Glacial Processes

Glaciers

Immense and extensive glaciers covered as much as a 1/3 of the Earth's land surface


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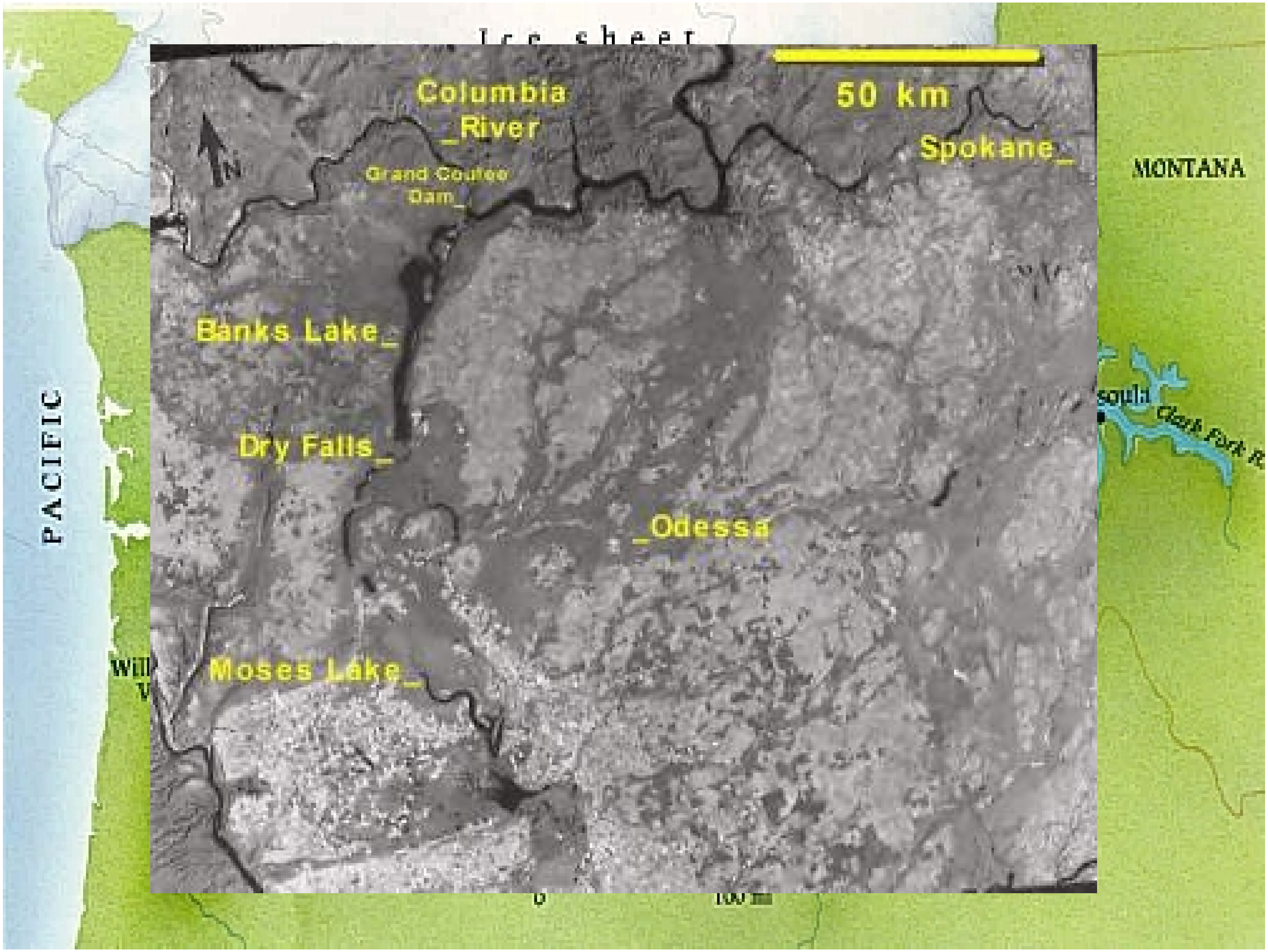
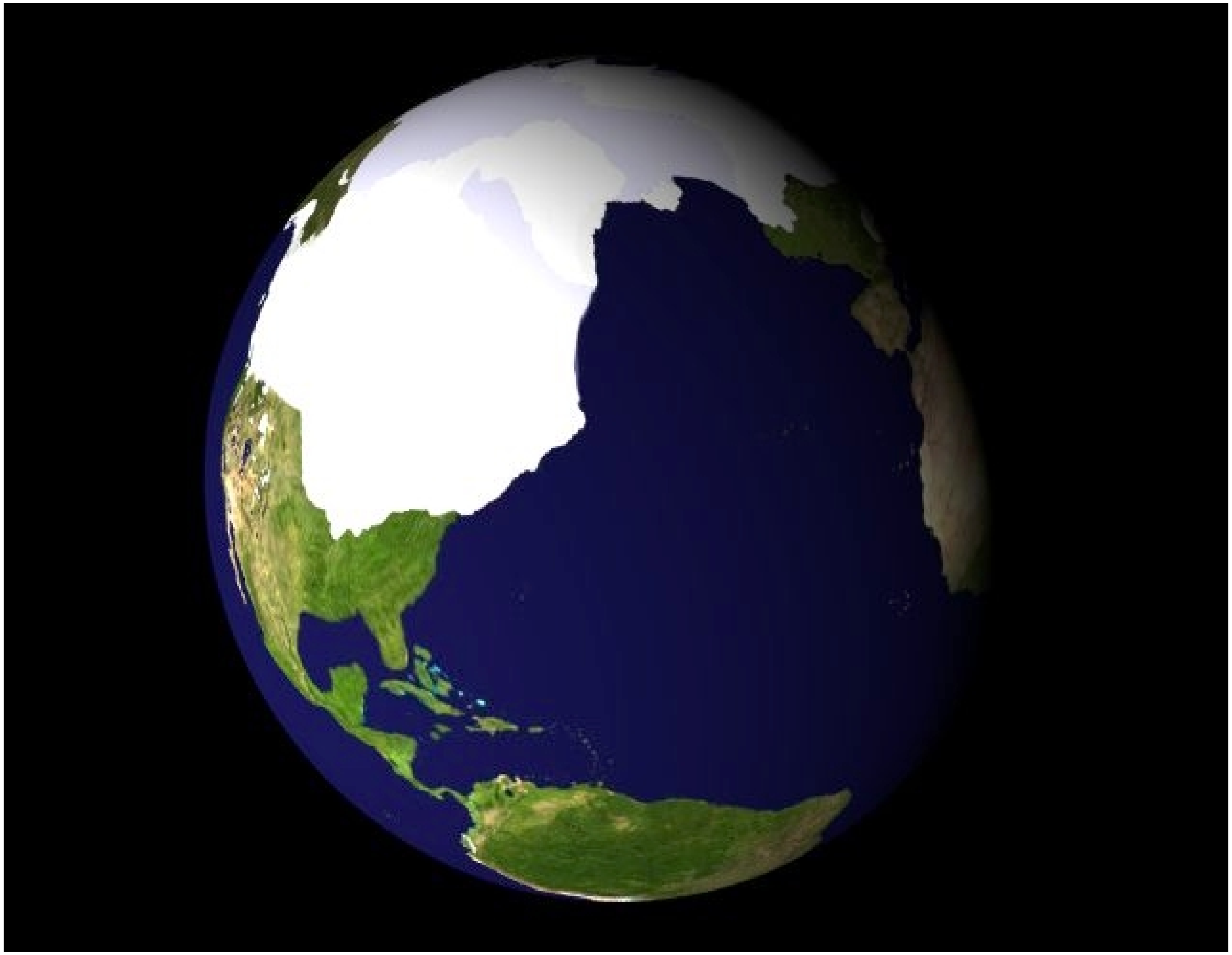


Ice sheet
50 km
Columbia
_River
Grand Coulee
Dam_
Spokane_
MONTANA
Banks Lake_
Dry Falls_
_Odessa
Moses Lake_
PACIFIC
Clark Fork R
0
100 mi

Glacial Processes

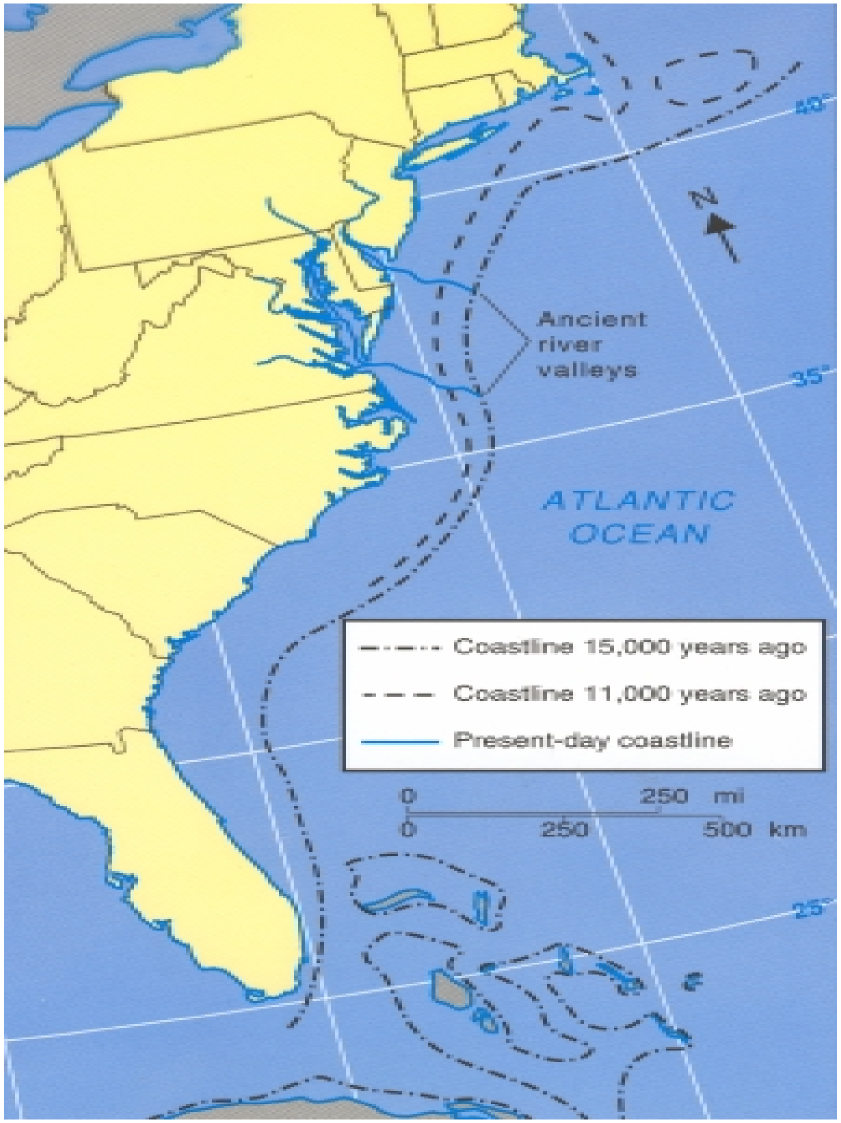
Glaciers



Glacial Processes

Glaciers

World-wide climatic changes during the colder glacial ages distinctly altered landscapes in areas far from the glacial boundaries.



Glacial Processes

Glaciers

This lowering of world-wide sea-levels likely resulted in the original peopling of North America.

Glacial Processes

Glaciers

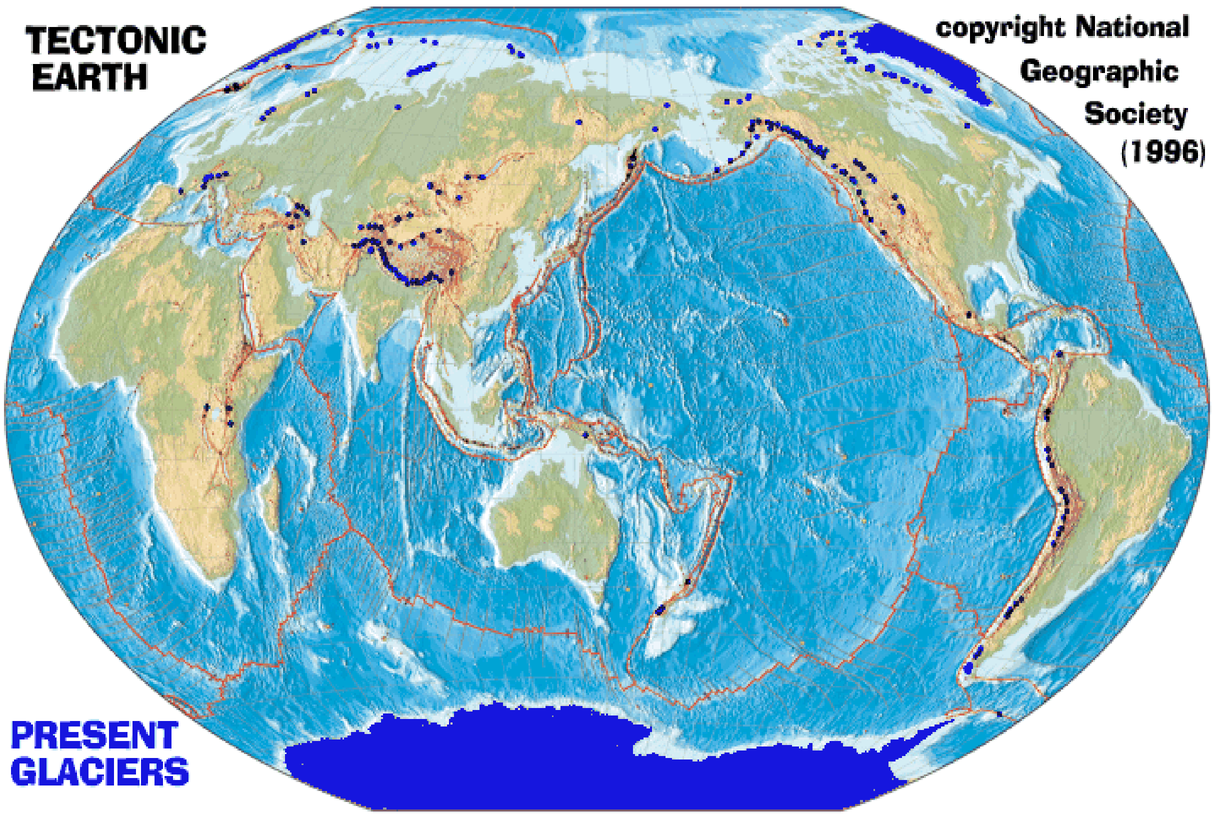
Glacier – a mass of ice that moves over land under its own weight due to gravity.

Simply put: **Snow accumulation > snow melting**

Glacial Processes

Glaciers – global distribution

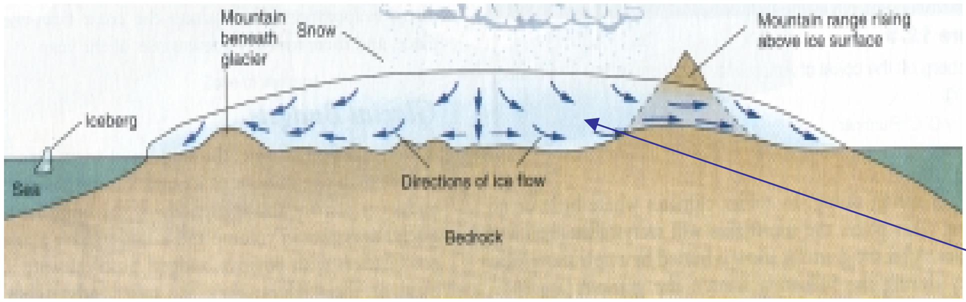
Glaciers are found in both polar regions, where there is little melting during the summer, and in temperate regions that have heavy snowfall during the winter months.



Glacial Processes

Glaciers – types

Two primary types of glaciers, ***valley glaciers*** are confined to valleys and owe their shape and size to the confines of the valleys they occupy.



Glaciers that are not confined to the landscape are called ***ice-sheets***.

Glacial Processes

Glaciers – classification

Morphological classification:

- Cirque glaciers
- Valley glaciers
- Ice sheets
  - Mountain ice sheets
  - Piedmont glaciers

Dynamic classification:

- Active glaciers
- Passive glaciers
- Dead glaciers

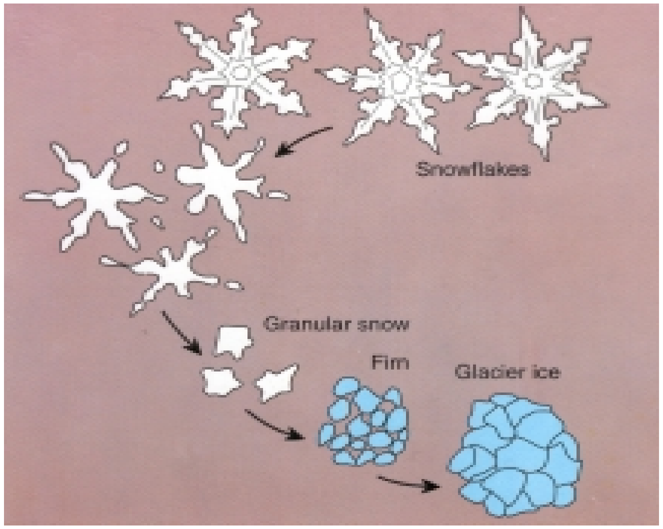
Thermal classification:

- Temperate glaciers
- Polar glaciers
- Sub-polar glaciers
- High-polar glaciers

Glacial Processes

Glaciers – dynamics

Glacial ice develops by the ***compression and compaction of snow and ice***.



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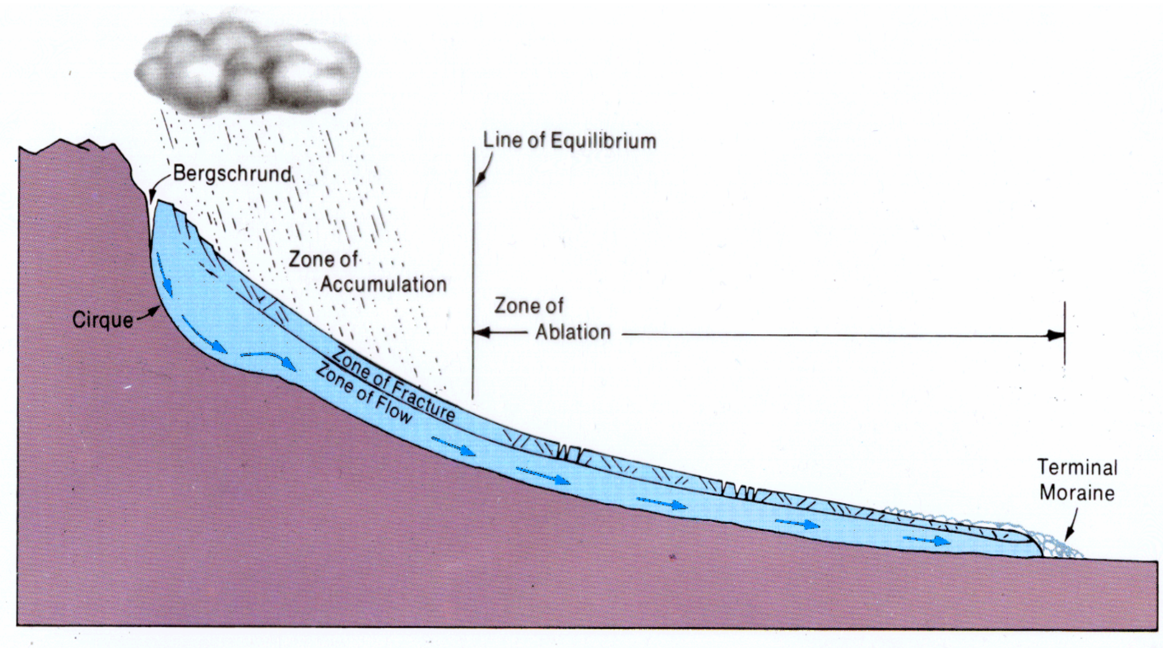
Glaciers – dynamics

A balance exists between the **zone of accumulation** and the **zone of wastage** on a glacier. The line separating these two conditions is called the ***line of equilibrium***.

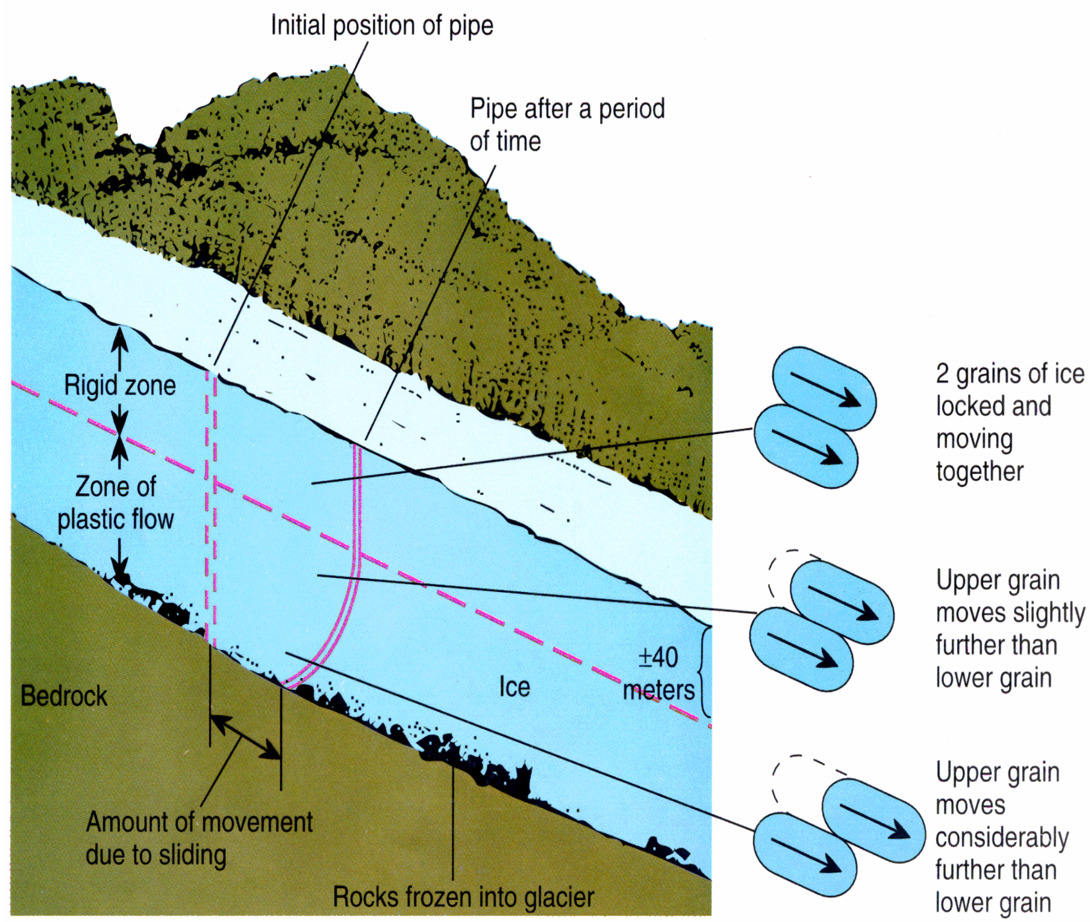


Glacial Processes

Glaciers – dynamics

Glaciers move by shearing within the ice mass.

A tremendous amount of sediment is produced as the ice moves over rock and the debris on the floor of the valley.



Glacial Processes

Glaciers – movement of glaciers

Glaciers move by one of two processes:

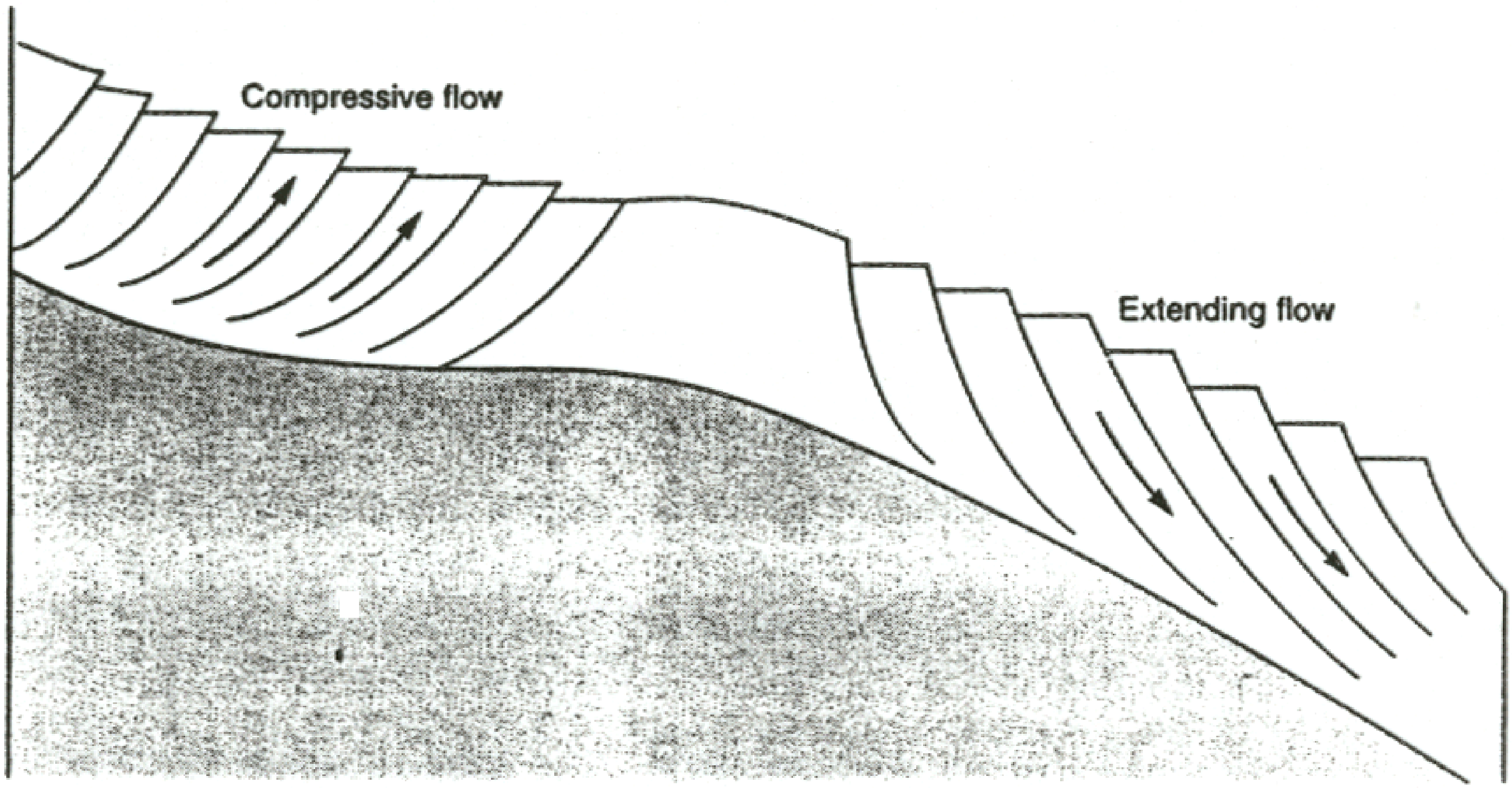
Internal deformation of the ice called ***creep***, and

sliding of the glacier along its base and sides.

A ***surging glacier*** is one in which sudden, brief, large scale ice displacements periodically occur.

Glacial Processes

Glaciers – movement of glaciers - Extending and Compressive Flow



Glacial Processes

Glaciers – ice structures

Glaciers usually develop a variety of structures that ***develop during growth of the glacial mass***, which we can call **primary structures*.***

Glacial Processes

Glaciers – ice structures

Stratification

Primary structures in glaciers appear as discernible layers or bands within the ice. The layering results from processes that ***reflect an annual cycle of snow accumulation and ablation above the firn line***.

Glacial Processes

Glaciers – ice structures

Foliation

Is produced by shearing during ice motion. It is sometimes difficult to distinguish from primary stratification because both types display similar grain size or textures.

Glacial Processes

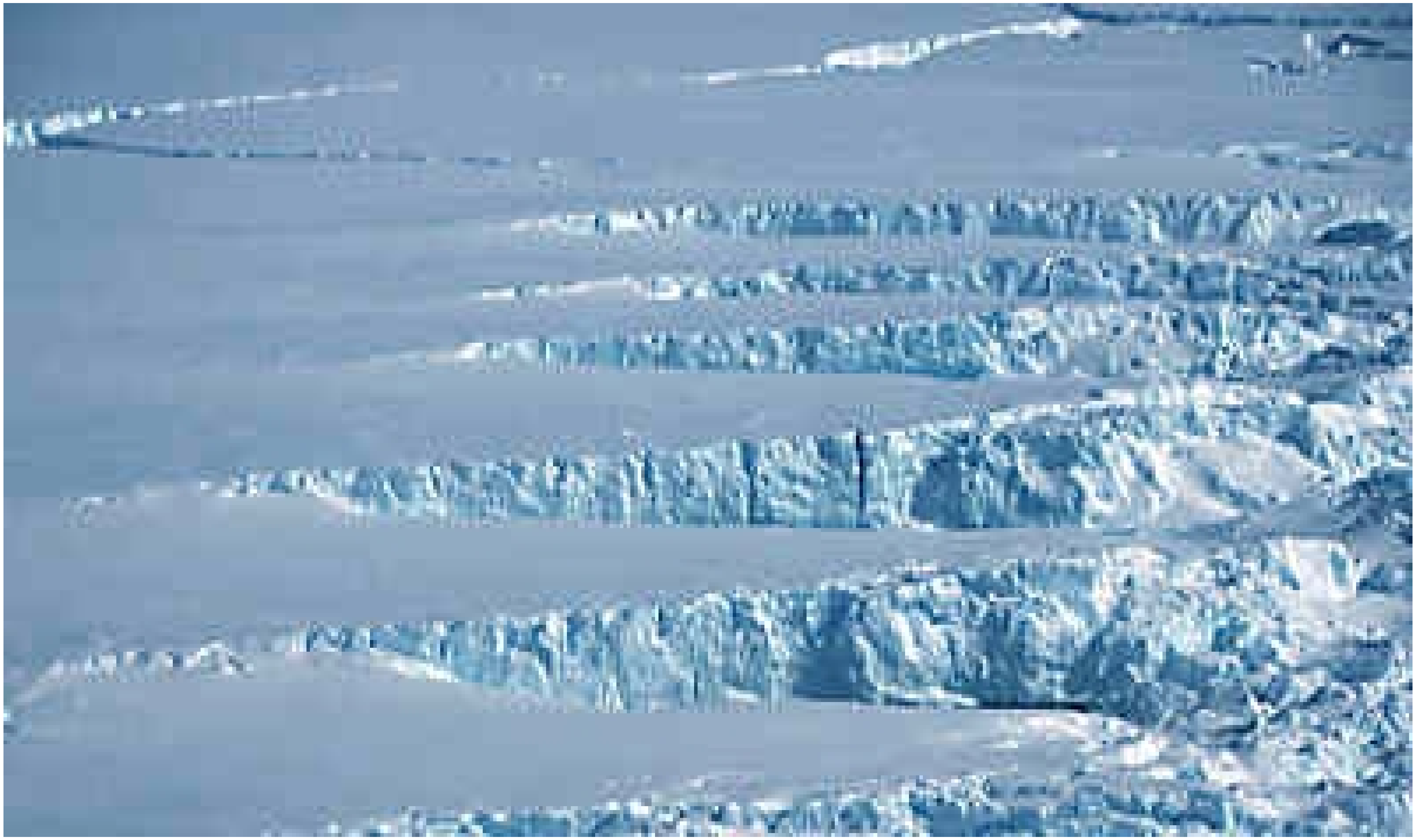
Glaciers – ice structures

Crevasses

Glacial Processes

Glaciers – ice structures

Crevasses



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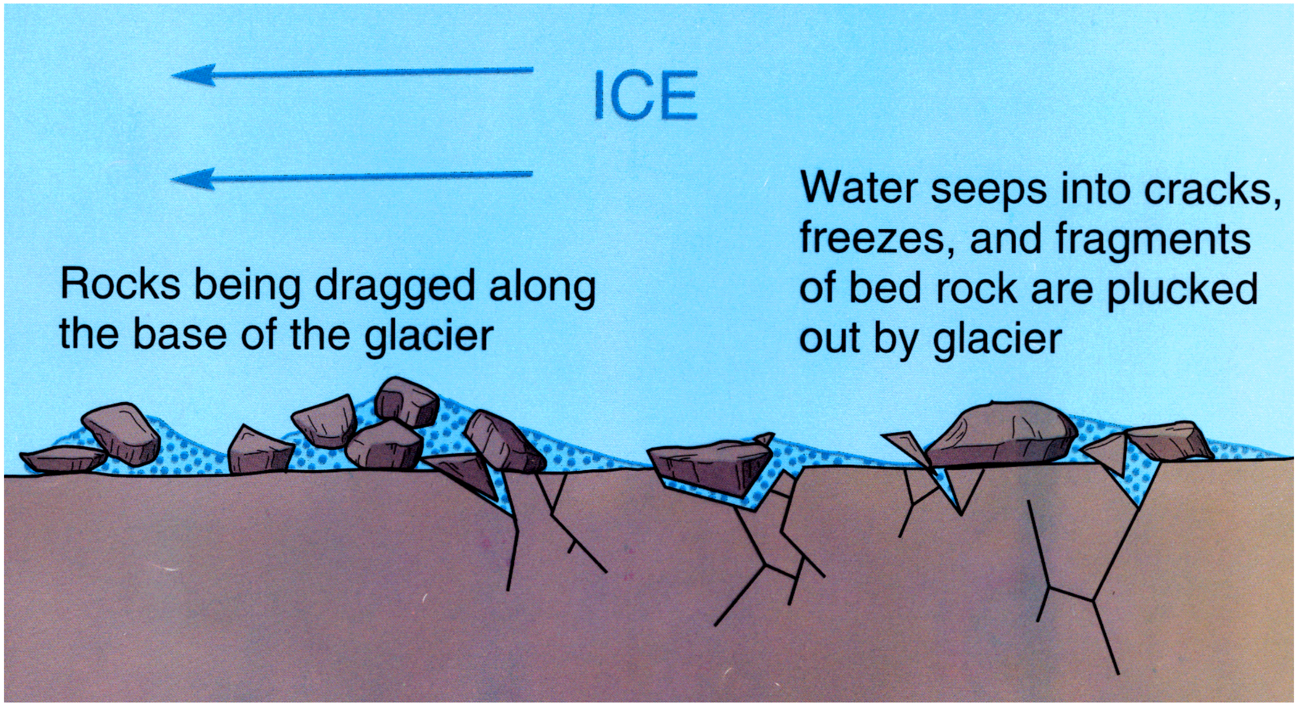
Glaciers – erosional processes

Glacial erosion is accomplished primarily by two processes, a scraping action called ***abrasion*** and a dislodgment or lifting action called ***quarrying*** or ***plucking***.



Glacial Processes

Glaciers – erosional processes

A ***cirque*** by any name is still a deep erosional recess with steep and shattered walls that is usually located at the head of a mountain valley.

Glacial Processes

Glaciers – erosional processes

The bowl shaped basin often contain lakes, called ***tarns***.

Glacial Processes

Glaciers – erosional processes

U-shaped glacial valley

Glacial Processes

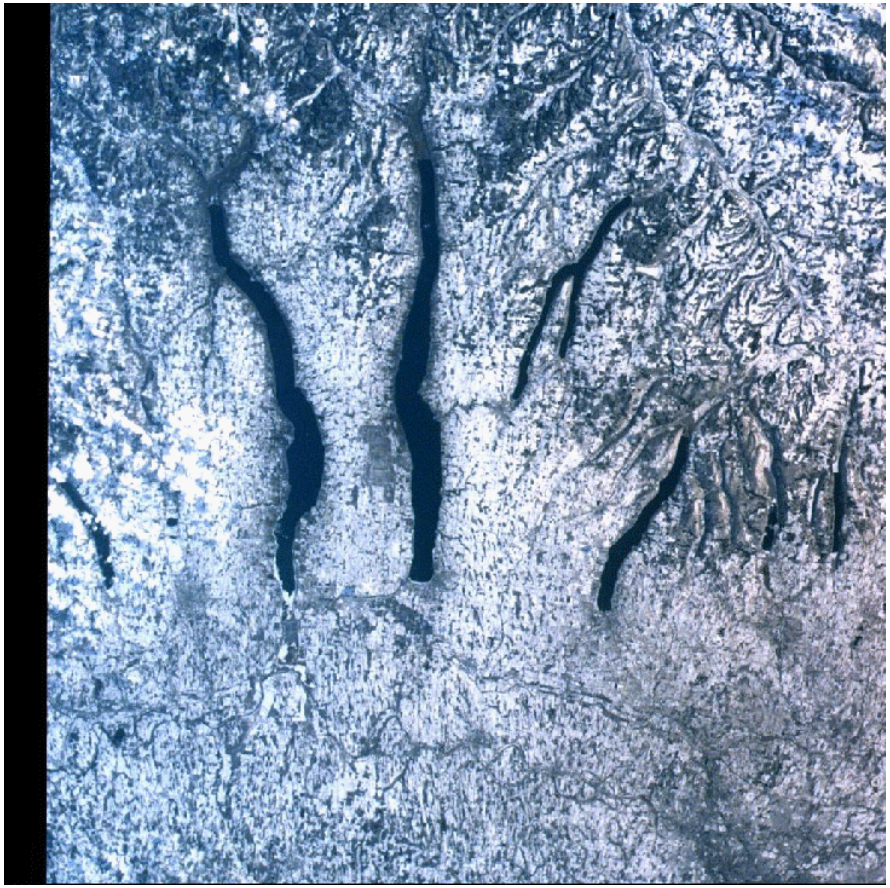
Glaciers – erosional processes

U-shaped glacial valley

Glacial Processes

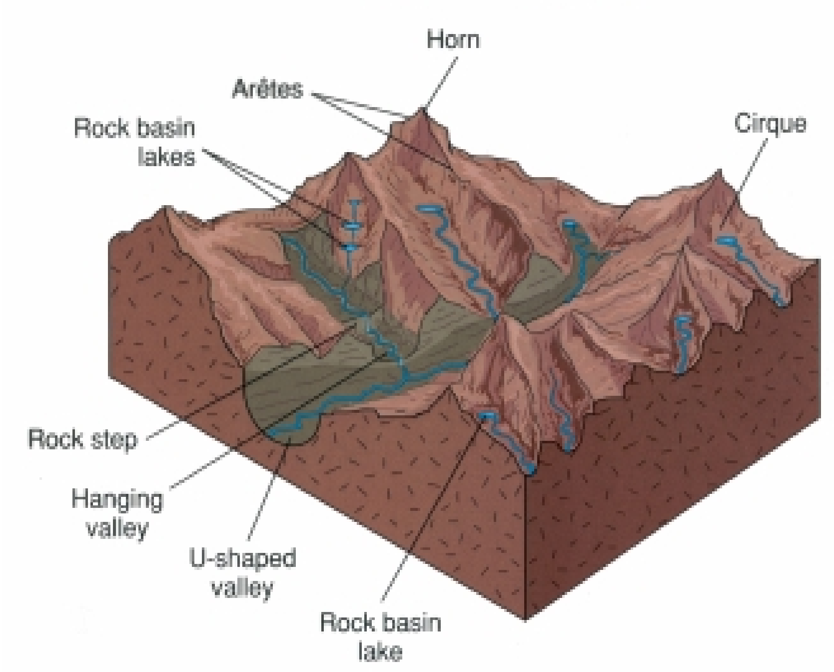
Glaciers – erosional processes

Glaciated valleys and troughs that contain lakes are sometimes called ***paternoster or finger lakes***



Glacial Processes

Glaciers – erosional landscapes



Valley glacier landscape development

Cirques

Horns

Arêtes

Hanging valleys

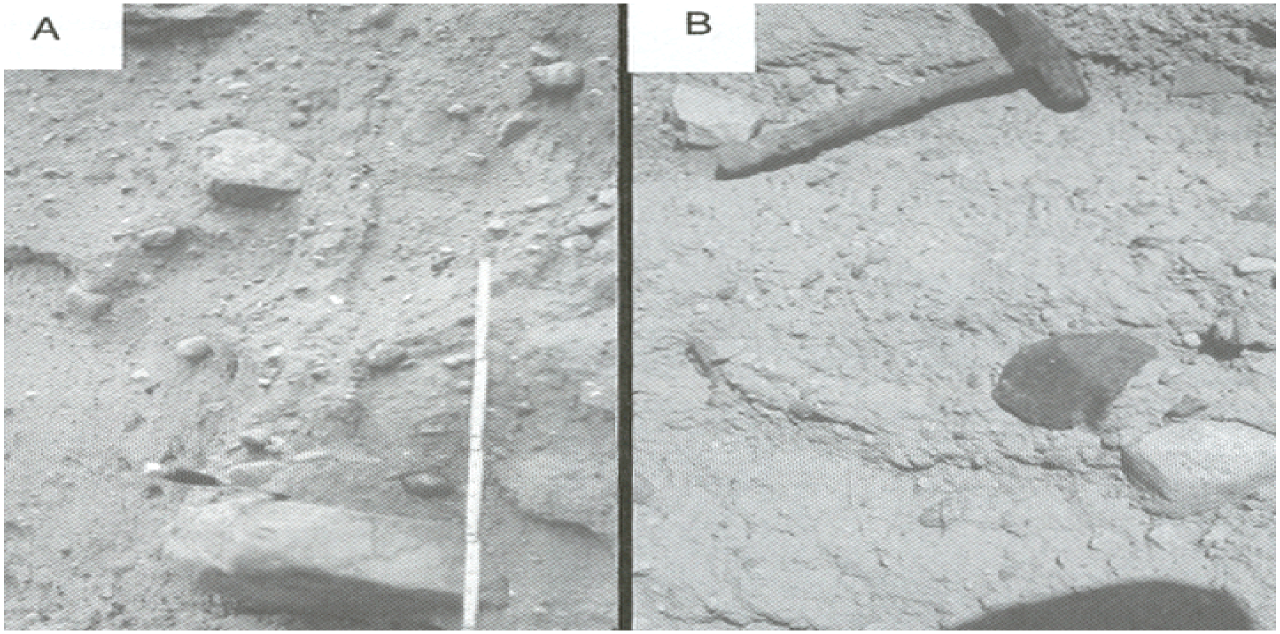
U-shaped valleys

Glacial Processes

Glaciers – depositional processes and landscapes

Nonstratified drift

Sediments originating directly from glacial ice characteristically has no discernible stratification and is generally called ***till*** .



Glacial Processes

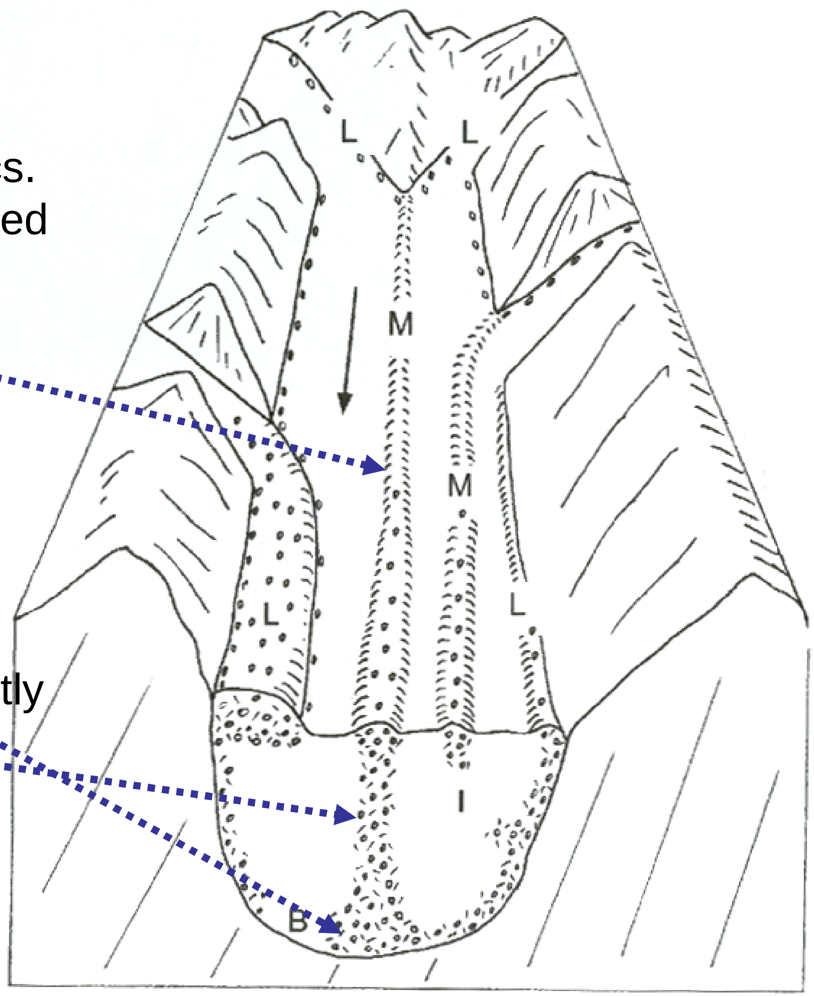
Glaciers – depositional processes and landscapes

Nonstratified drift

Each transport sub-environment produces till with different characteristics. ***Supra-glacial*** till has a texture dominated by coarse, angular clasts

Sub-glacial till is more compact and contains a higher percentage of fine-grained sediments.

En-glacial load can be deposited directly on the bedrock floor as sub-glacial matter, and a considerable thickness of the glacier will remain above it at the moment of deposition.

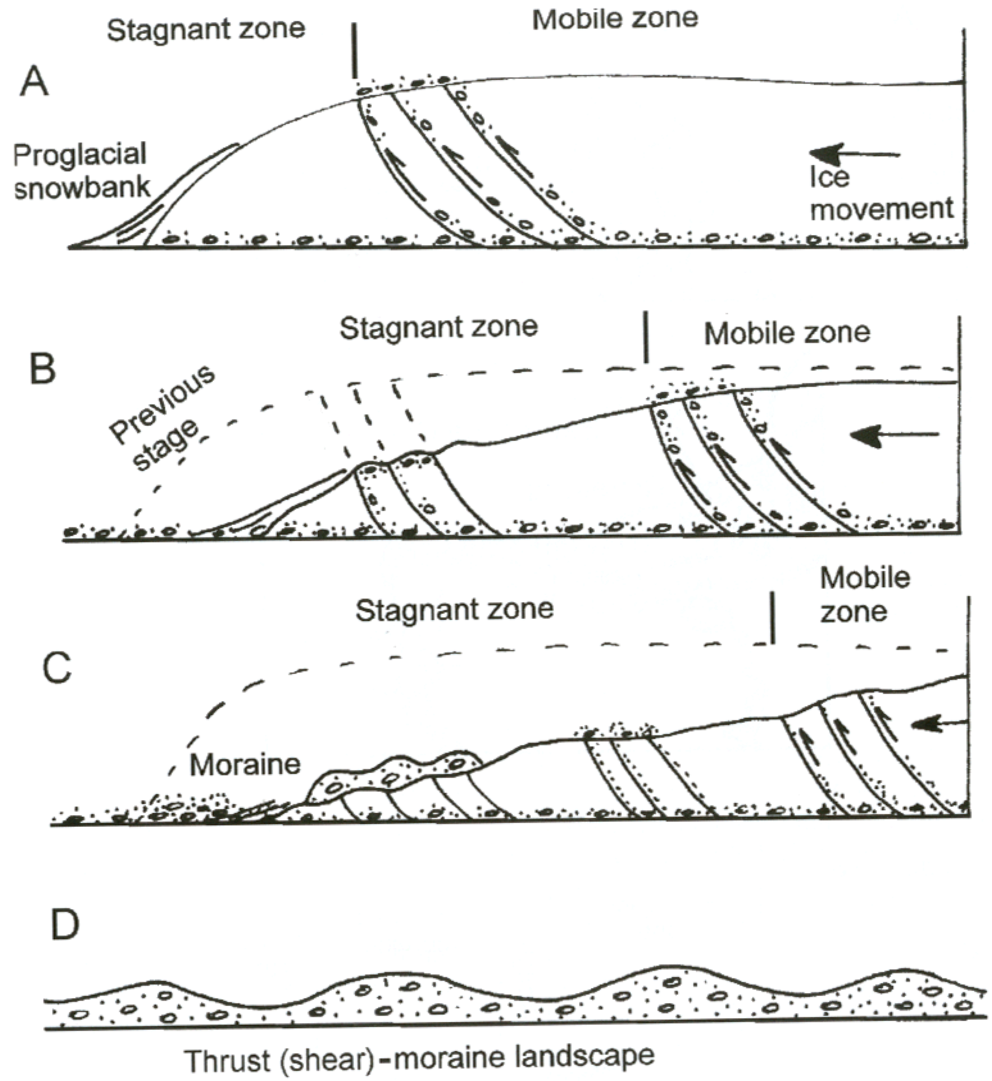


Glacial Processes

Glaciers – depositional processes and landscapes

Stratified Drift

Moraines



Glacial Processes

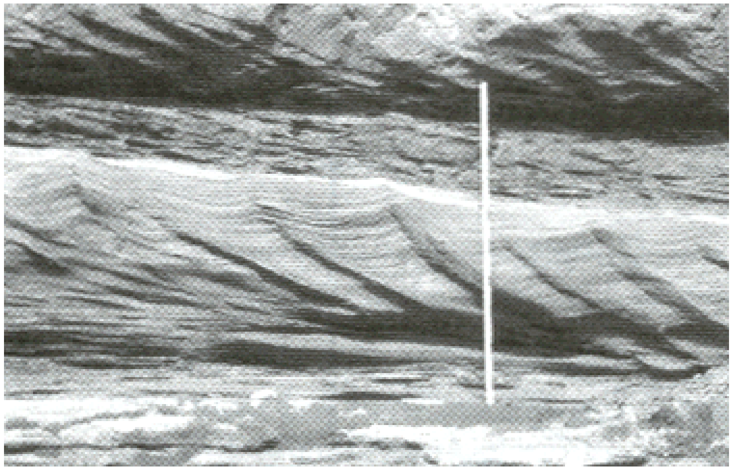
Glaciers – depositional processes and landscapes

Stratified Drift

Fluvioglacial because running water is involved in its origin even though the water may not always be confined in discrete channels.

Fluvioglacial deposits are also distinguished from till in that they are usually sorted and the clasts contained in the mass are more rounded. Sorting is also partly a function of:

- the energy possessed by the meltwater,
- the distance of transport, and
- the continuity of the sorting process.

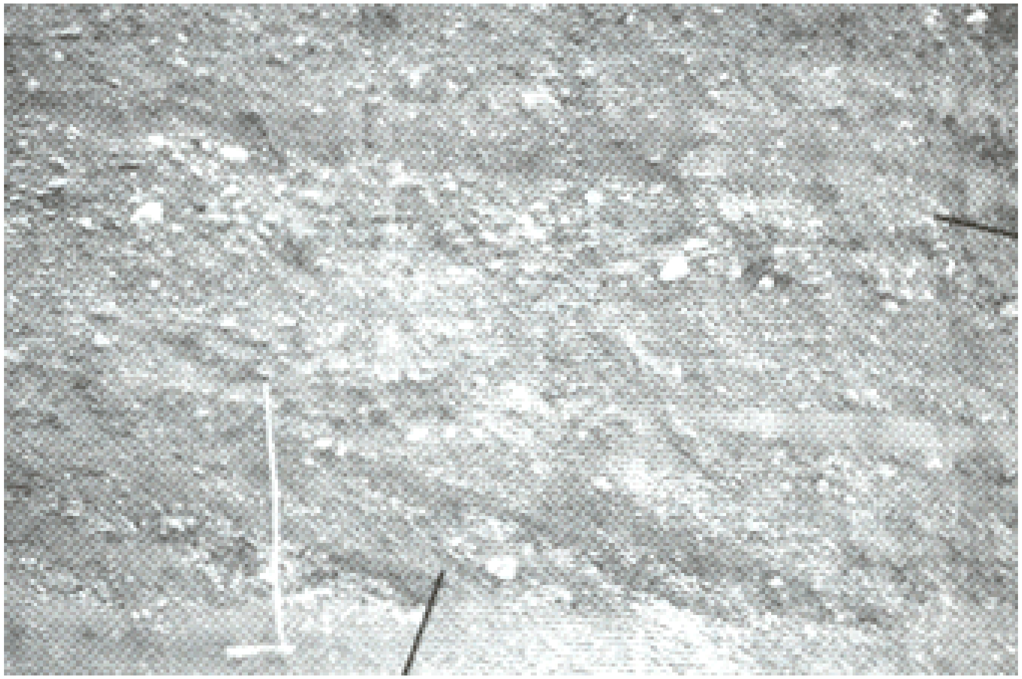


Glacial Processes

Glaciers – depositional processes and landscapes

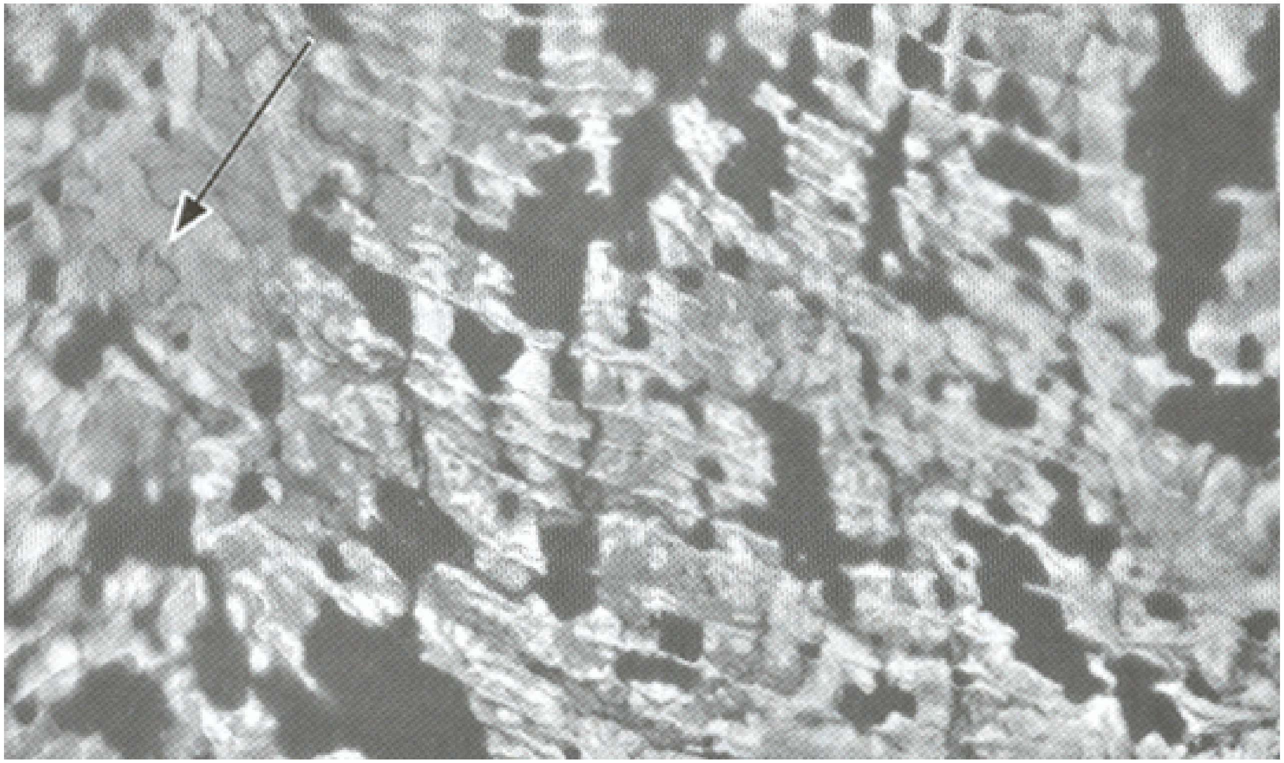
Stratified Drift

Sediments deposited beyond the terminal margin of the ice are formed in the proglacial environment and are often referred to as ***outwash***.



Glacial Processes

Glaciers – depositional processes and landscapes
Stratified Drift
end (recessional) moraines and
terminal moraine.



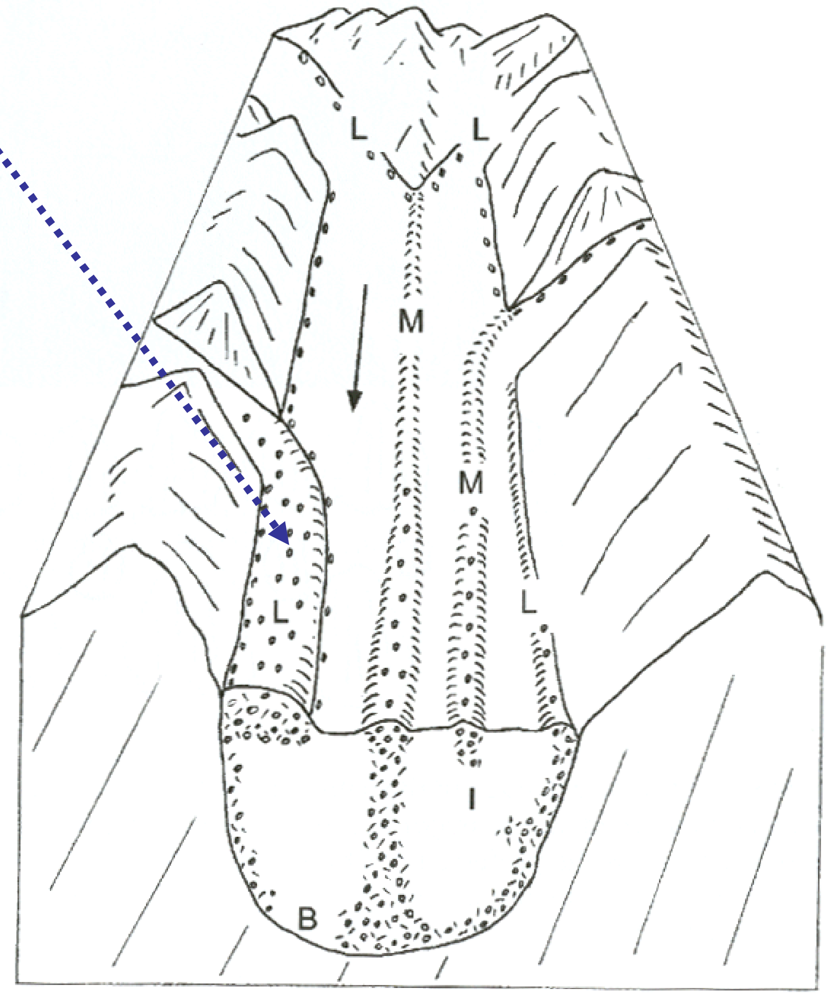
Central
Canada

Glacial Processes

Glaciers – depositional processes and landscapes

Stratified Drift

In valley glacier systems, ***lateral moraines*** occur on both sides of the valley.



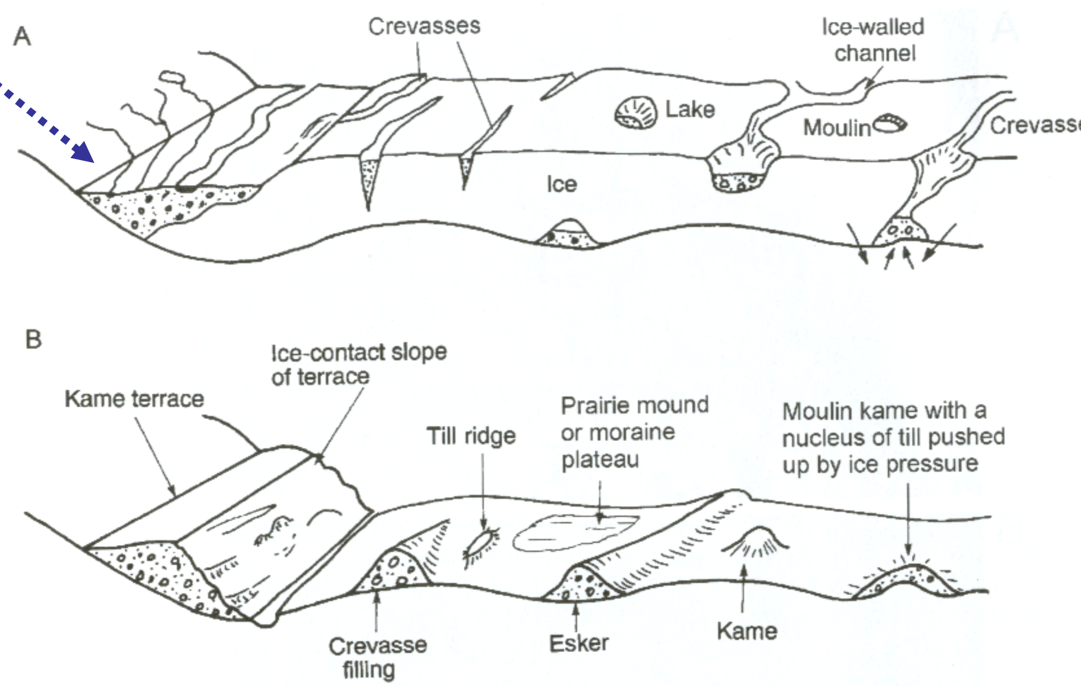
Glacial Processes

Glaciers – depositional processes and landscapes

Glacial Processes

Glaciers – depositional processes and landscapes

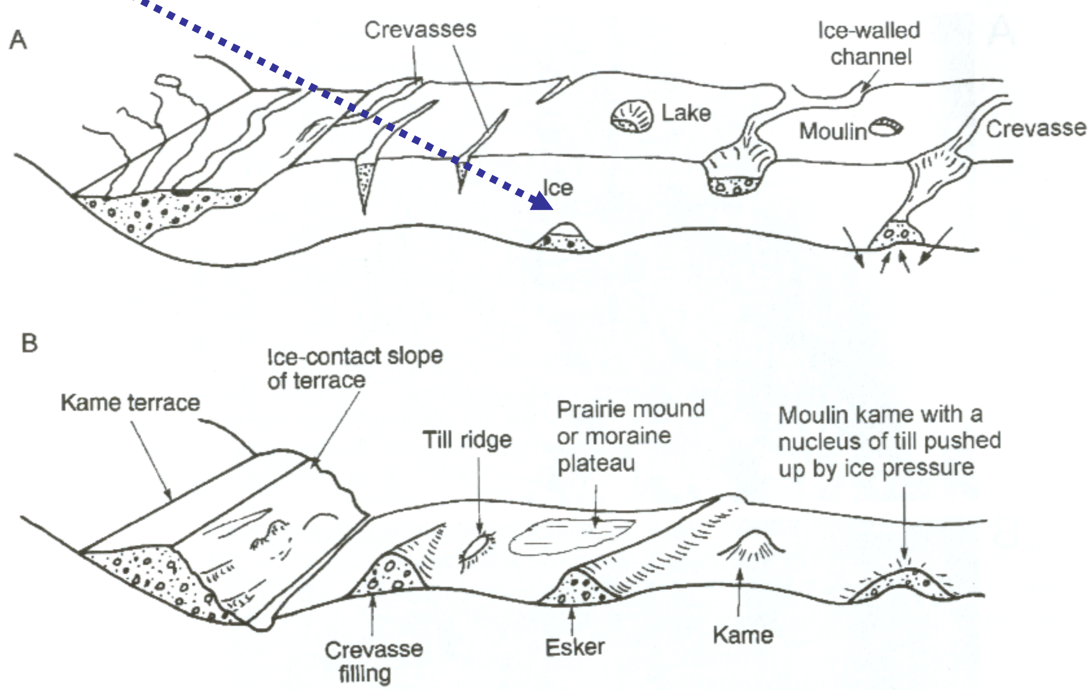
Kames are only one of many forms with essentially the same origin. ***Kame terraces*** originate from drift deposited in narrow lakes or stream channels between the valley side and the lateral edge of the stagnating ice. When the supportive ice disappears, the inner edge of the deposit collapses into the terrace scarp.



Glacial Processes

Glaciers – depositional processes and landscapes

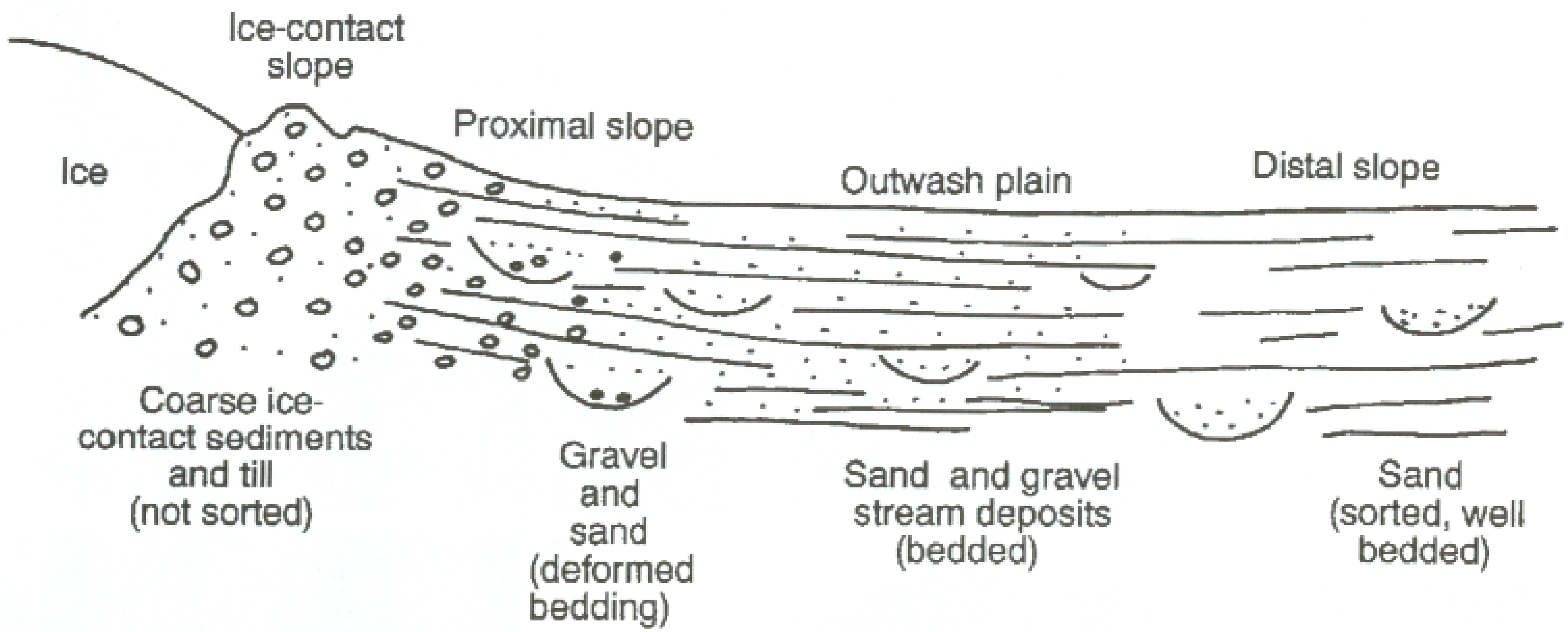
Eskers describe a wide variety of ridged ice-contact features.



Glacial Processes

Glaciers – depositional processes and landscapes

outwash plain

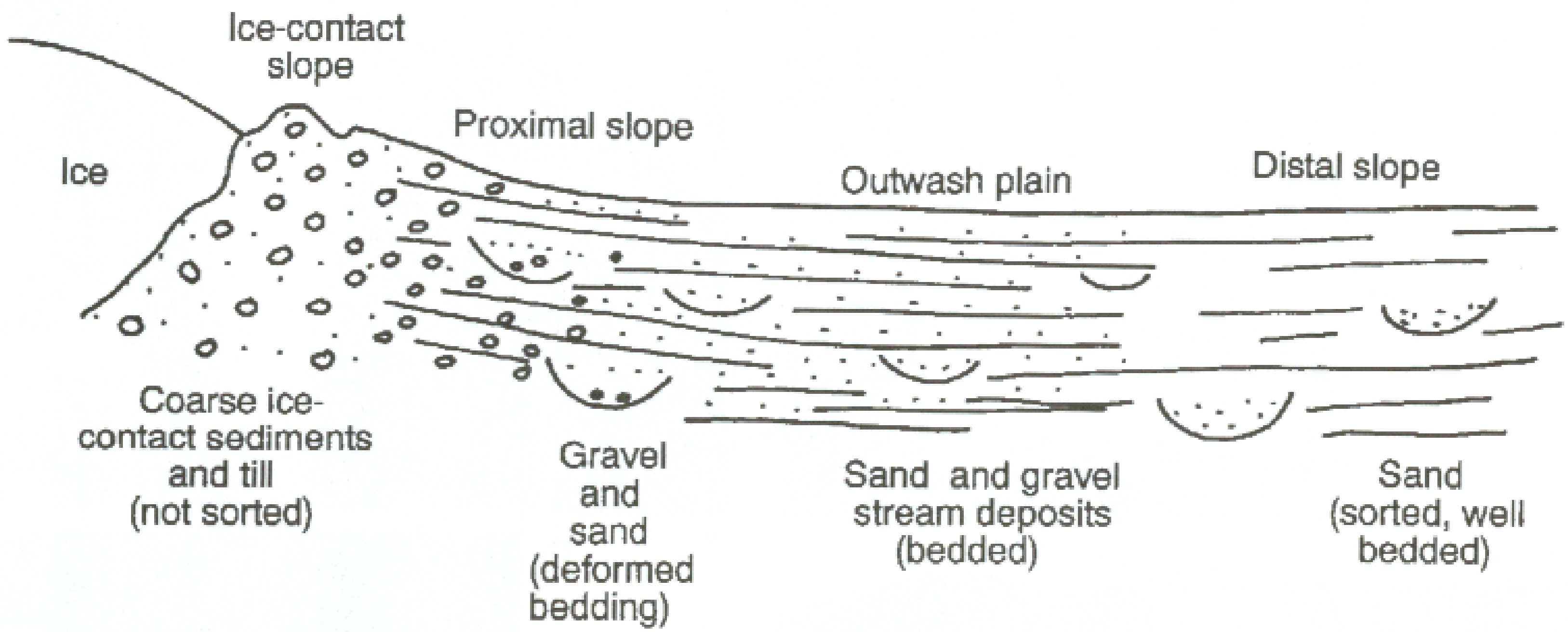


Glacial Processes

Glaciers – depositional processes and landscapes

Three distinct zones recognized on the outwash plain.

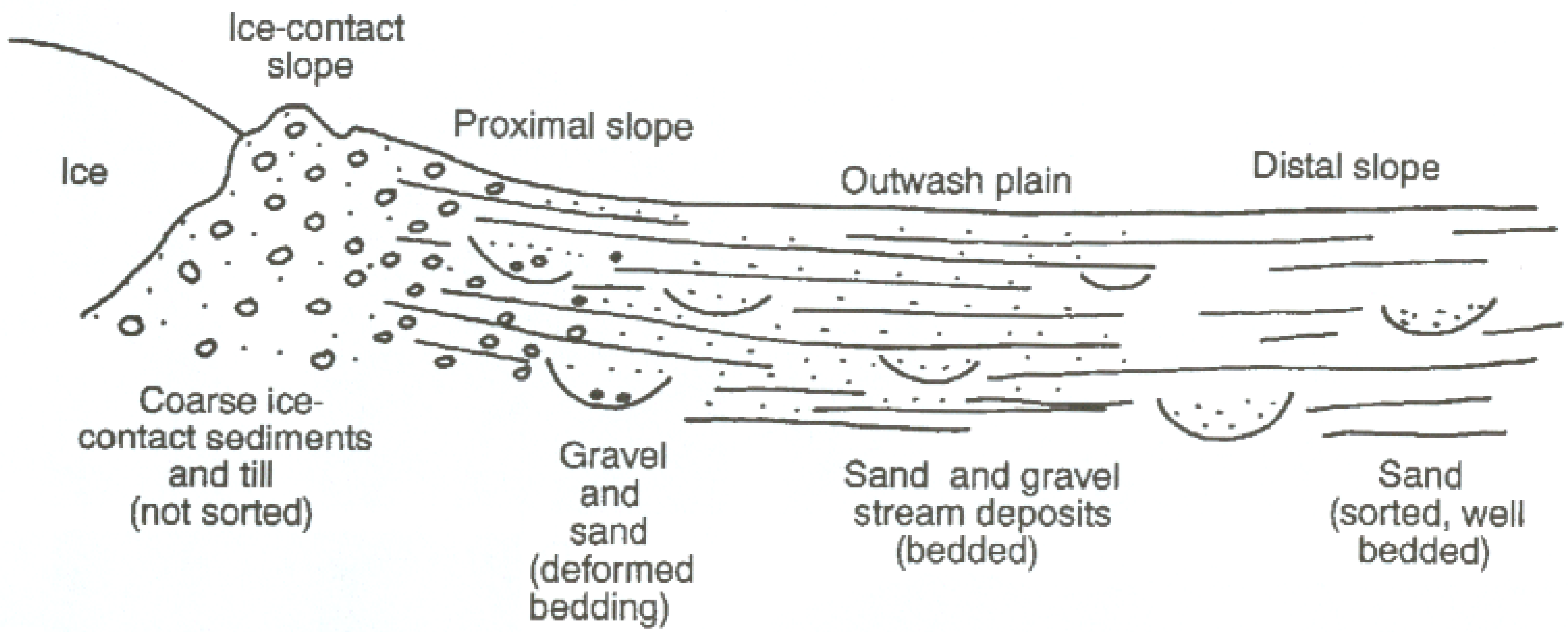
The ***proximal zone,*** closest to the ice, is usually transversed by only a few main rivers that flow in well-defined entrenched channels.



Glacial Processes

Glaciers – depositional processes and landscapes

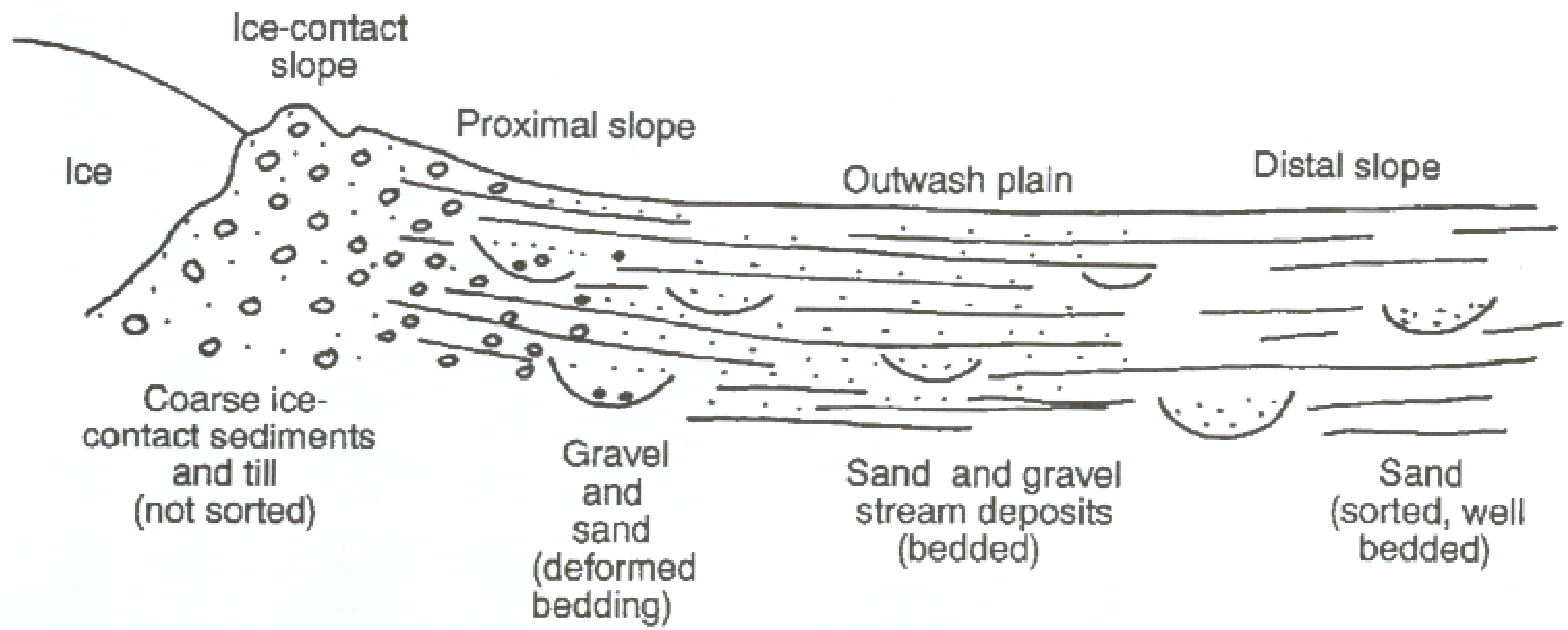
In the ***intermediate zone***, the channels become wide and shallow and distinctly braided, and the entire depositional network shifts its position rapidly from side to side.



Glacial Processes

Glaciers – depositional processes and landscapes

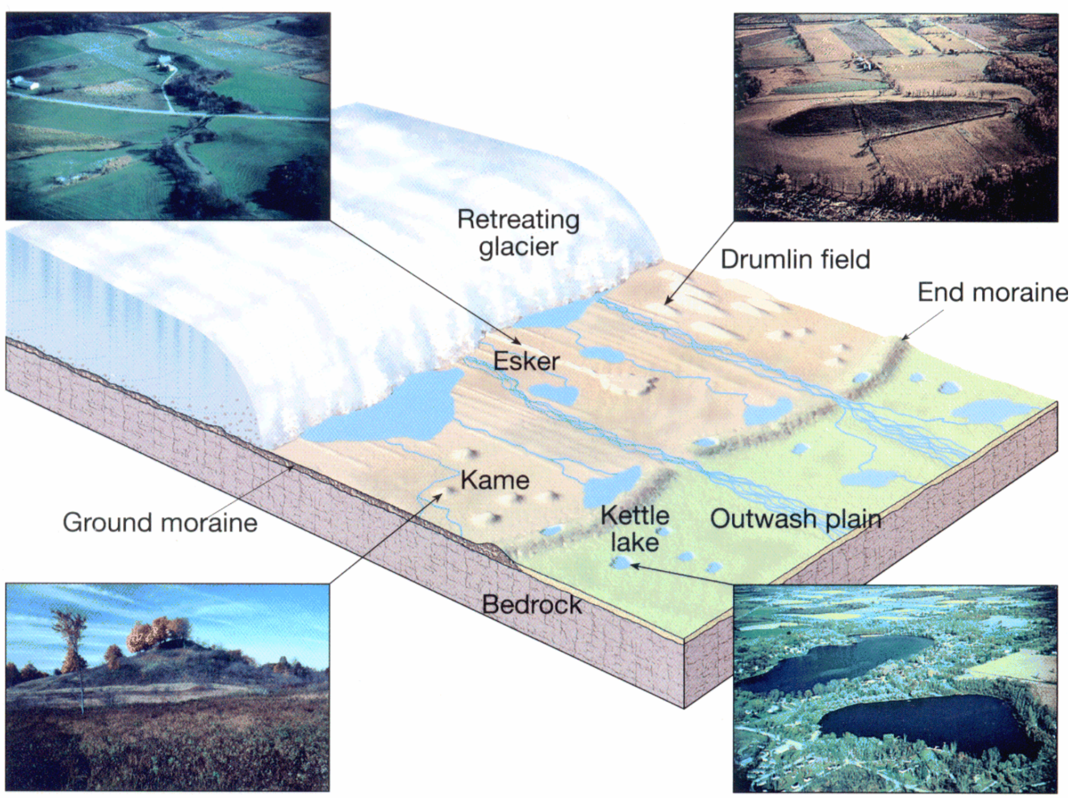
Downstream the system changes gradually into the ***distal zone***, where channels become so shallow that the rivers may merge into a single sheet of water during high flow.



Glacial Processes

Glaciers – depositional landscapes

Glaciers are also depositional machines. They deposit all of that sediment that they erode. Although all glaciers both erode and deposit sediment, the ice-sheets drop substantial loads of sediment as they melt. Produces many of today's landscapes.



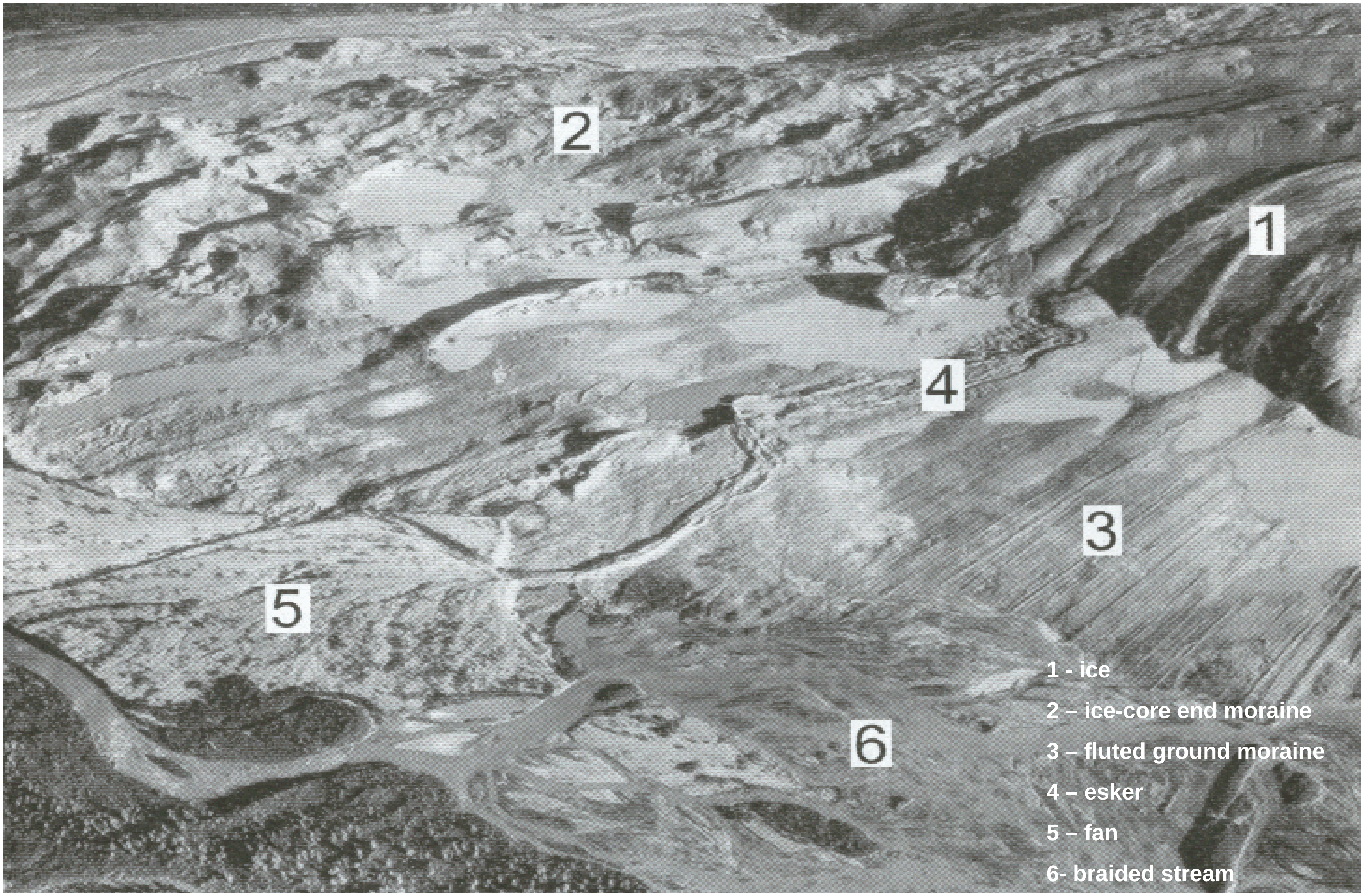
Moraine

Kettle lakes

Eskers

Drumlins

Glacial Processes

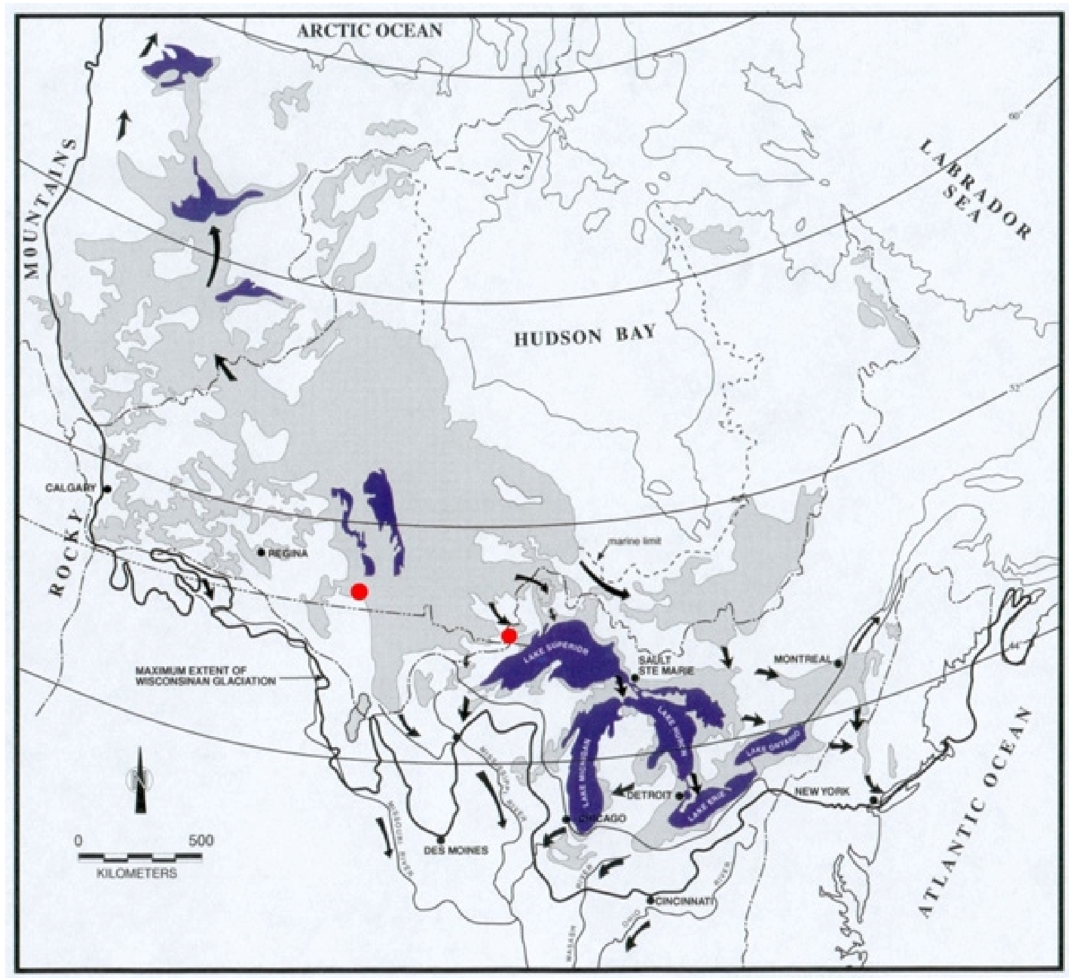


Glacial Processes

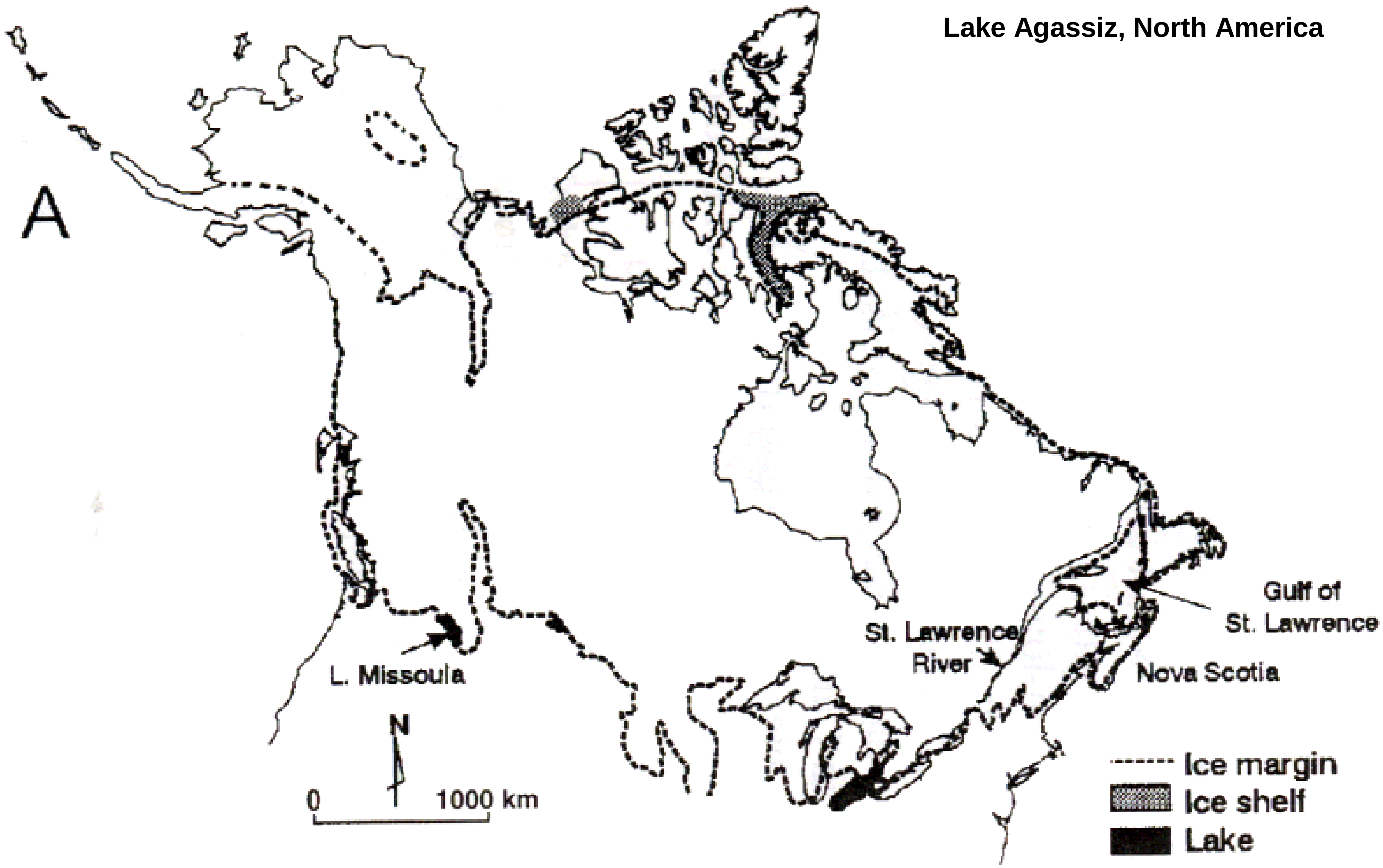
Glaciers – pro-glacial lakes

As glacial ice masses melt, they release a tremendous amount of water that often collects at the melting edge of the glacier due to isostatic depression of the land mass. These areas form ***pro-glacial lakes*** and can cover very large tracts of land.

Lake Agassiz, North America



Glacial Processes



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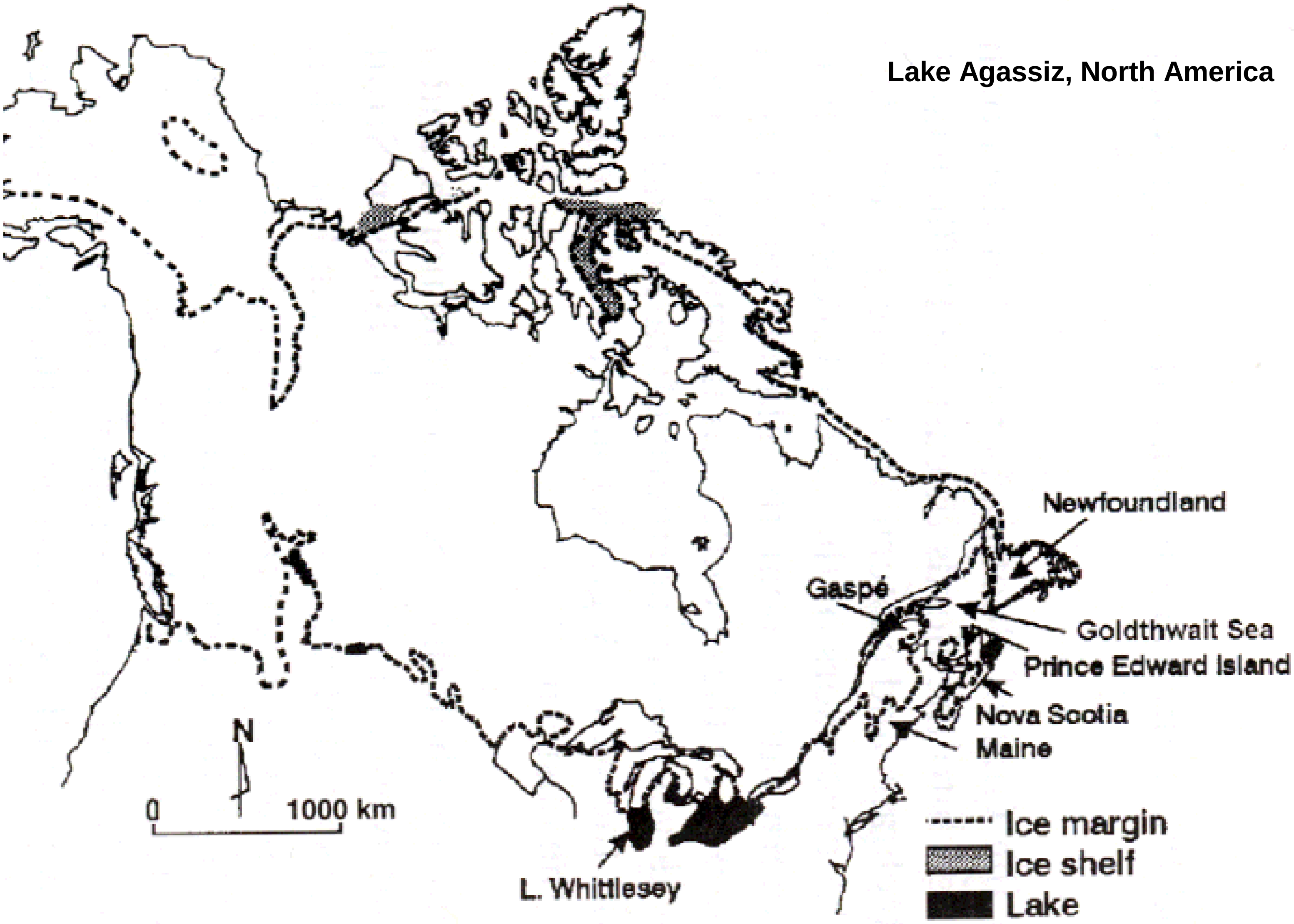
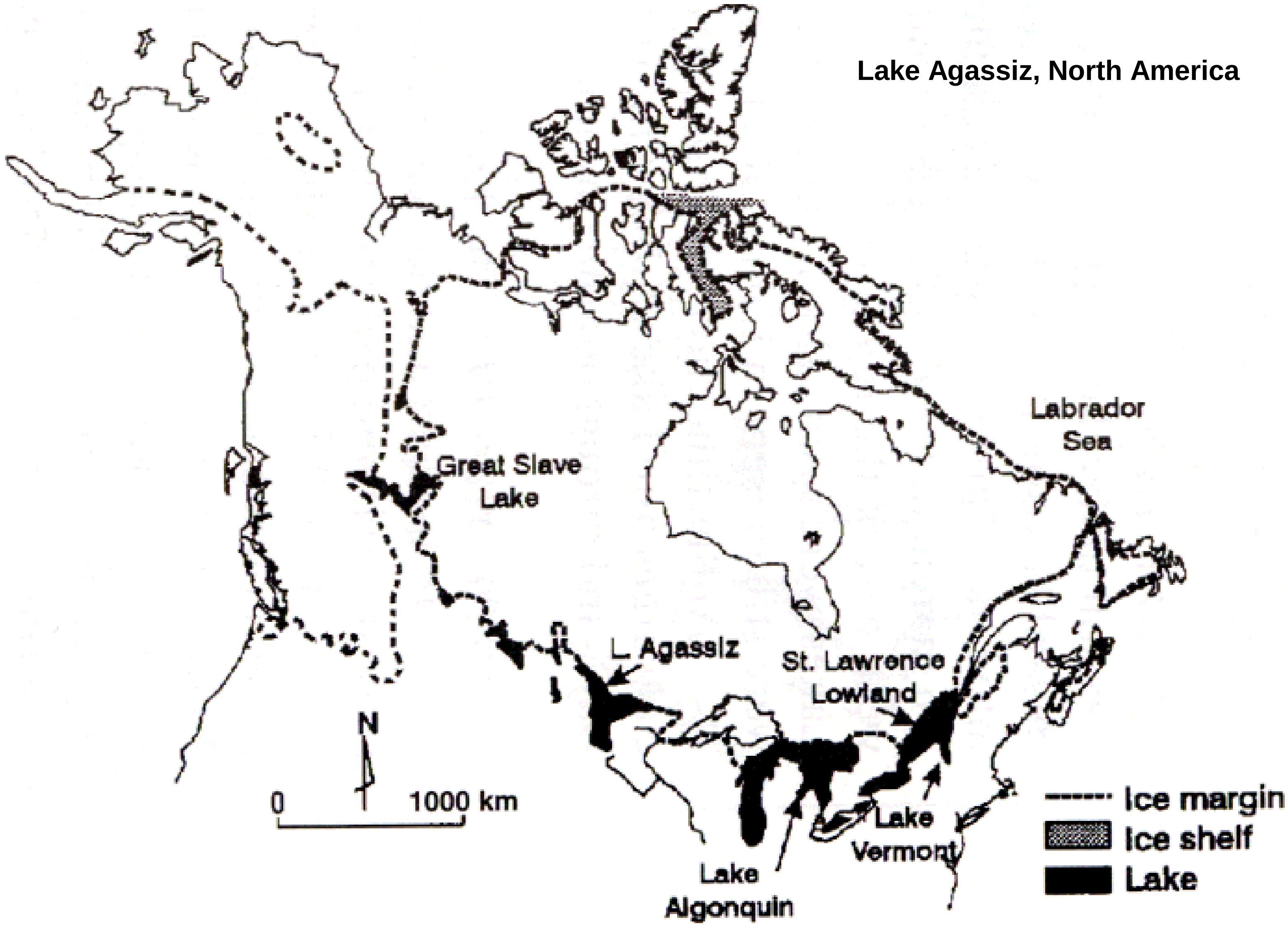


Glacial Processes

Lake Agassiz, North America



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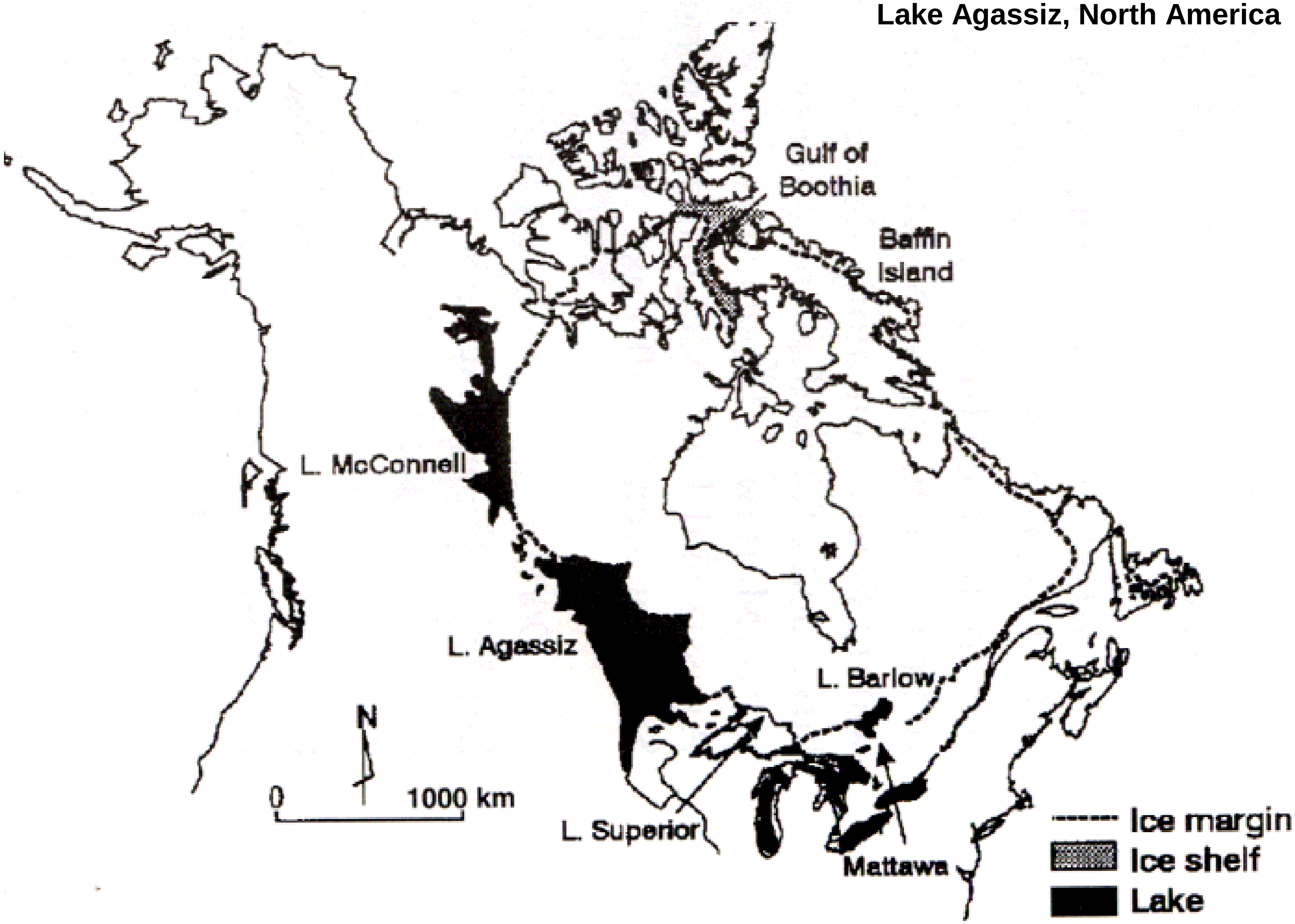
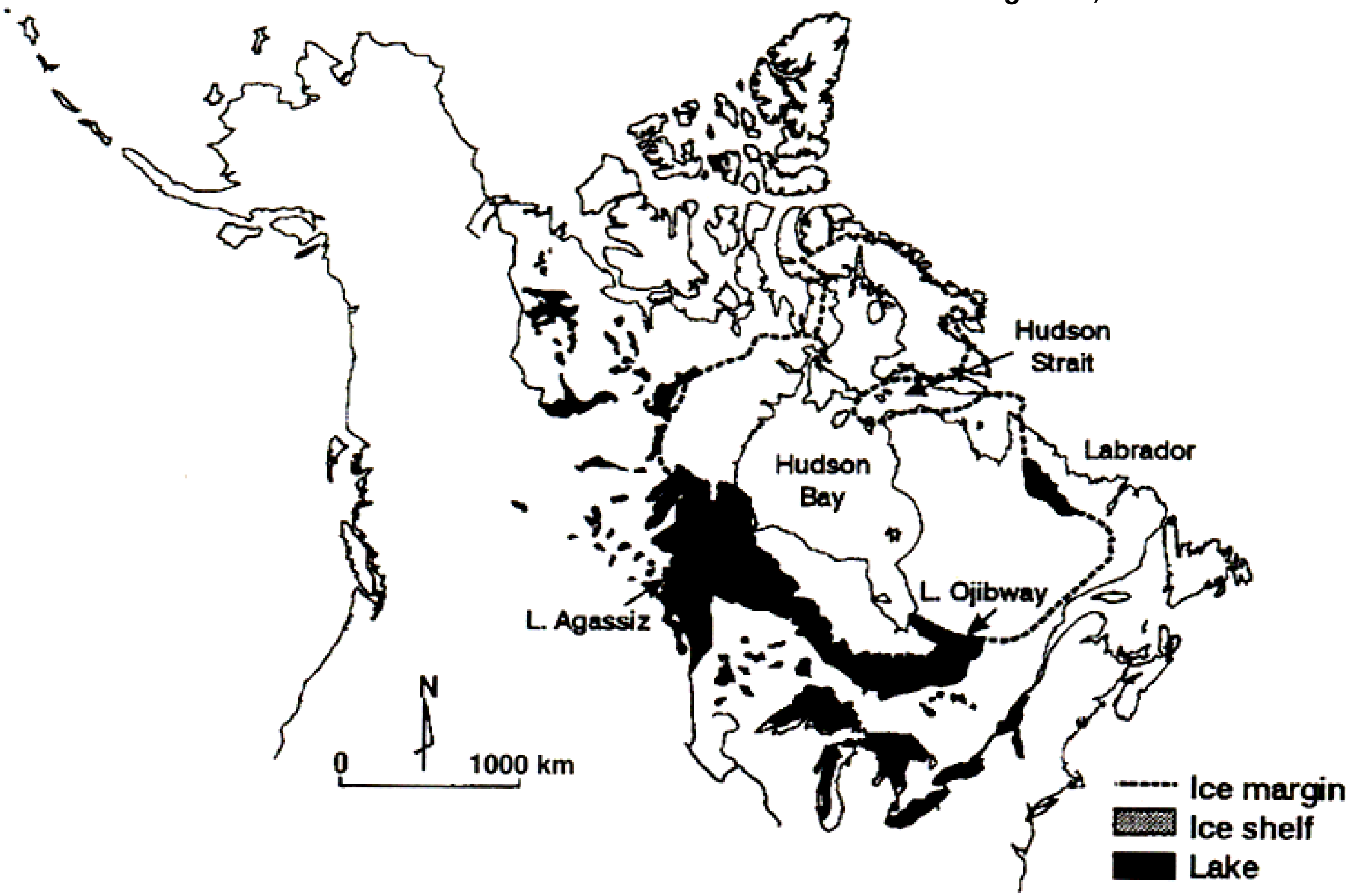
Lake Agassiz, North America

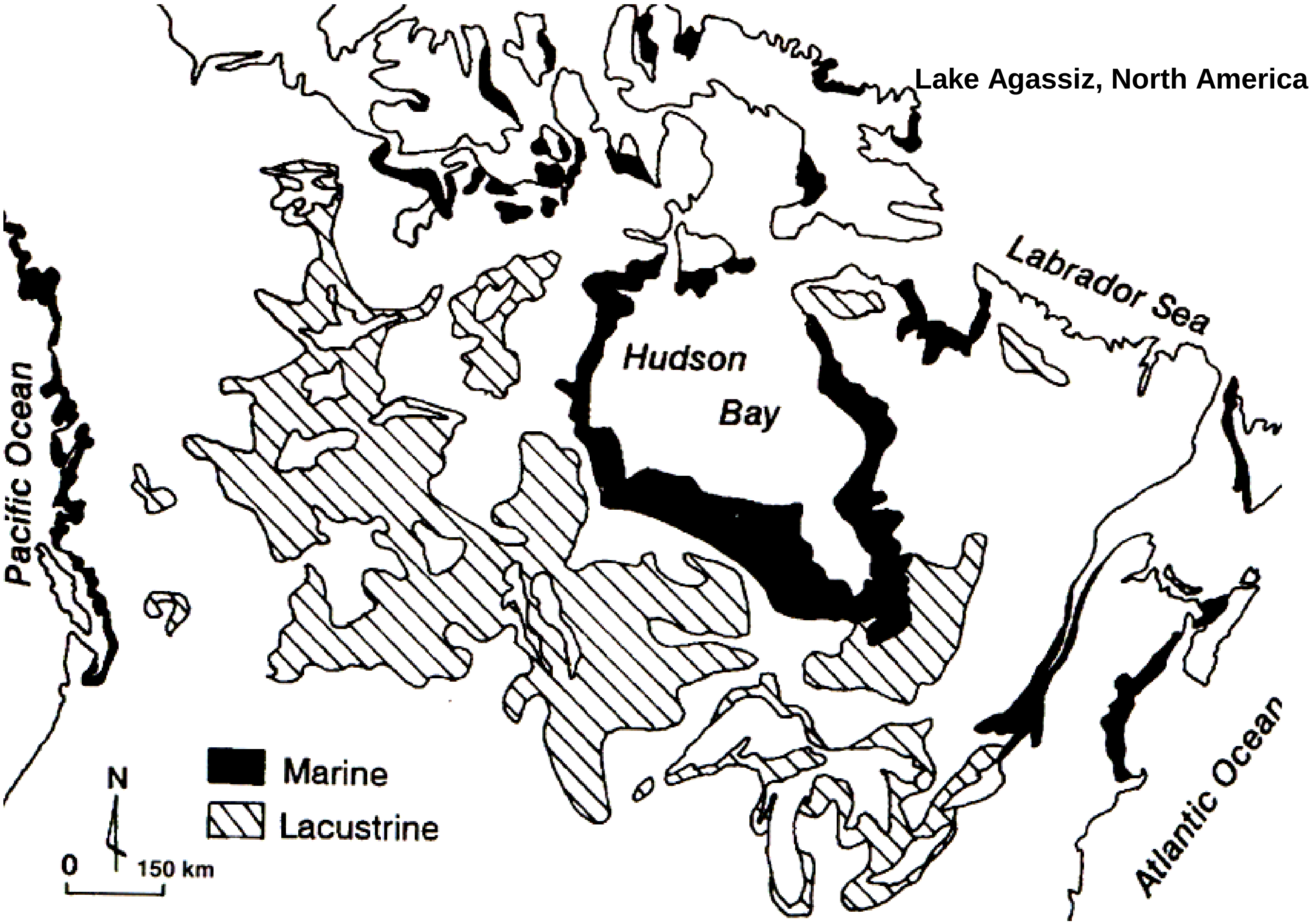


Glacial Processes

Lake Agassiz, North America



Glacial Processes

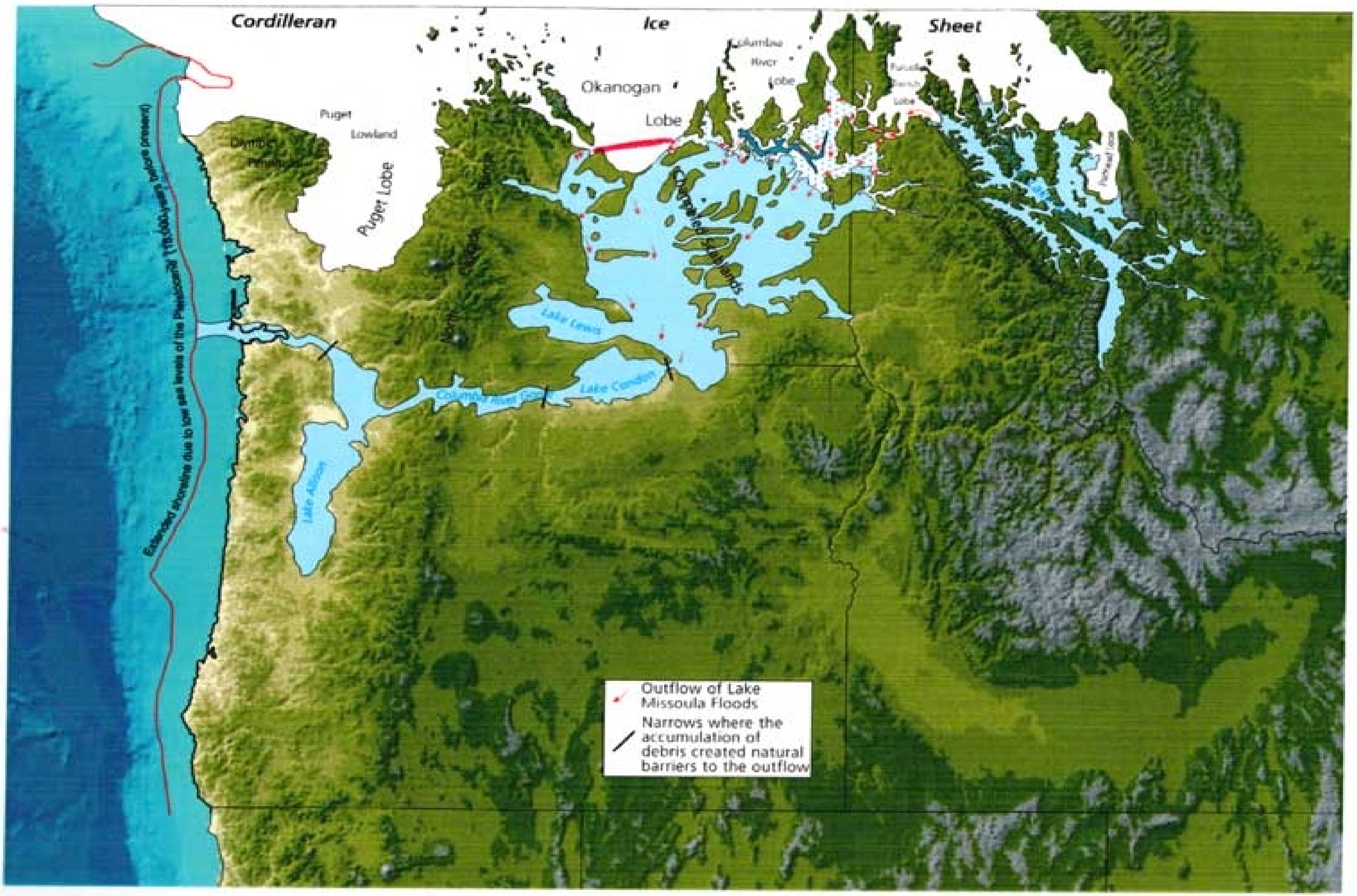


Glacial Processes

Lake Missoula, North America

Glacial Processes

Lake Missoula, North America



Glacial Processes

Lake Missoula, North America

Strandlines (ancient lakeshores) on Mt. Jumbo/ NPS photo

GLACIERS

Why does the Earth experience glacial epics at all?

So there were vast ice-sheets that covered substantial portions of the Earth's landmass in the geologic past. Obviously it must be too warm today to support such ice sheets because we don't see them, so what causes the Earth to get cool enough to start growing glaciers?

Possible cause:

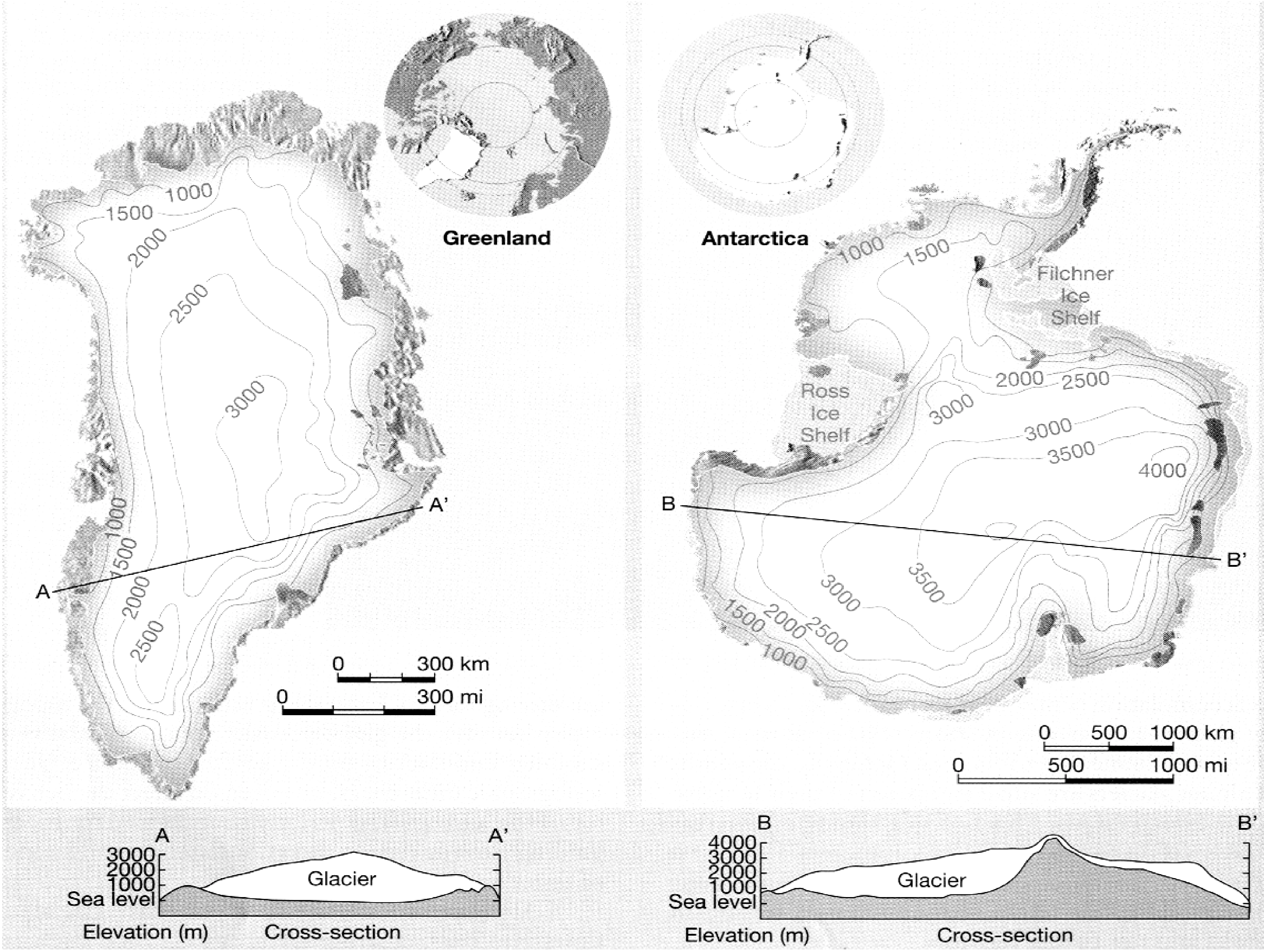
Changes in the position of the continents

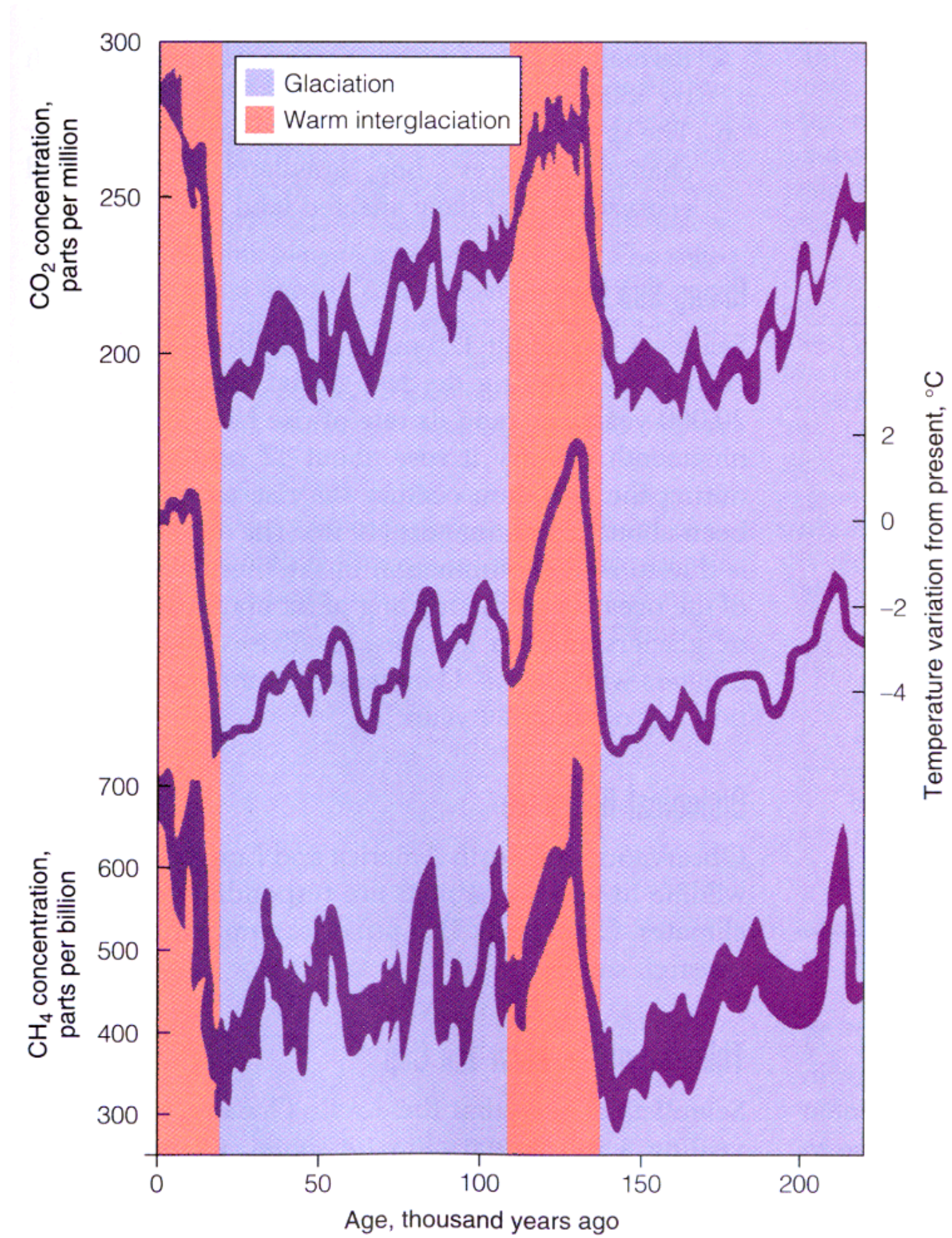
Changes in the circulation of sea water

Milankovitch cycles

Changes in the atmosphere – reduction in greenhouse gases

links

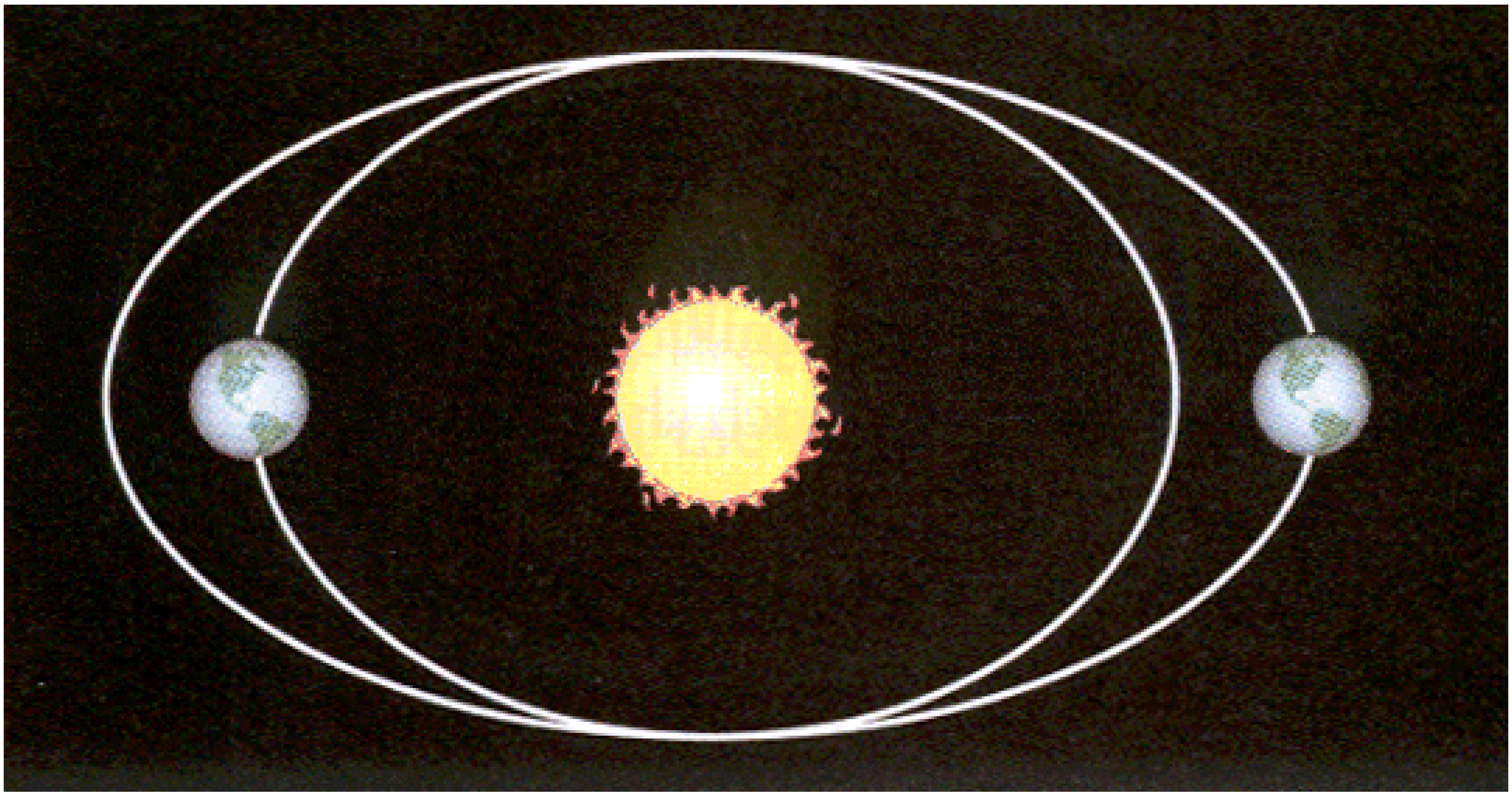

Greenland
Antarctica
1000
1500
2000
2500
3000
A
A'
0 300 km
0 300 mi
Filchner Ice Shelf
Ross Ice Shelf
3500
4000
B
B'
0 500 1000 km
0 500 1000 mi
3000
2000
1000
Sea level
Glacier
Elevation (m)
Cross-section
4000



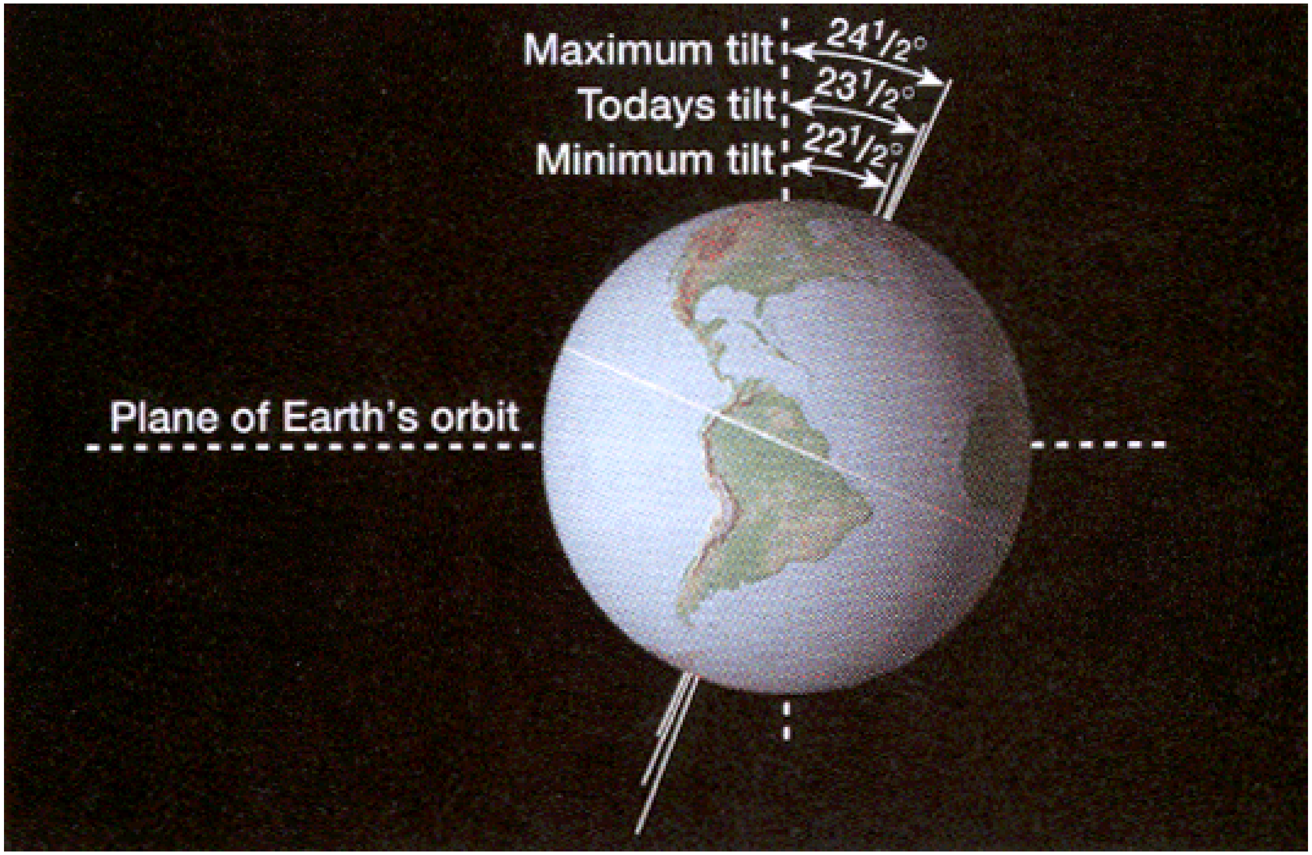
Glaciation
Warm interglaciation
CO_2 concentration, parts per million
300
250
200
Temperature variation from present, °C
2
0
−2
−4
CH_4 concentration, parts per billion
700
600
500
400
300
0
50
100
150
200
Age, thousand years ago


South Cascade Glacier (Washington 1957-1980)

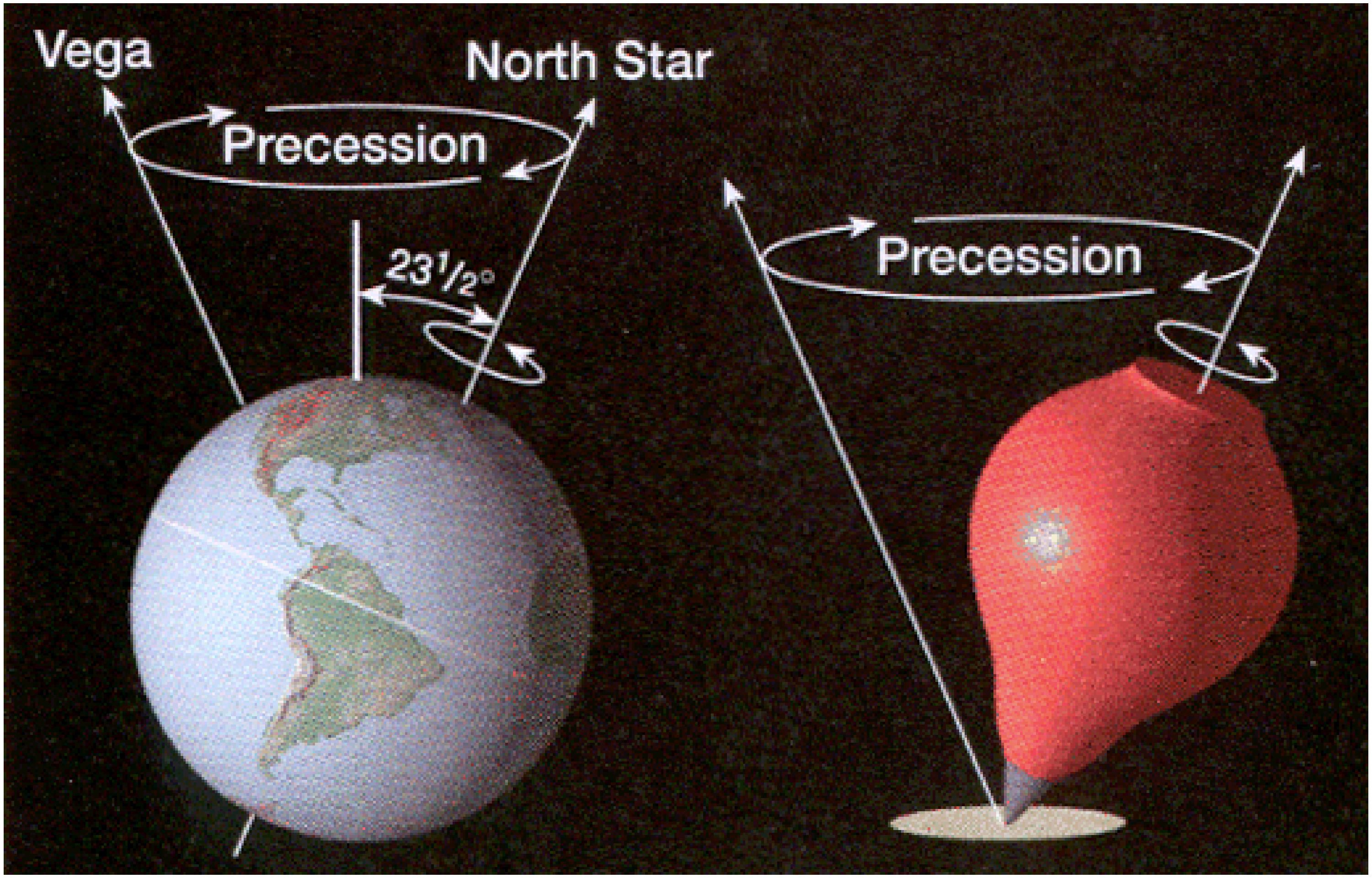
Eccentricity of the Earth's orbit – 96,000 years



Axial Tilt – 42,000 years



Precession of the equinoxes – 21,000 years



Periodicity