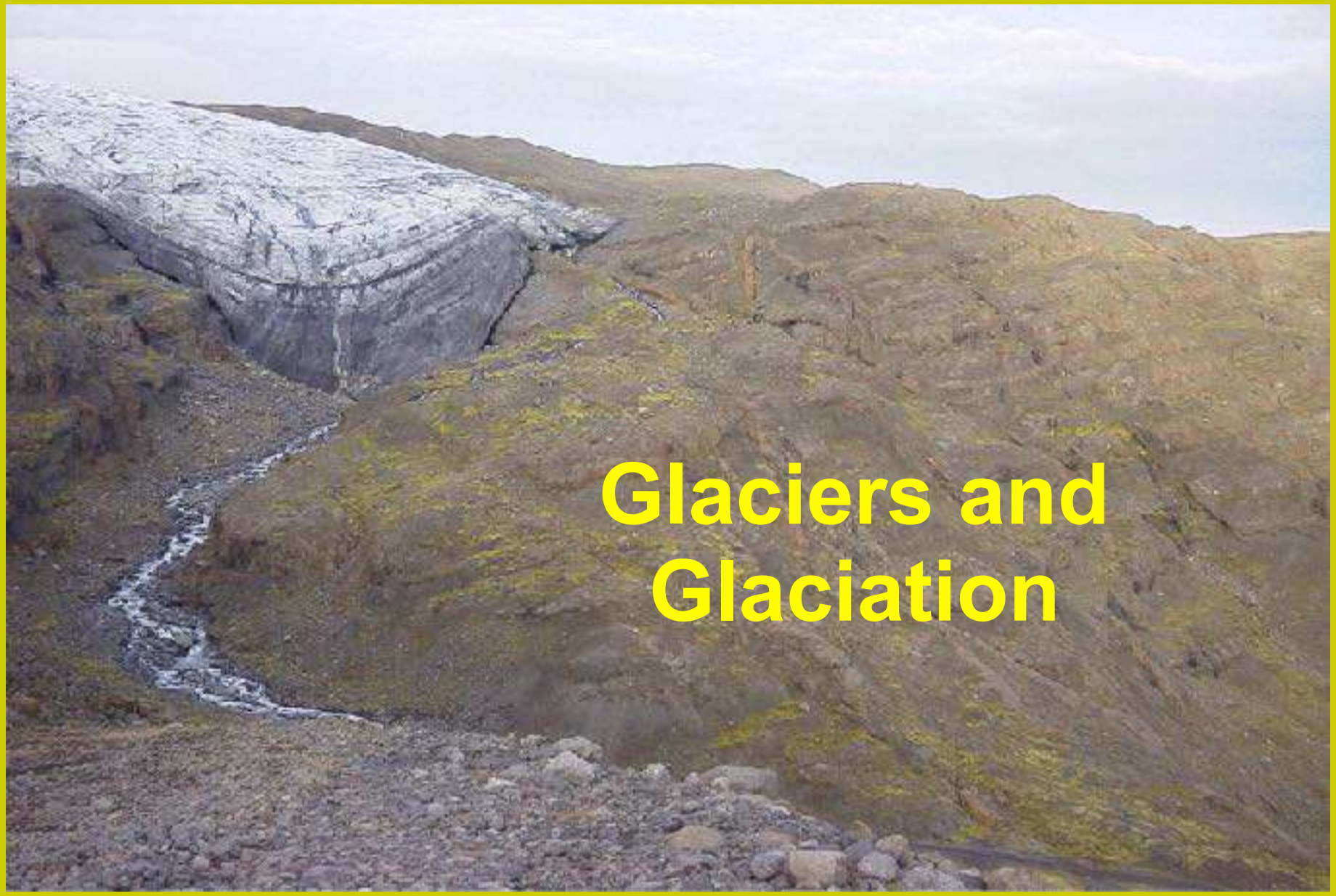


Photo credit: G. Mattioli

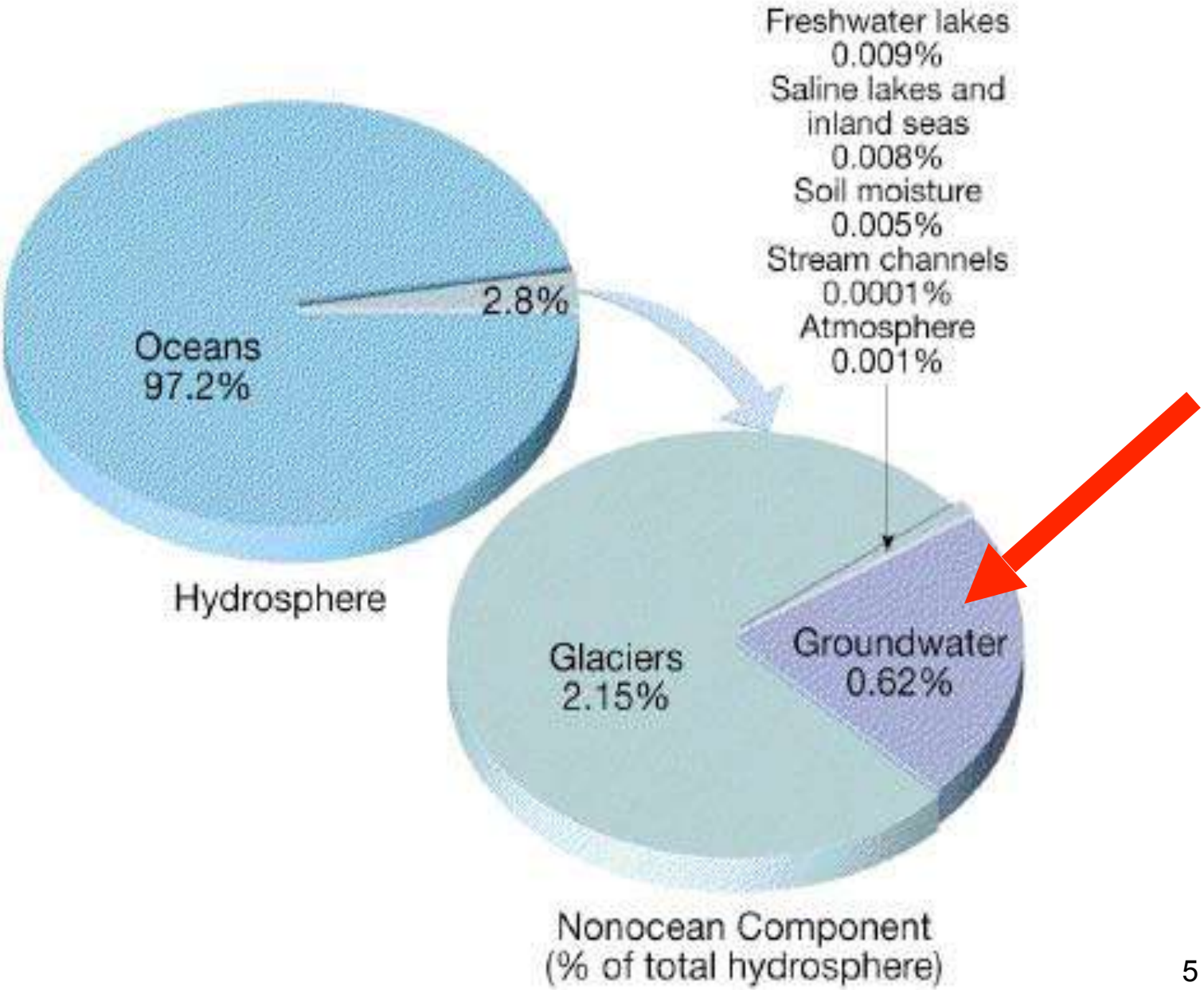
Glaciers and Glaciation Topics

- Glaciers
  - Global Distribution
  - Mechanisms of Formation
  - How and Why They Move

Modern Glacier Distribution

- Mostly limited to Polar Regions
  - Northern Hemisphere Sea Ice Pack is seasonal and ephemeral
  - Greenland Ice Sheet is “permanent” (10%)
  - Antarctic Ice Sheet is “permanent” (85%)
  - Remaining Alpine glaciers amount to only 5%
- **Most of the Earth’s freshwater is bound up in Antarctic Ice Sheet**
  - **~2 % of total global water budget**

Global Distribution of Water



Northern Hemisphere Polar Ice (N Pole)

NASA/CSA Resources - Composite radar image draped on visible image

Image source: NASA Jet Propulsion Lab

Glacial Characteristics

- Distribution of Glaciers
- Types of Glaciers
  - Continental Ice Sheets
  - Alpine
- Formation and Growth of Glaciers
- Movement of Valley Glaciers
- Movement of Ice Sheets

Modern Valley Glacier

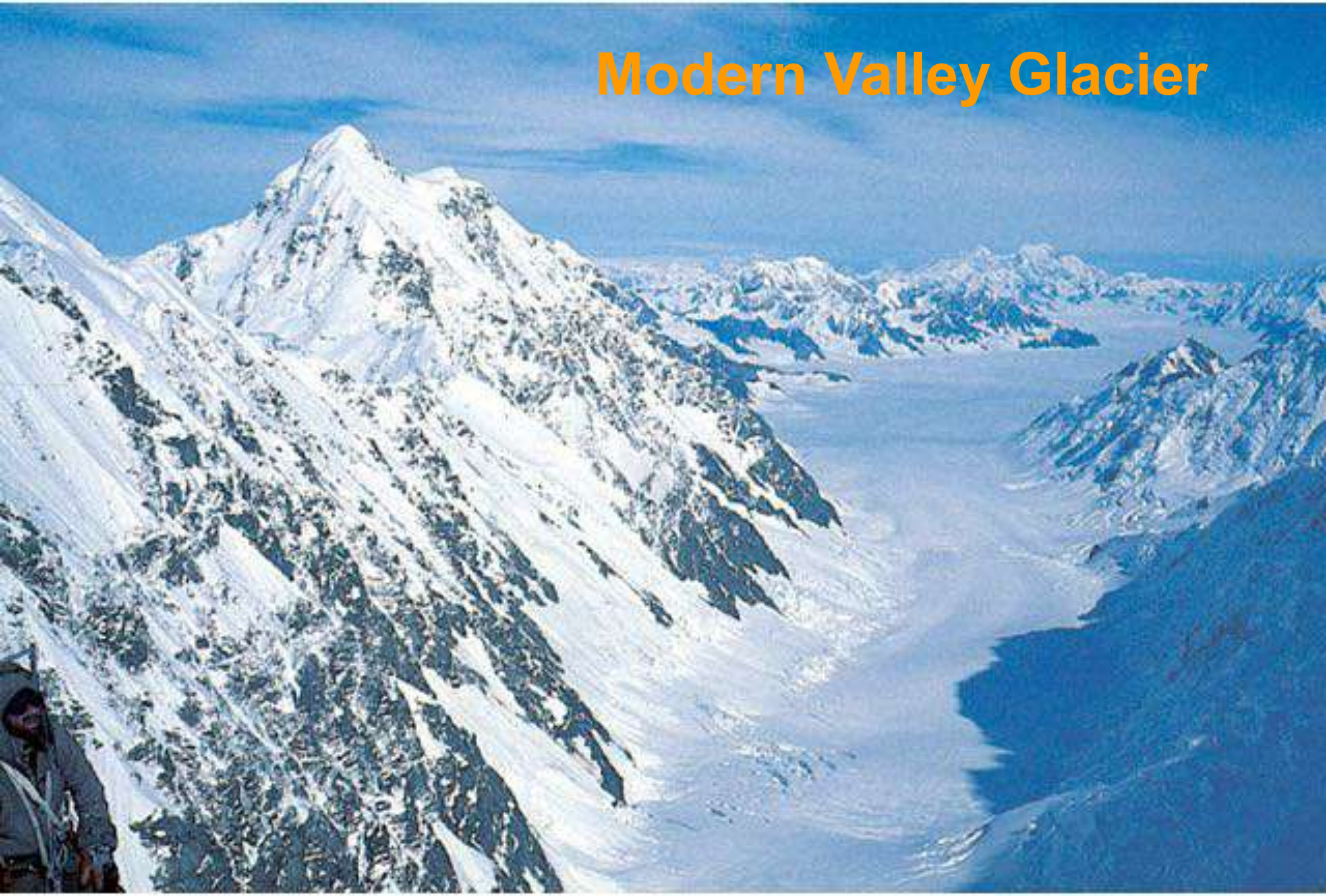
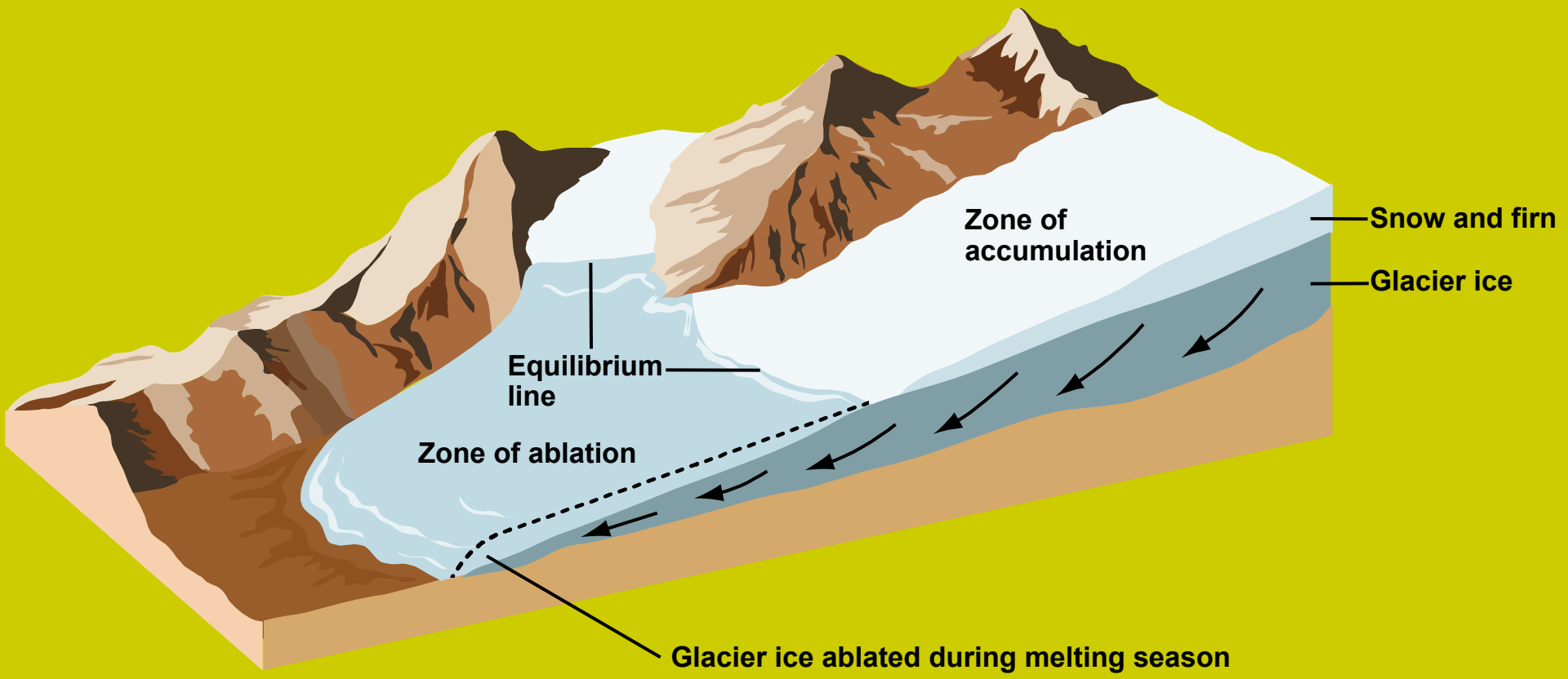


Photo by C. C. Plummer

Valley Glacier Zones



Receding South Cascade Glacier

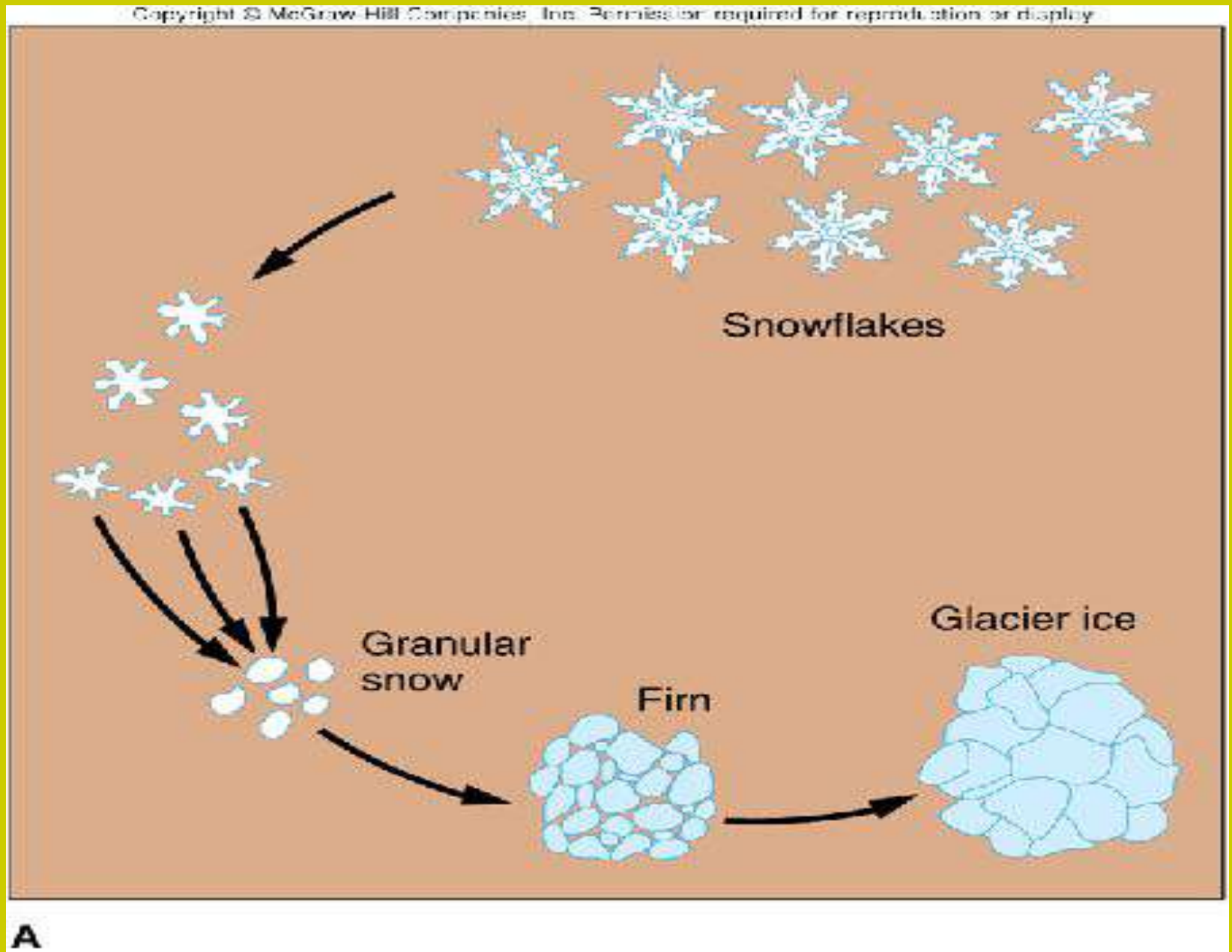
1957

1980

Loss of 18.7 M m³ of ice - Due to global warming?

Photo credits: U.S. Geological Survey

Snow to Ice



LANDSAT Composite Antarctica

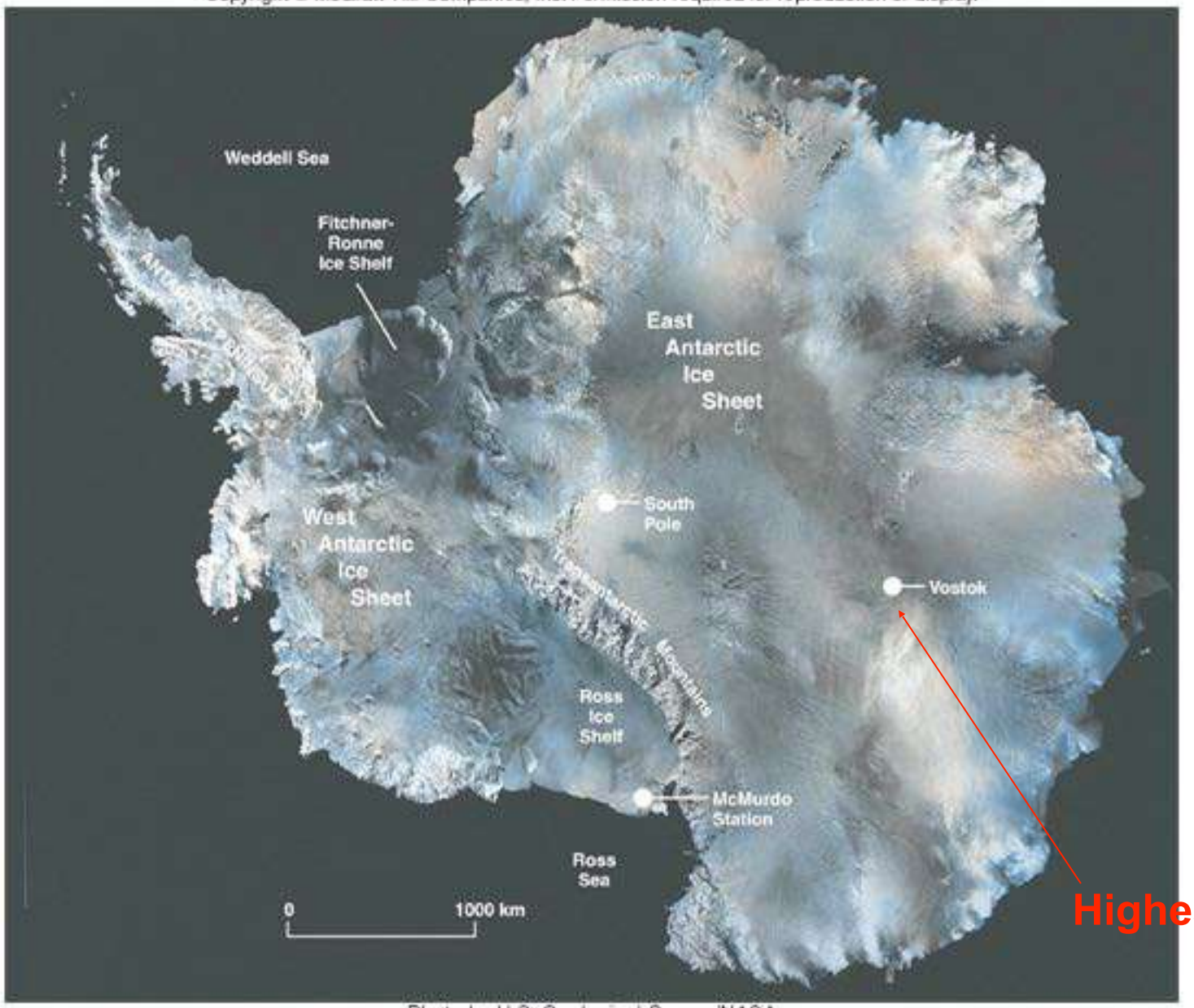
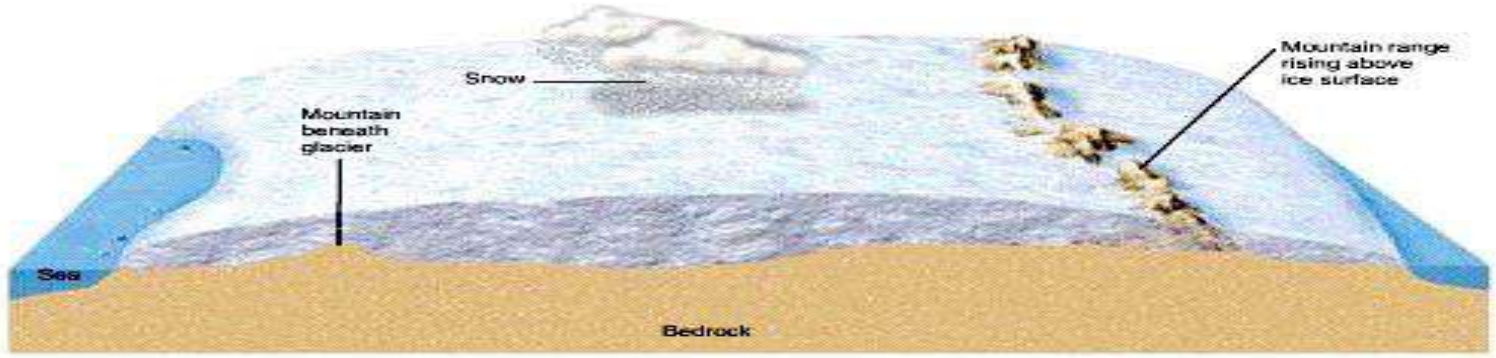


Photo by U.S. Geological Survey/NASA

Continental Ice Sheet Development



South Pole

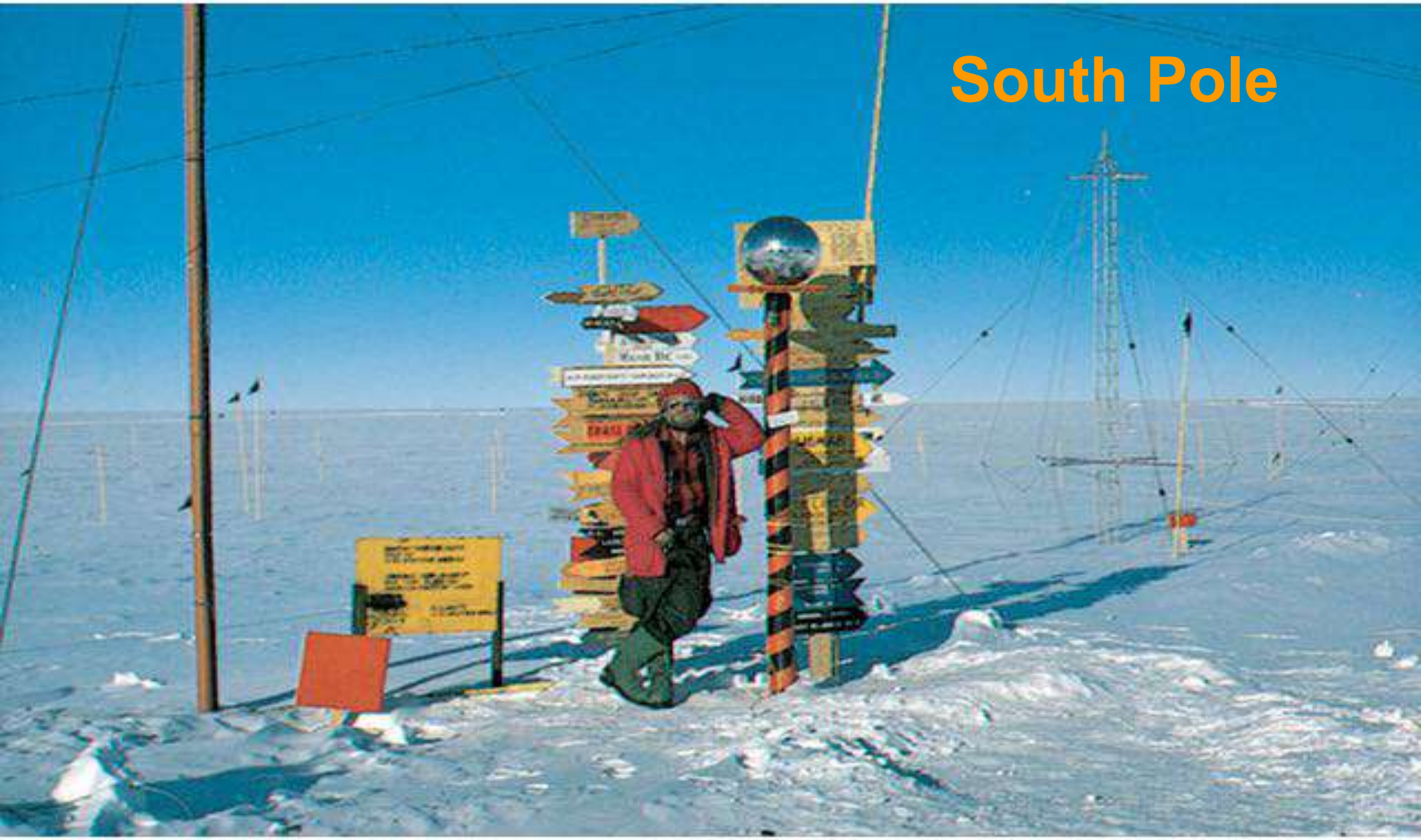


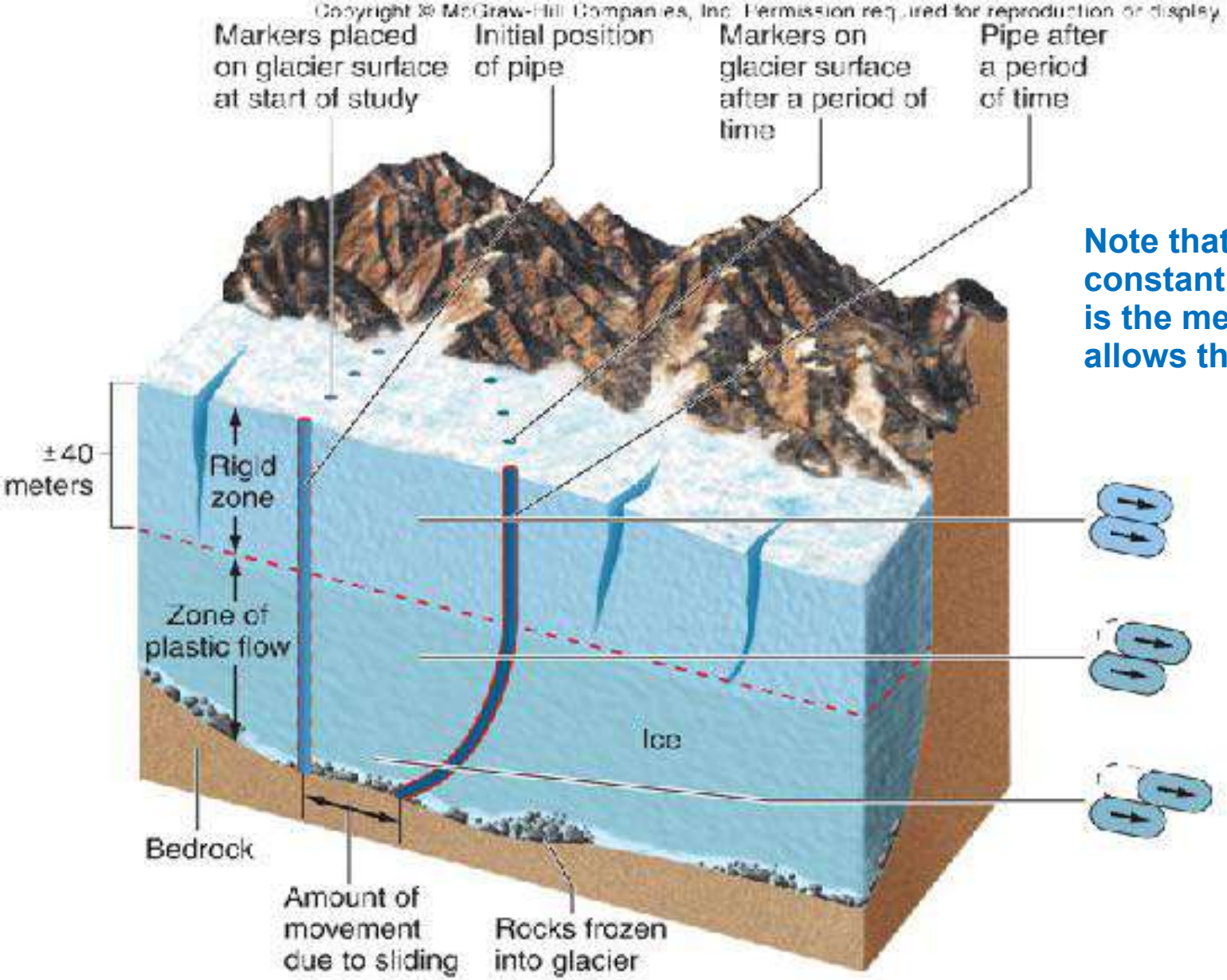
Photo by C. C. Plummer

Pole erected 1956 - Movement of Ice Sheet has displaced it from current geographic south pole several km away!

Icebergs (in Continental Ice sheet)

Photo by C. C. Plummer

Glacial Movement - Mechanisms



Note that velocity is NOT constant with depth nor is the mechanism that allows the ice to move!

Glacial Crevasses

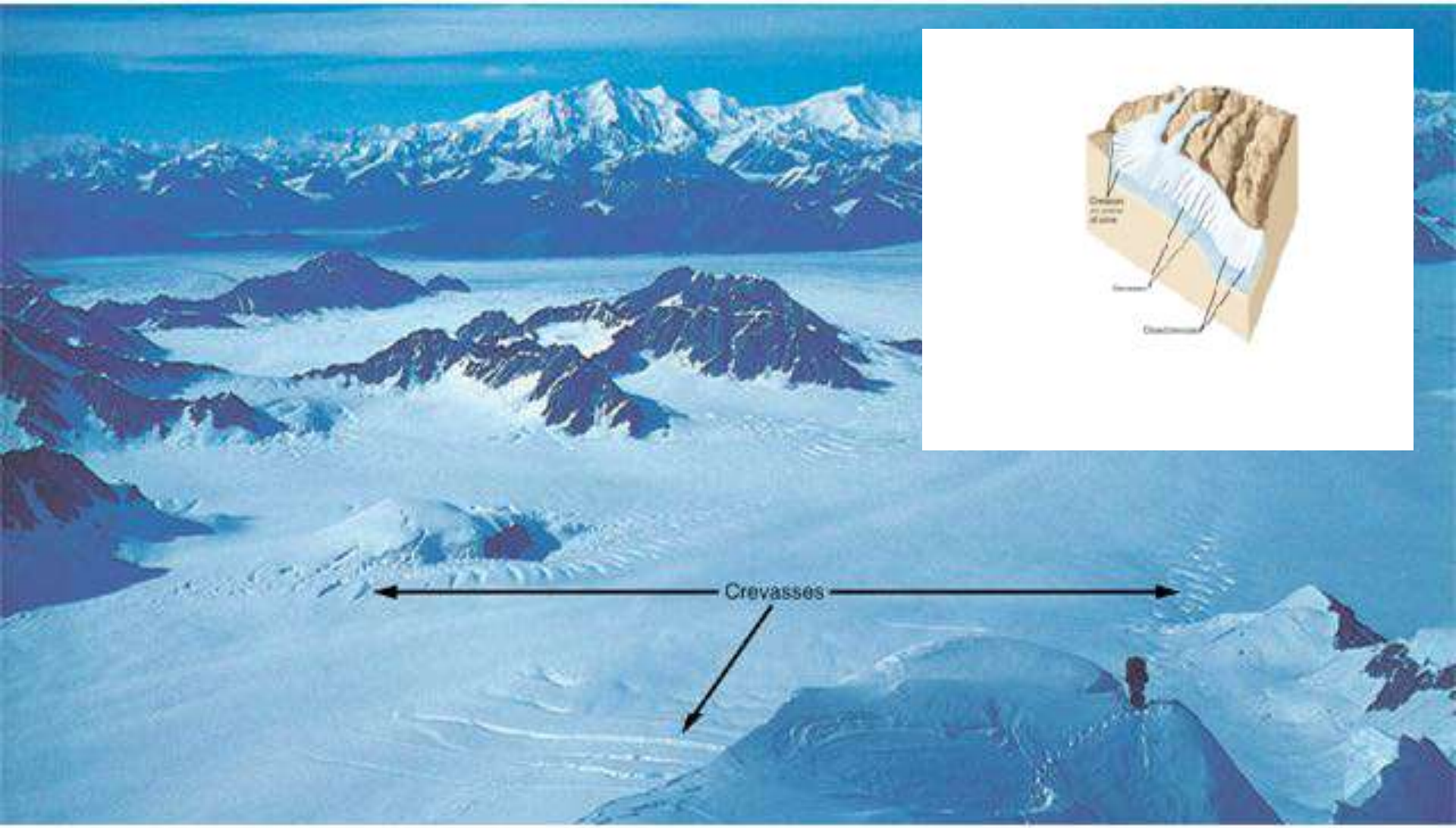
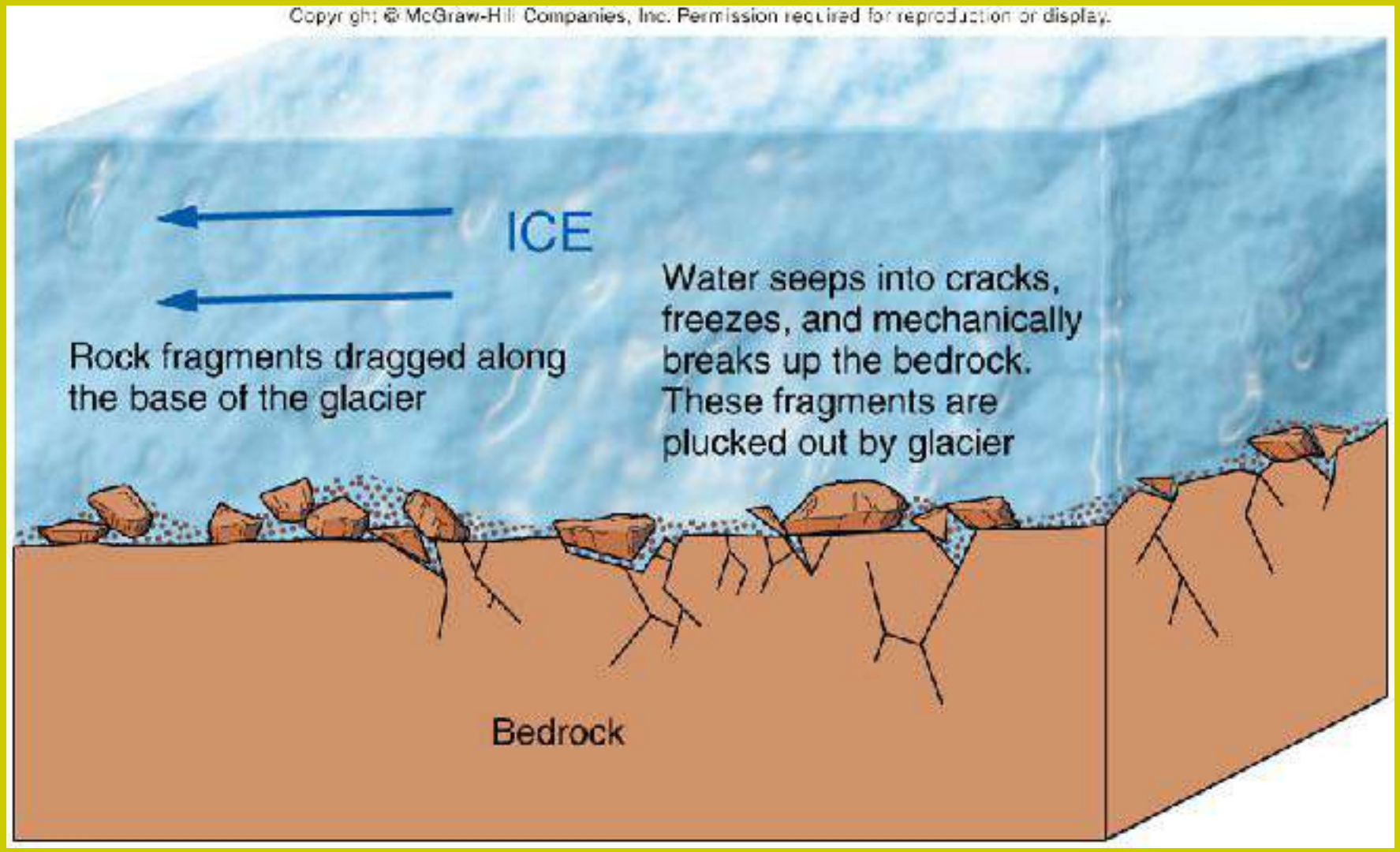


Photo by C. C. Plummer

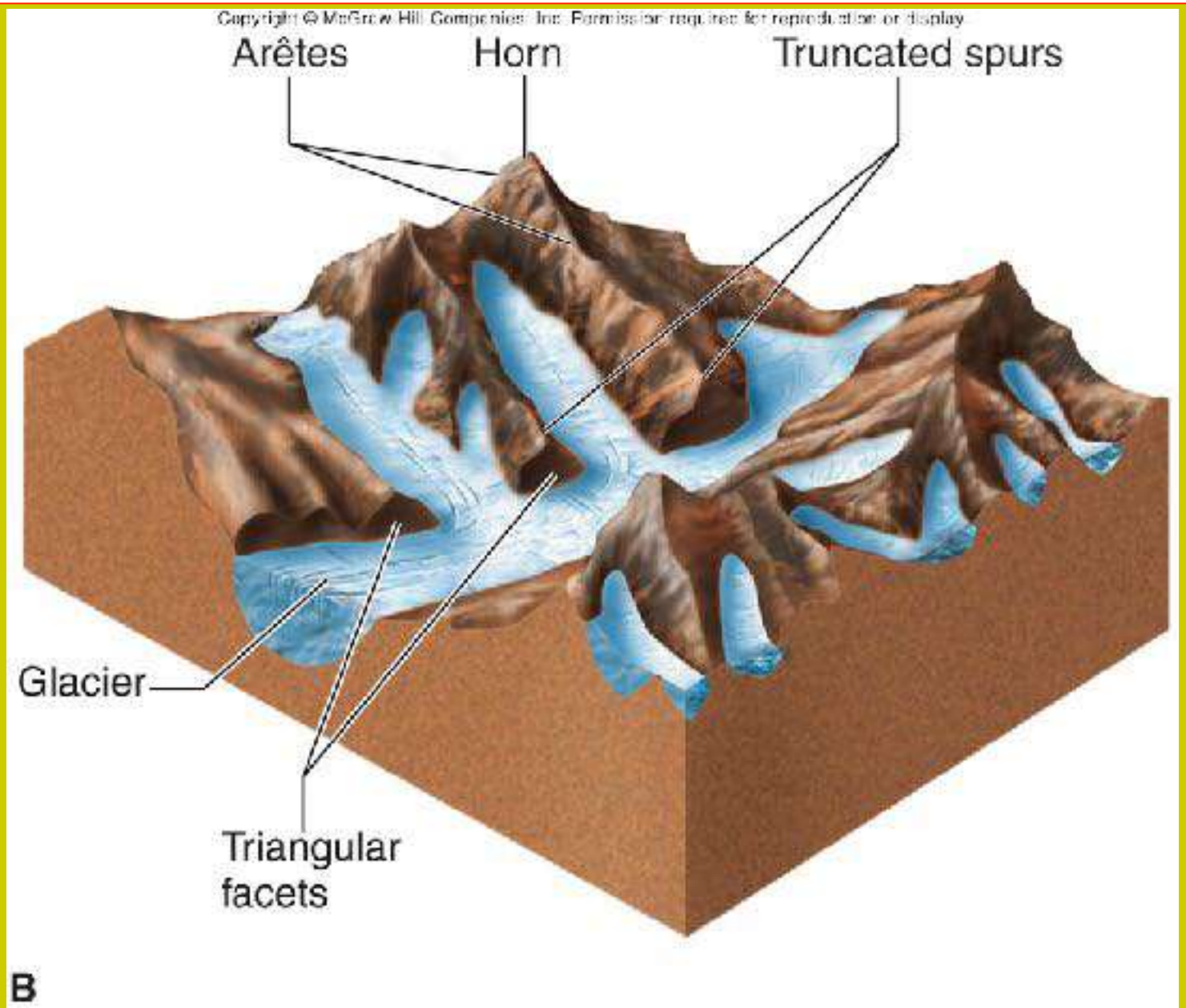
Glacial Erosion

- Erosional Landscapes Associated with **Alpine Glaciation**
- Erosional Landscapes Associated with **Continental Glaciation**

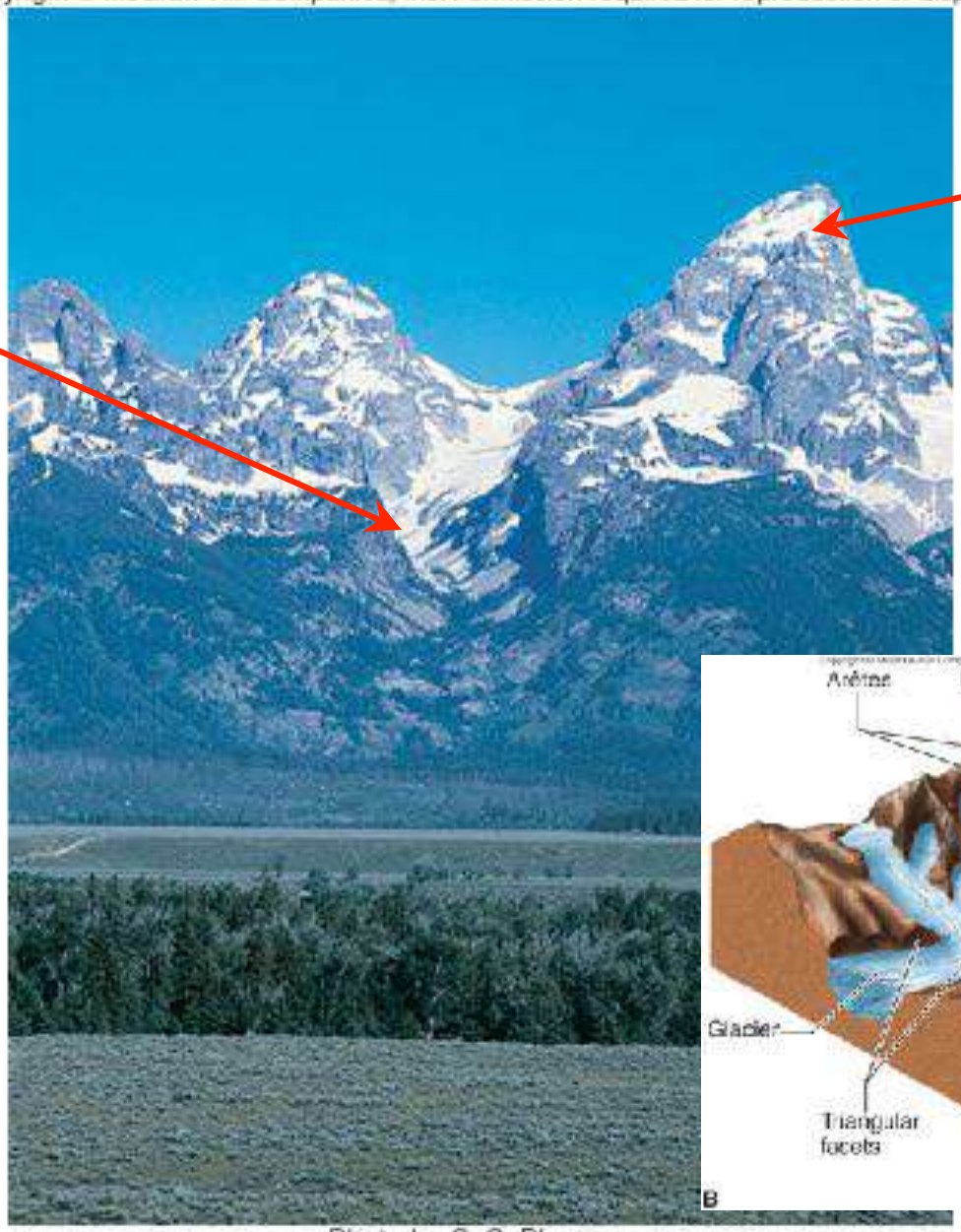
Glacial Erosion & Striations



Alpine Glacial Landforms



Alpine Glacial Features - Grand Teton



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Hanging Rivers - U shaped Valley

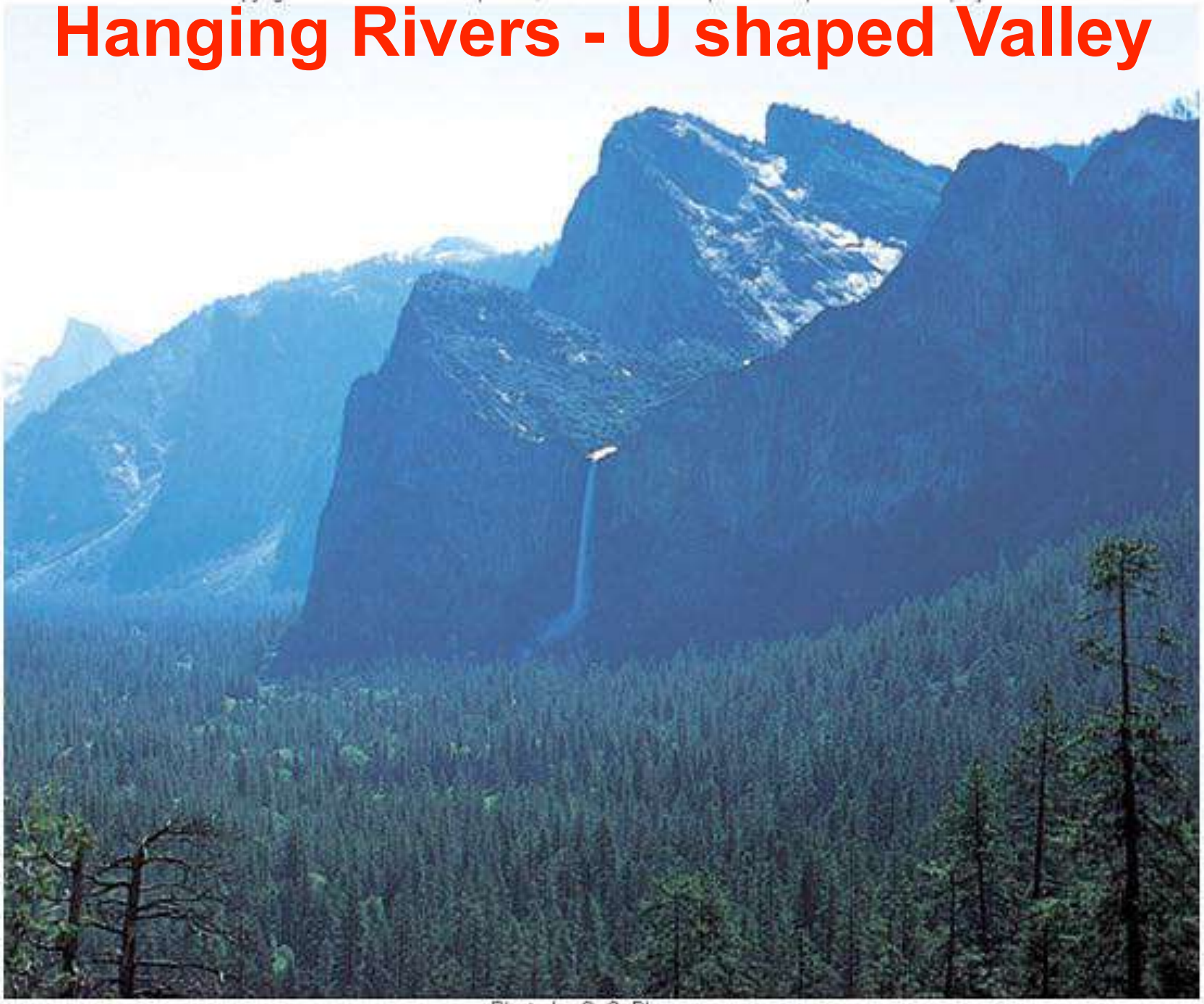
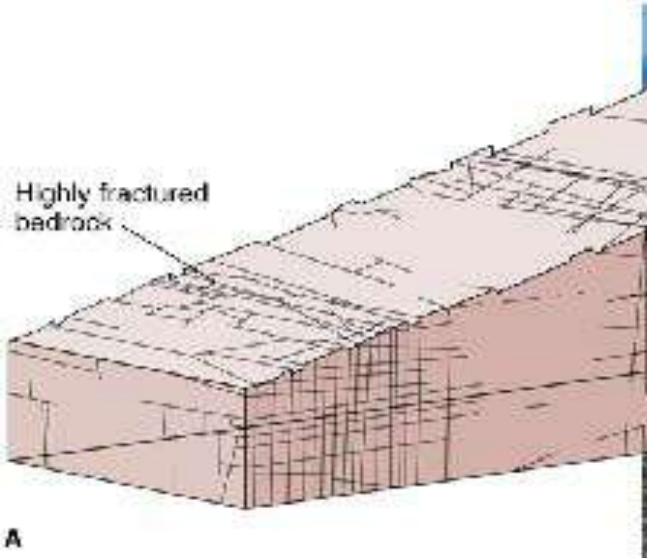


Photo by C. C. Plummer

Bedrock Fractures and Glacial Erosion



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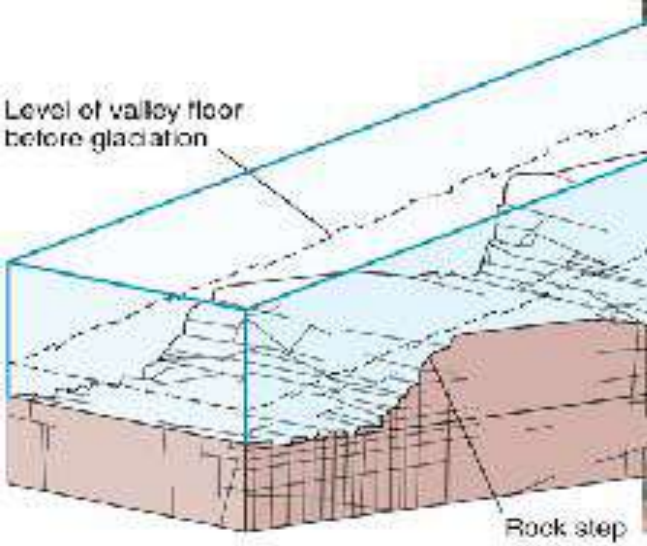

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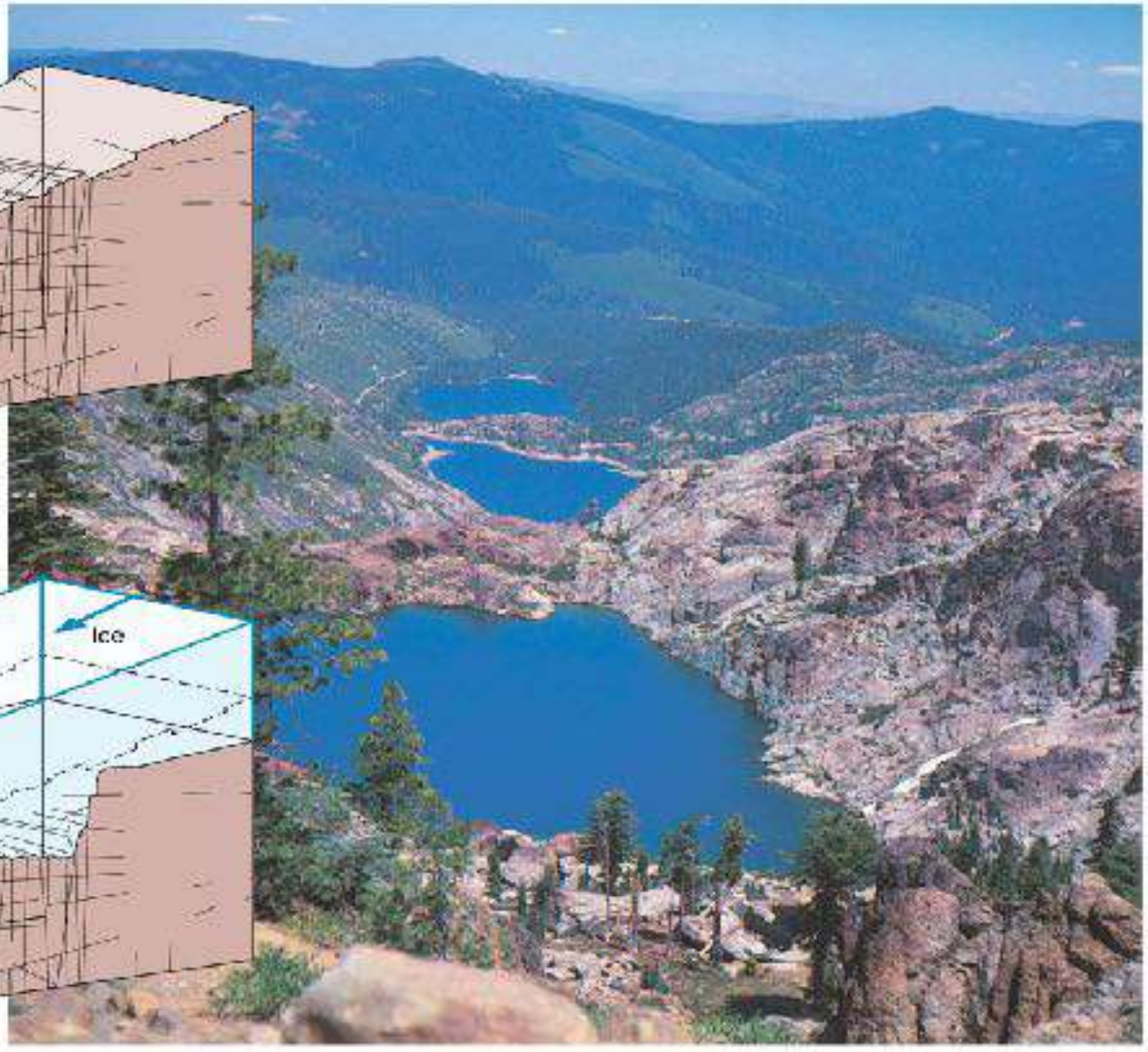
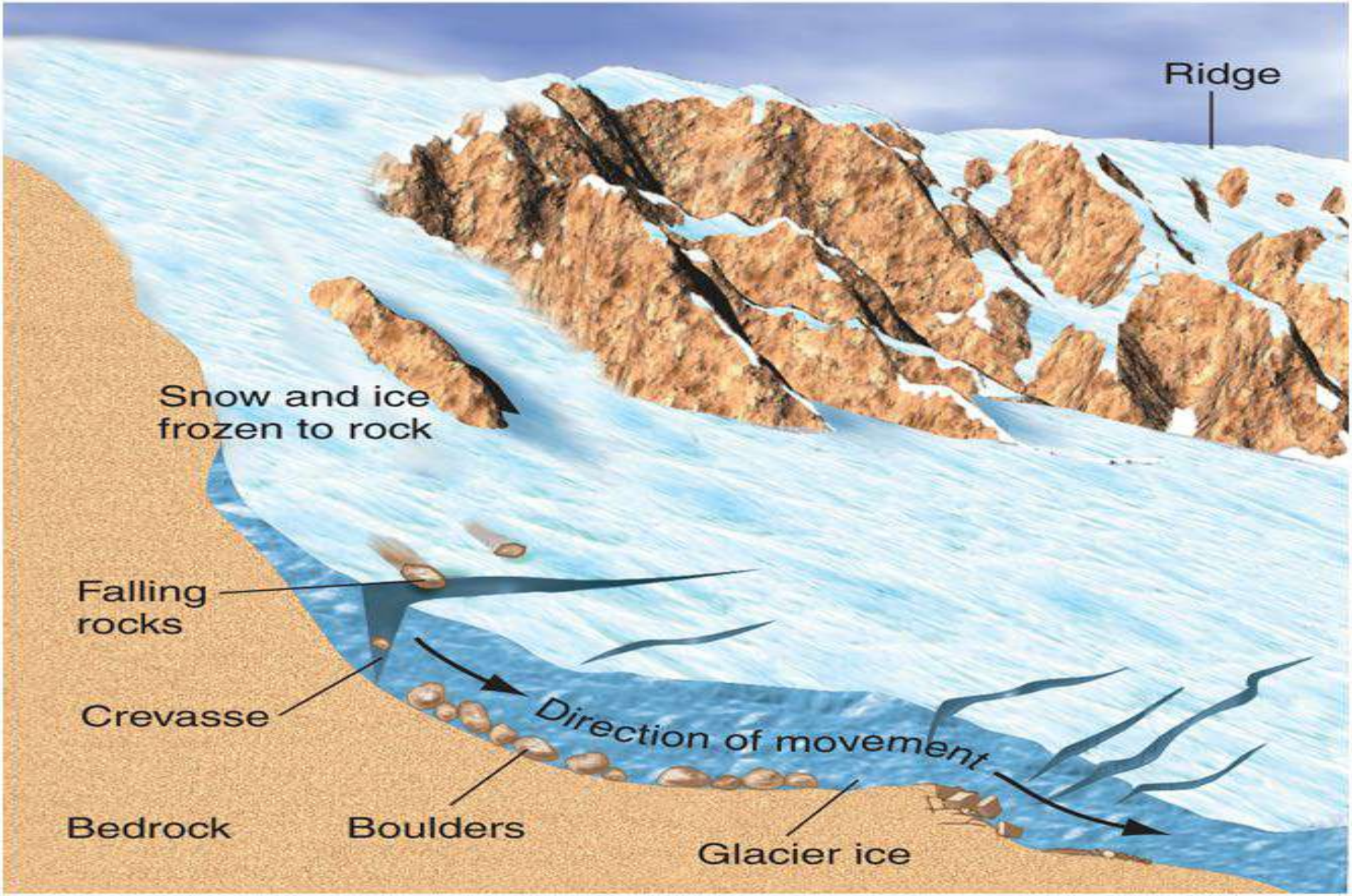
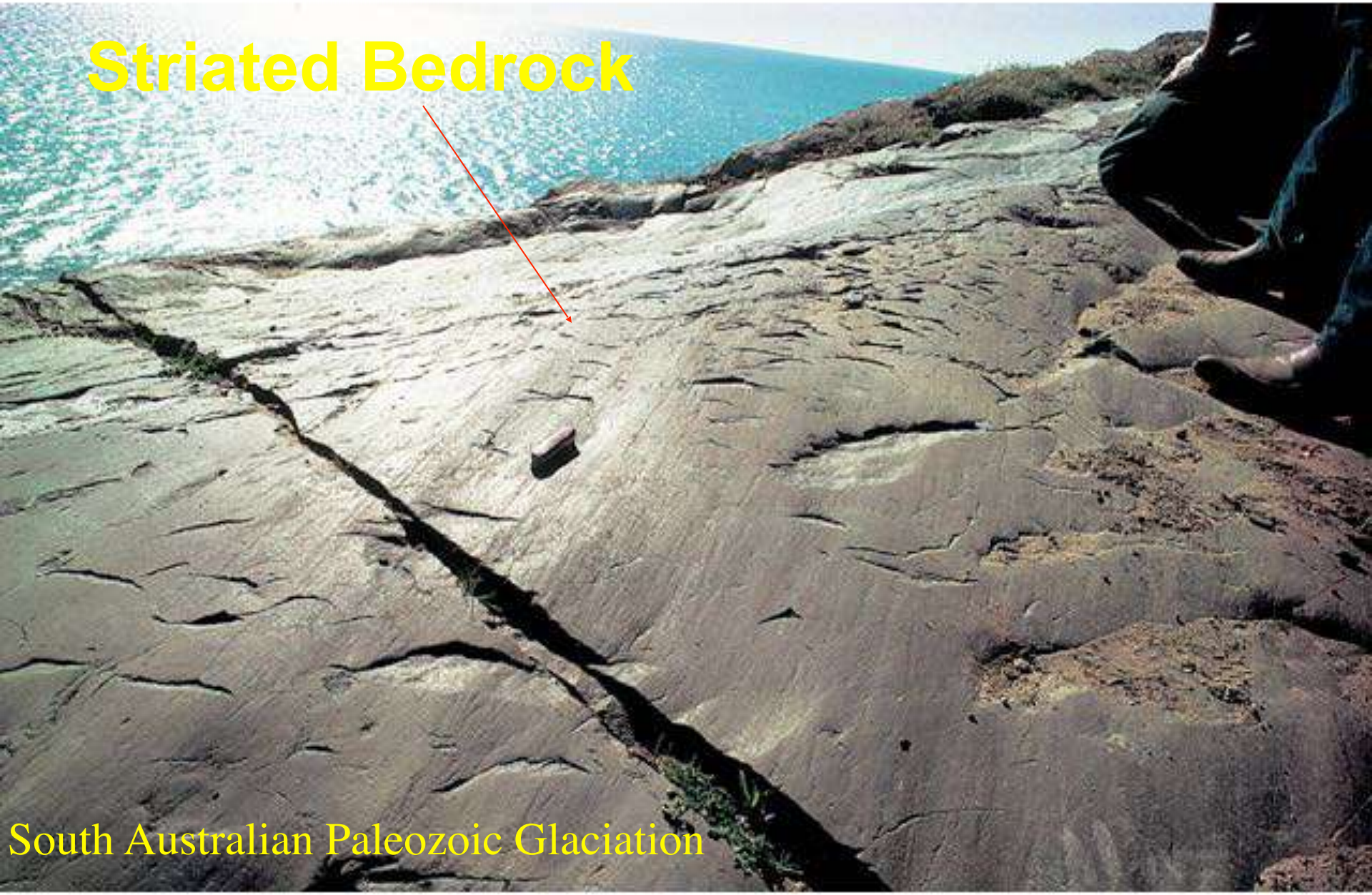


C

Photo by C. C. Plummer

Crevasse Development





South Australian Paleozoic Glaciation

Photo by C. C. Plummer

Glacially Scoured Terrain, Canadian Arctic

Photo by Paula J. Noble

Glacial Deposition

- Moraines

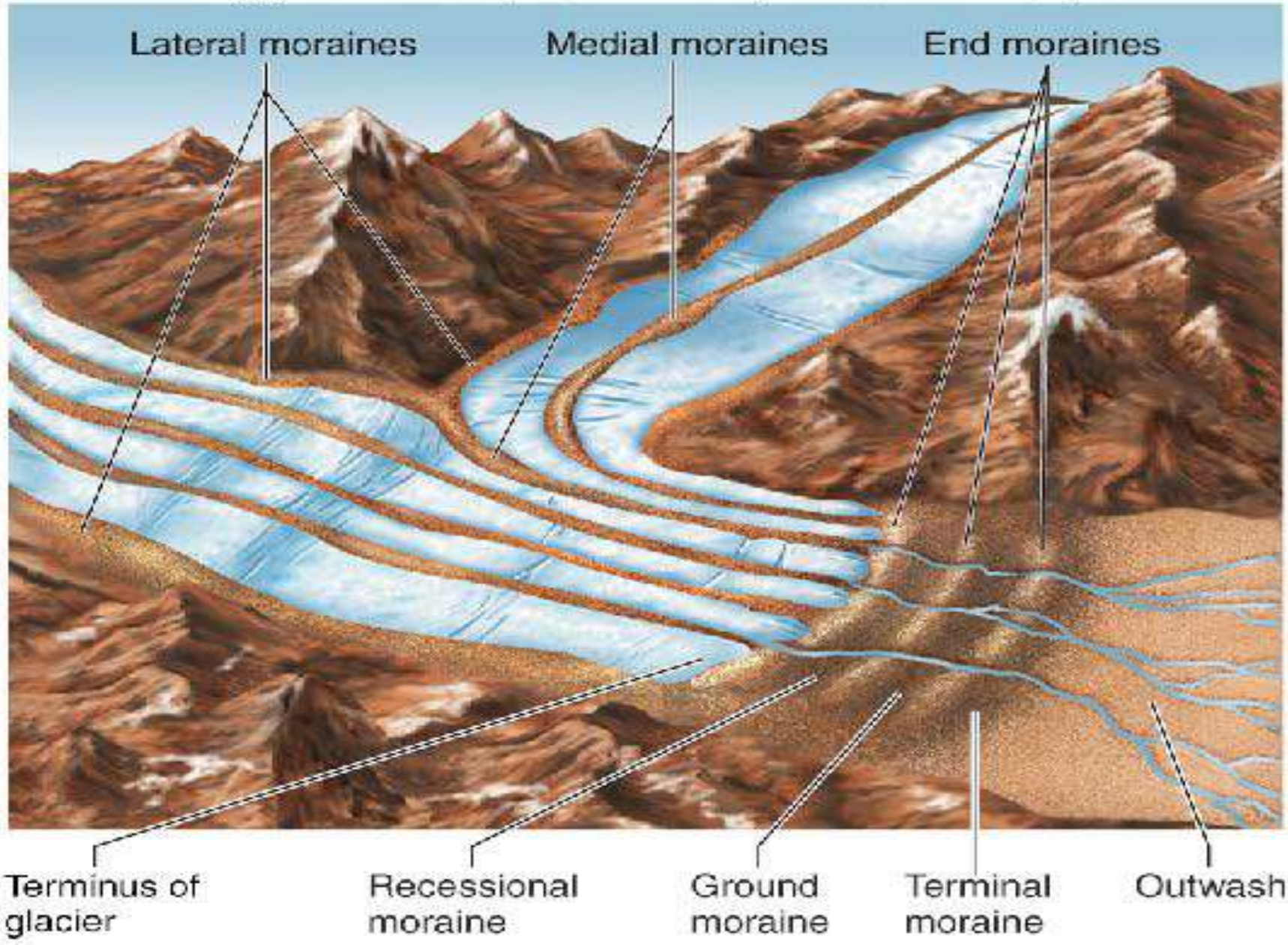
Outwash

- Glacial Lakes and Varves

Alpine Moraines and Till

Photo by C. C. Plummer

Moraine Types



Lateral and Medial Moraines

Photo by C. C. Plummer

Glacial Valley Landforms

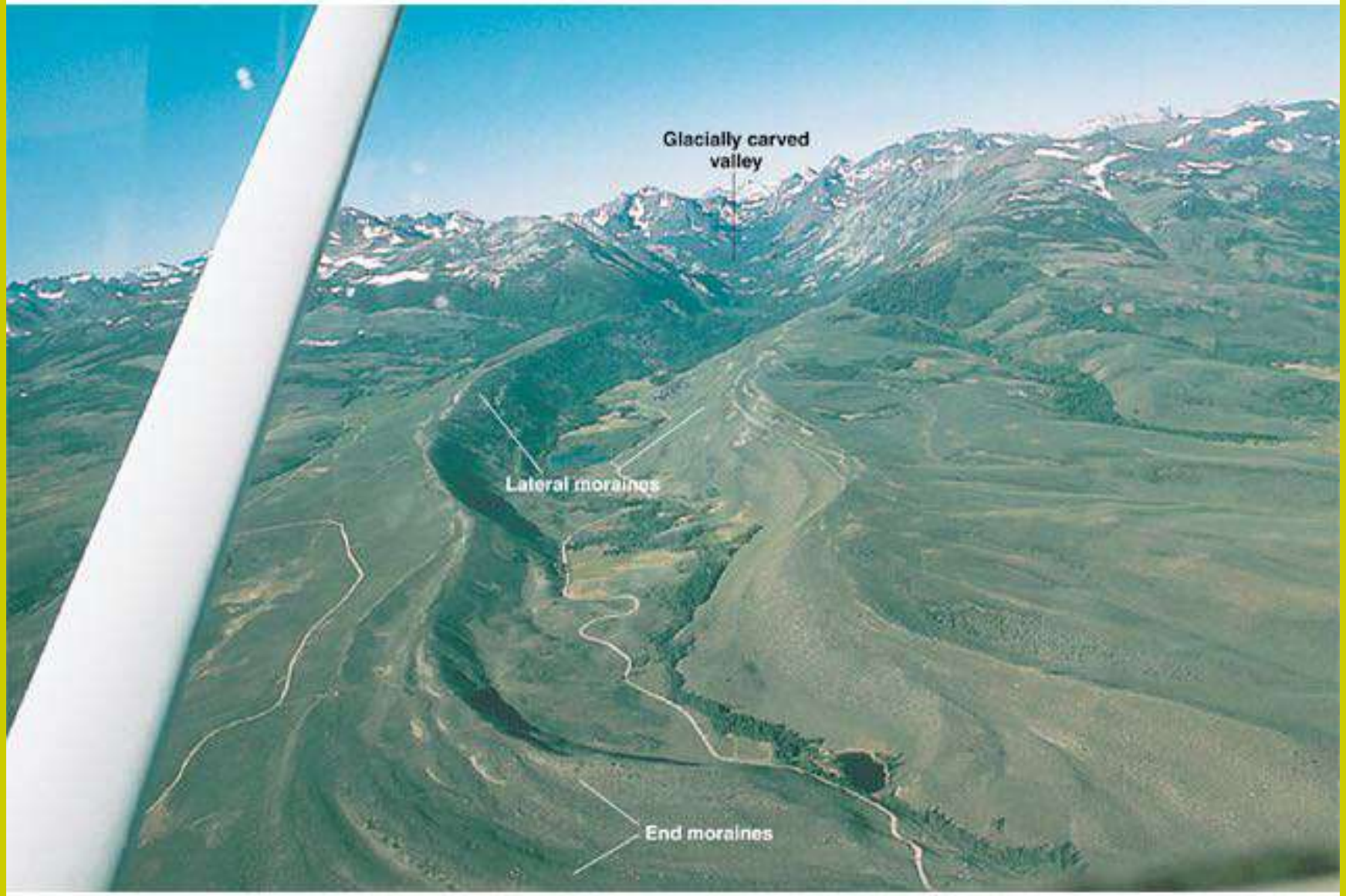
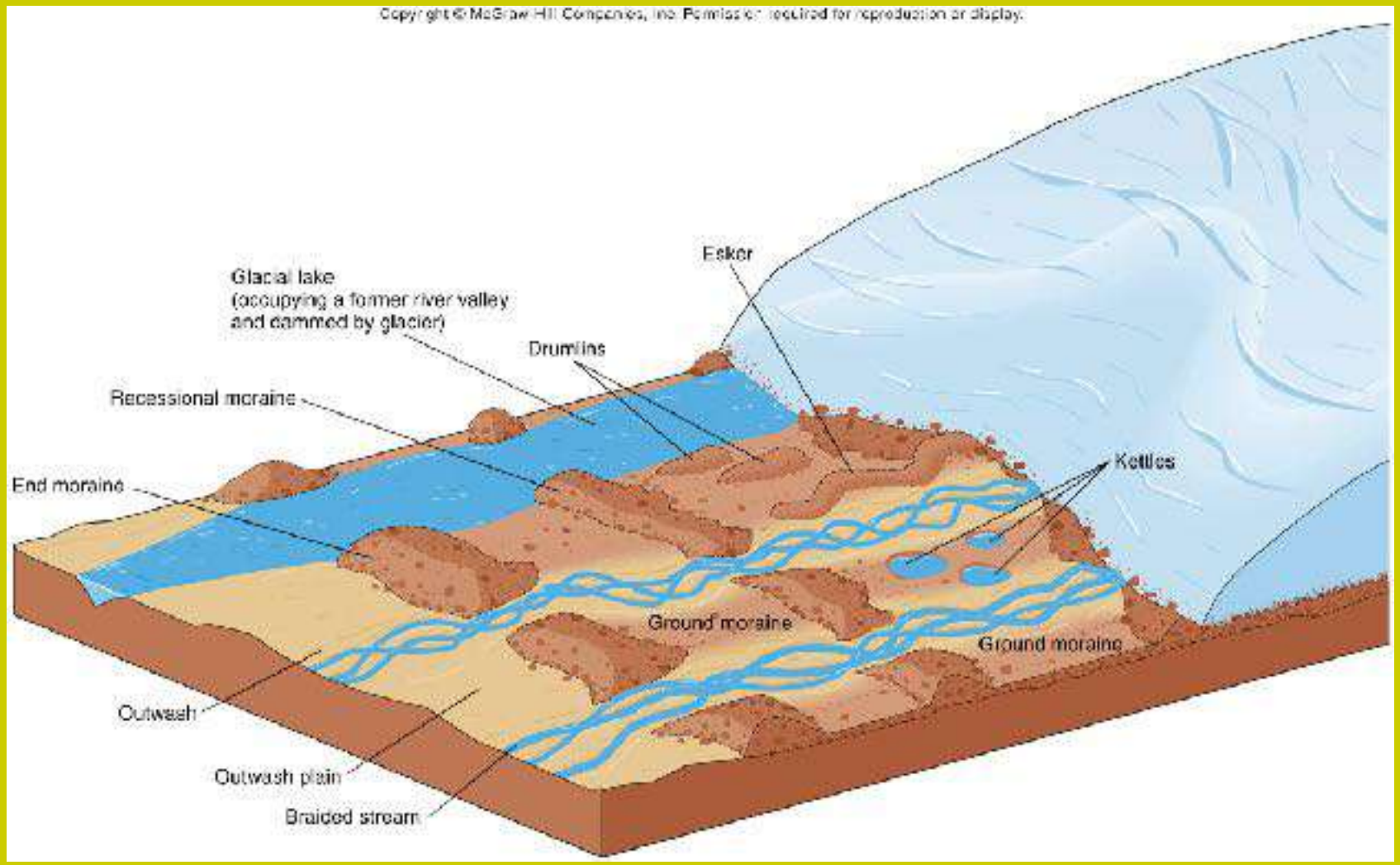


Photo by C. C. Plummer

Glacial Outwash Features



Outwash Features

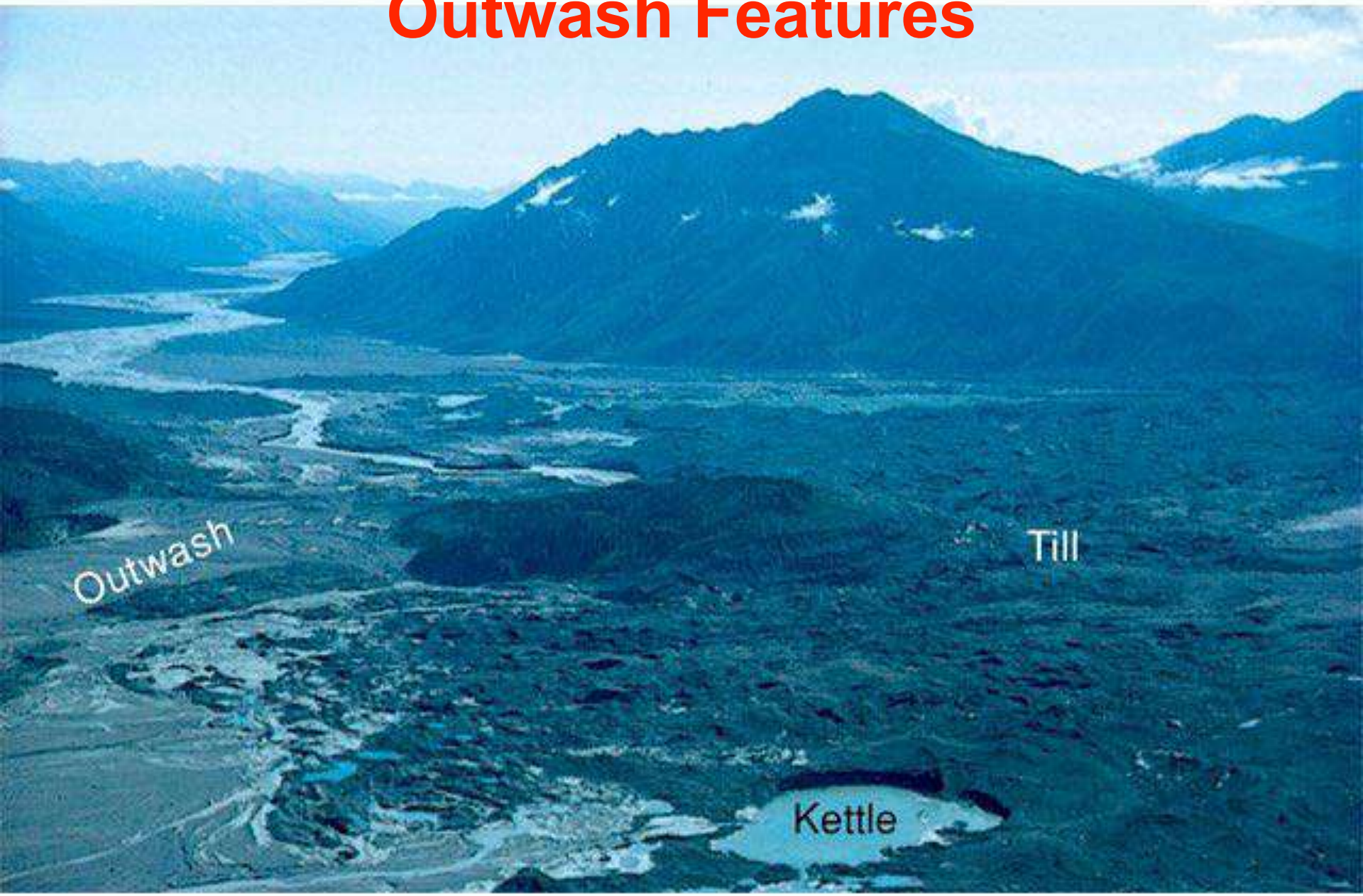


Photo by C. C. Plummer

Varved Sediments

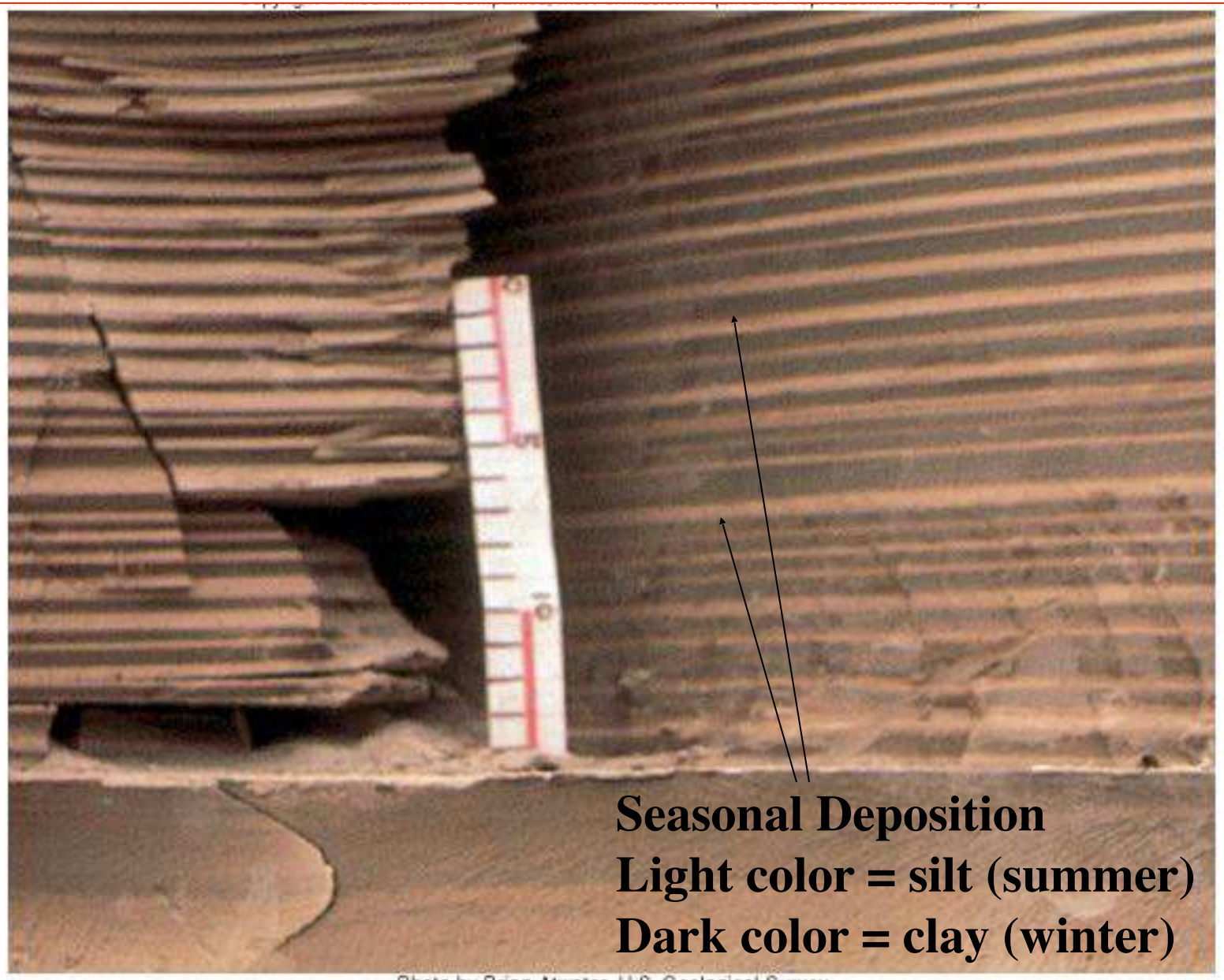


Photo by Brian Atwater, U.S. Geological Survey

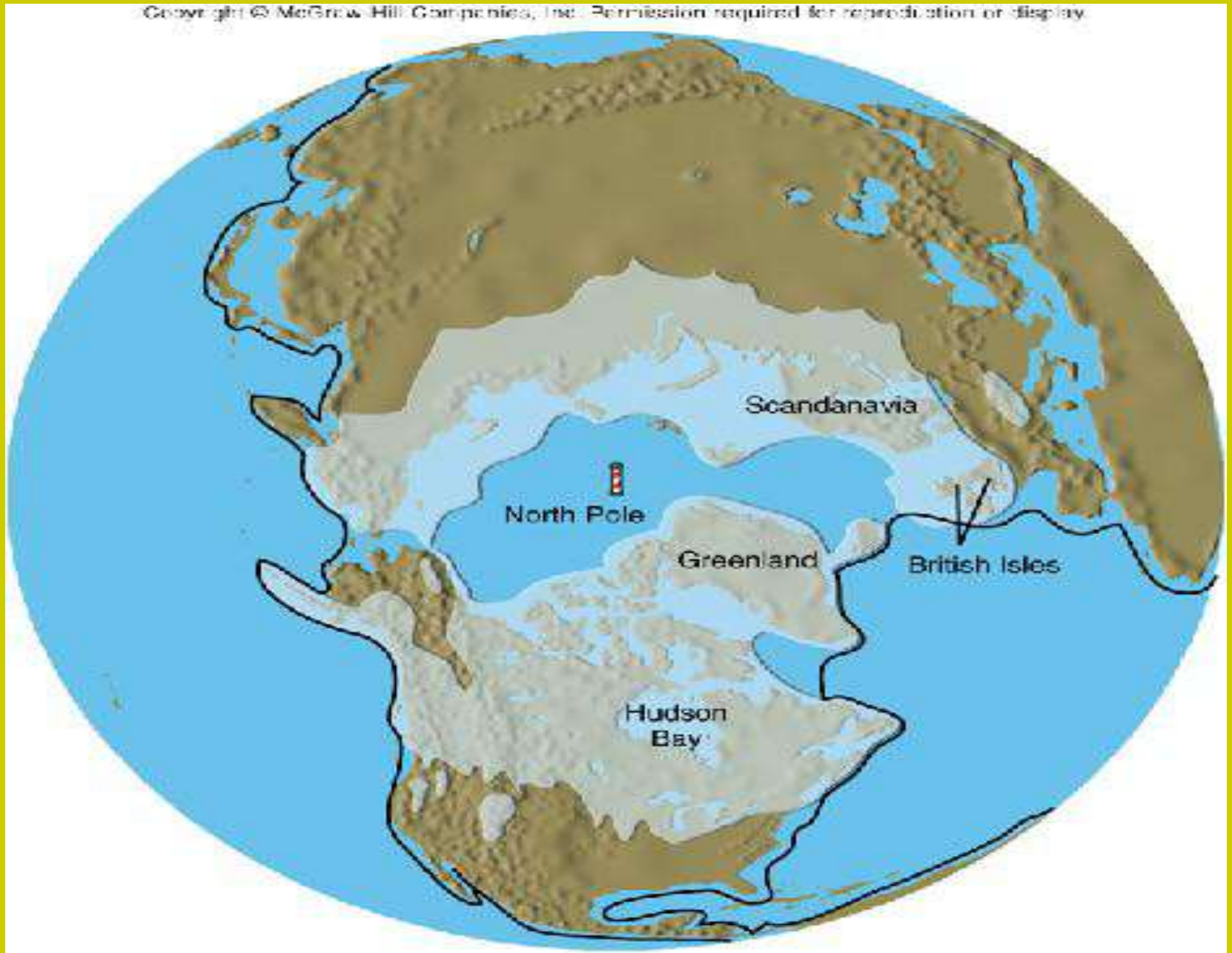
Effects of Past Glaciation - 1

- **The Glacial Ages**
  - Occur repeatedly through geologic time
  - Most recent period initiated ~3 Ma ago and peaked 18 Ka ago
  - Antarctica has been glaciated for >20 Ma
- **Direct Effects of Past Glaciation in North America**
  - Great Lakes, Finger Lakes
  - Terminal Moraines, Drumlins
  - Glacial Erratics - odd rocks from northern craton

Effects of Past Glaciation - 2

- **Indirect Effects of Past Glaciation**
  - Pluvial Lakes
  - Lower Sea Level - Submerged Canyons on the Shelf
  - Coastal Fiords
  - Crustal Rebound
- **Evidence for Older Glaciation**
  - Tillites (lithified glacial till)
  - Evidence for Continental Drift and Plate Tectonics
  - “Snowball Earth” hypothesis - cold, ancient Earth due to weaker sun, lower CO_2

Pleistocene Glaciation



Lake Missoula, MT

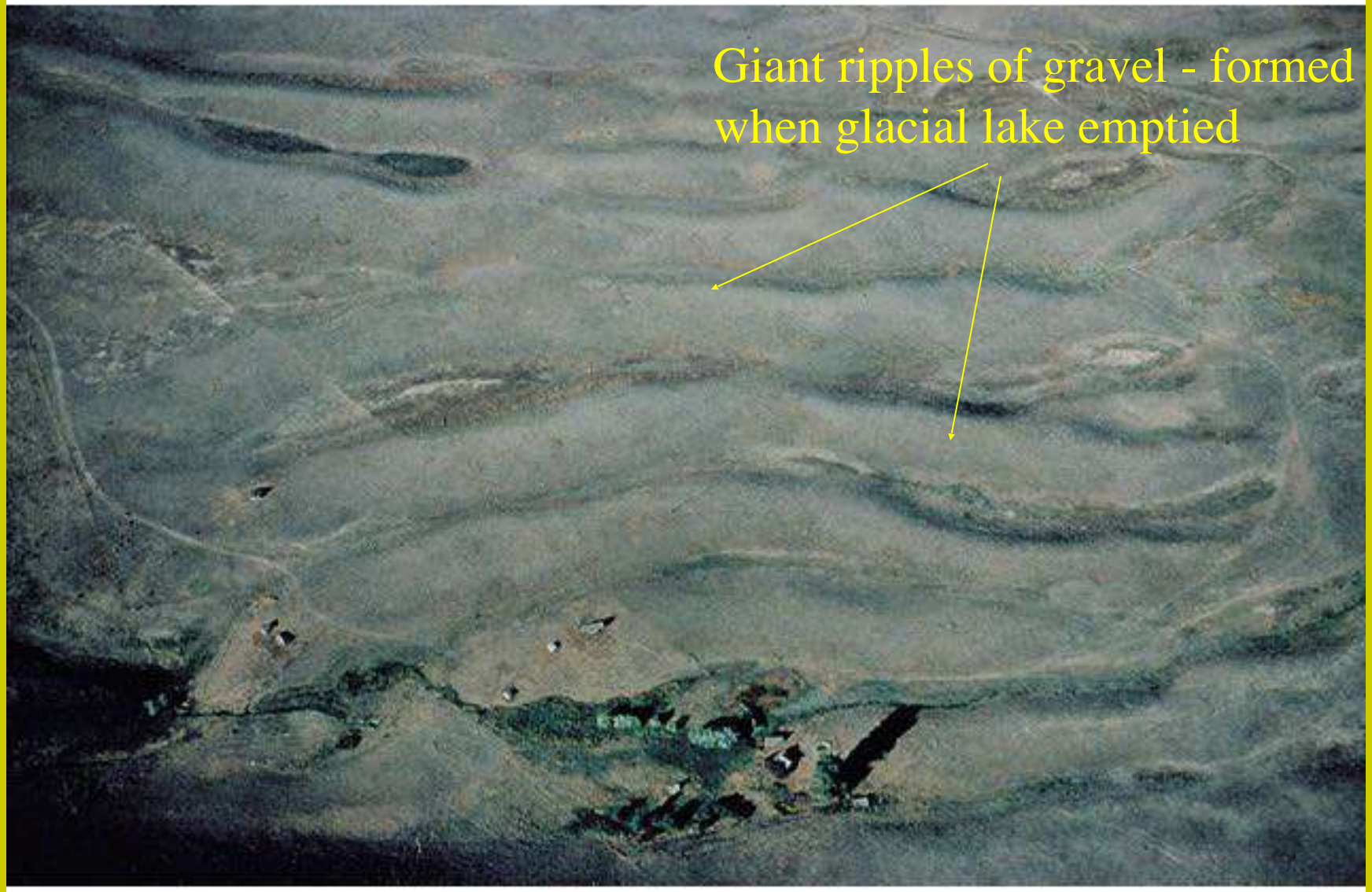


Photo by P. Weiss, U.S. Geological Survey

Mechanisms for Past Glacial Periods

- Pleistocene glacial and interglacial episodes are correlated with variations in the Earth's orbit at 21 ka, 41 ka, and 100 ka. Discovered by M. **Milankovitch** in 1921.
- General absence of glacial periods in the past is **NOT** explained by Milankovitch cycles.
- **Other mechanisms**:
  - Changes in CO_2 content in the atmosphere (large volcanic eruptions can lower global temperature).
  - Movement of the continental landmasses by tectonics.
  - Changes in oceanic circulation as a result of both atmospheric and tectonic processes.

Milankovitch Cycles in Earth's Orbit

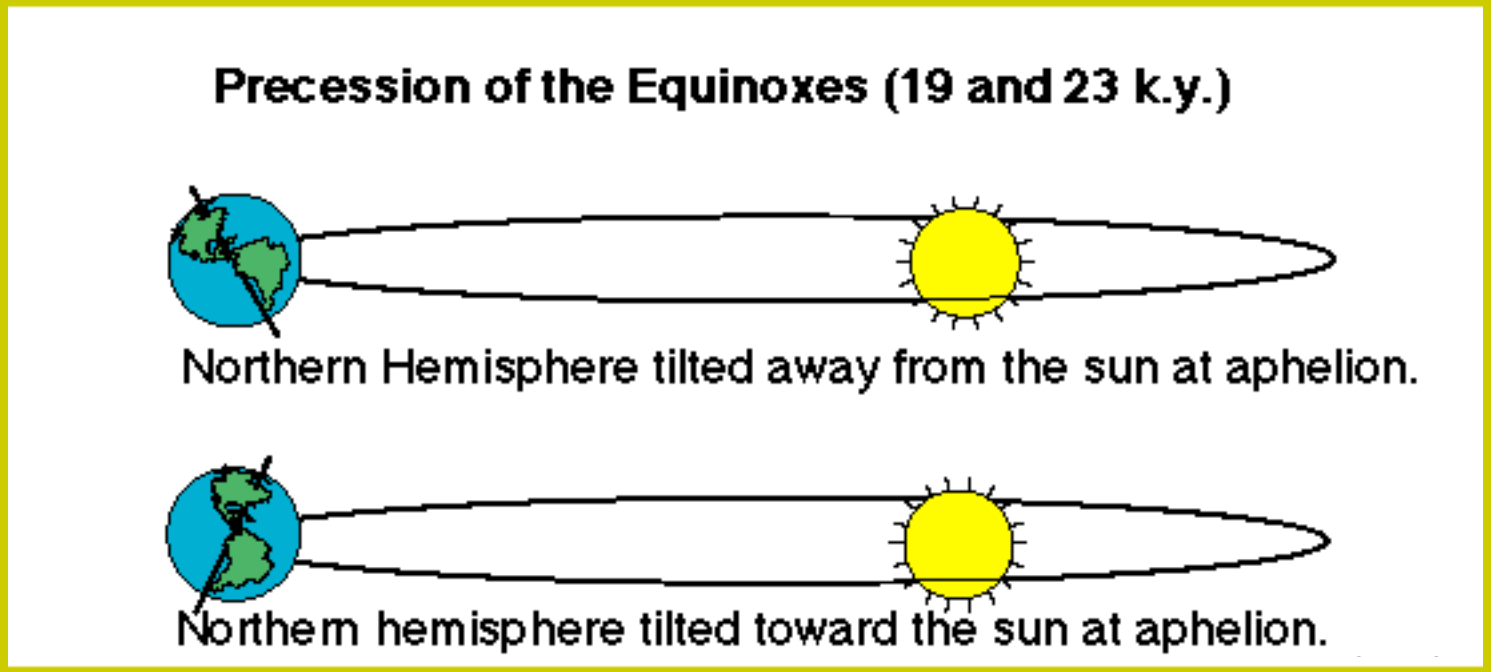


Image Source: Scott Rutherford

THANK YOU