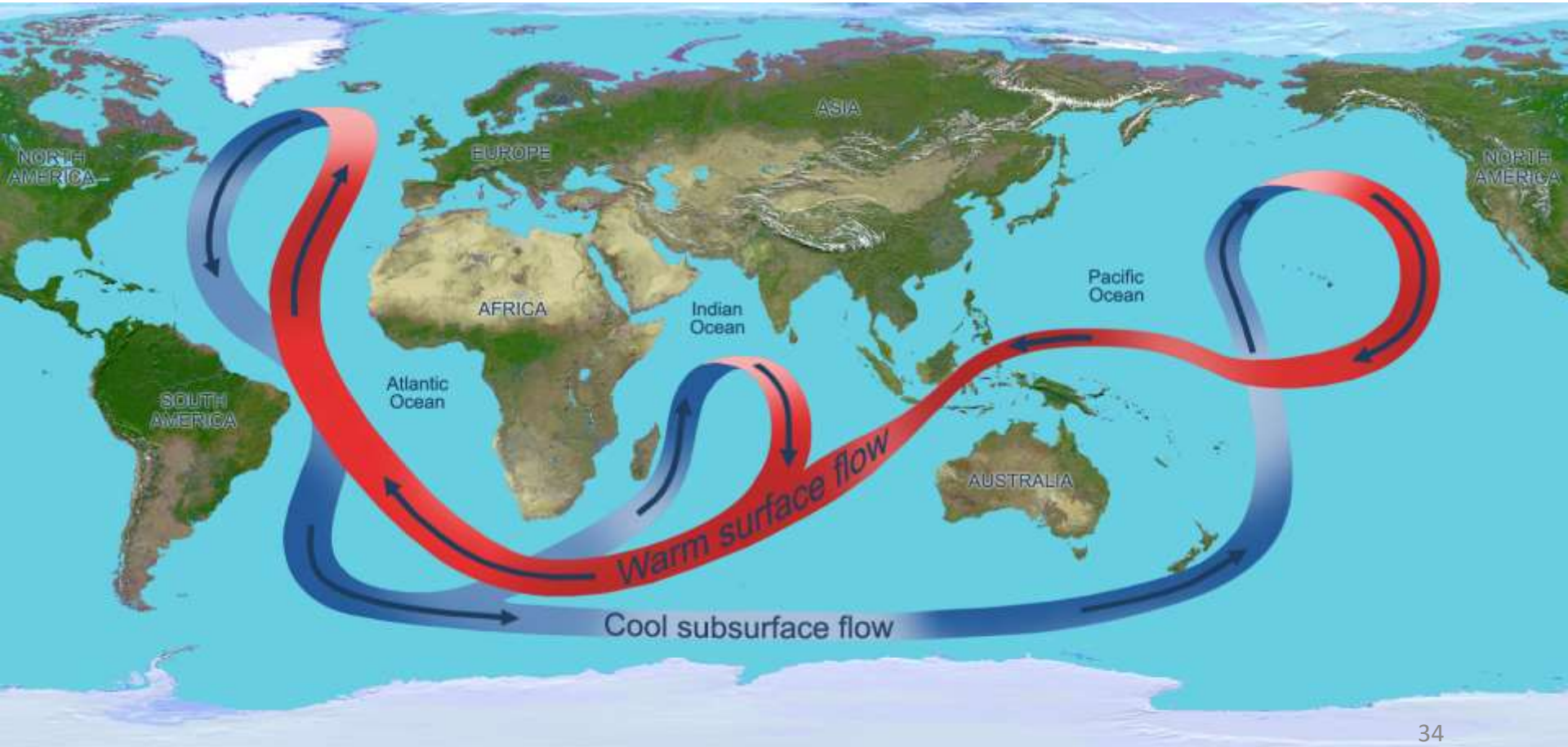
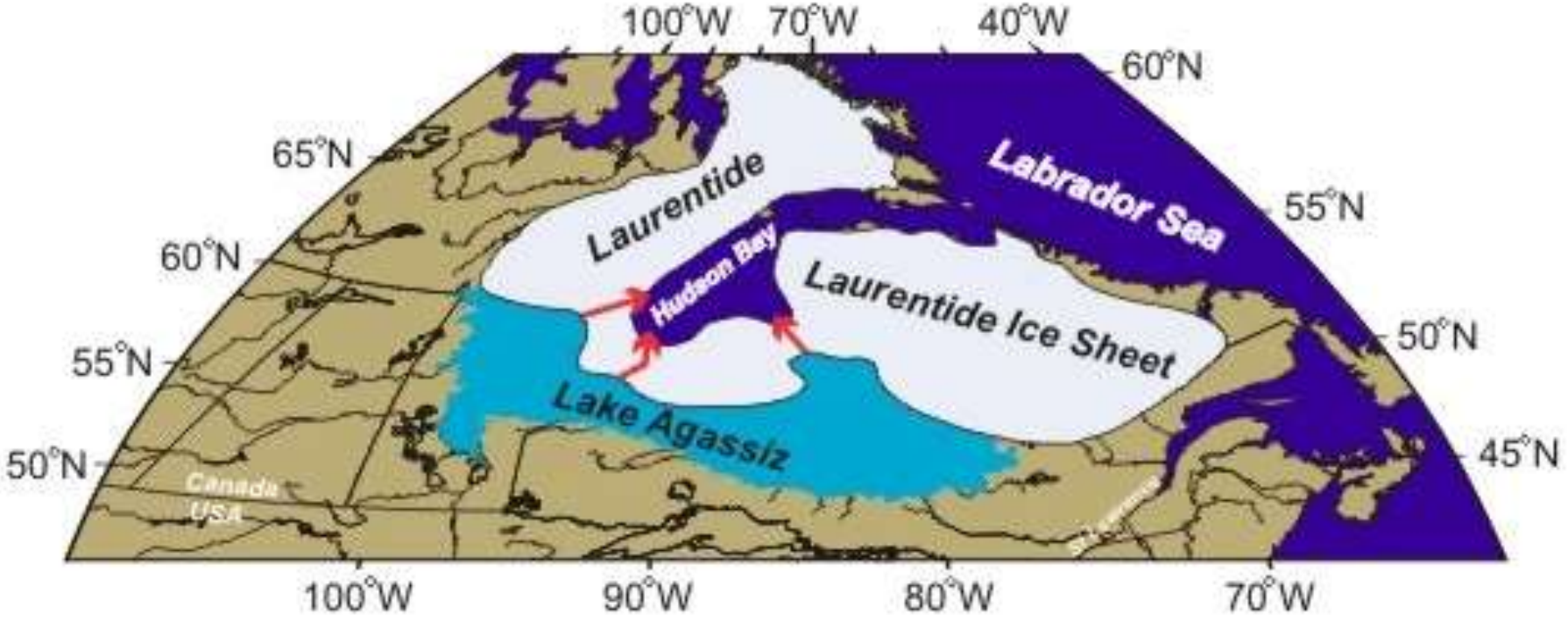
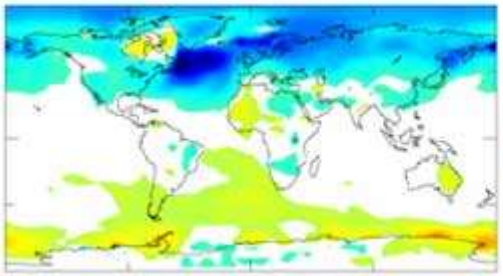
Thermohaline Circulation Currents

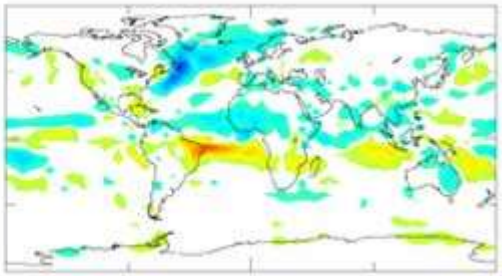


from NASA

Lake Agassiz Outburst Flood ~8,200 ago







NASA Climate model of air temp. and precip. post-outburst

Lake Agassiz Outburst Flood

- This flood came from a glacial lake (Lake Agassiz) that catastrophically broke through its ice-dam
- The fresh, cold water entered the Labrador Sea in the North Atlantic and caused a temporary climate change
  - The fresh water is less dense than saline ocean water, and it stalled the thermohaline circulation in the north Atlantic Ocean.
    - Fresh water has different density than salt water
  - Preceded the global cooling event

The Phanerozoic Oxygen Isotope Record of Seawater

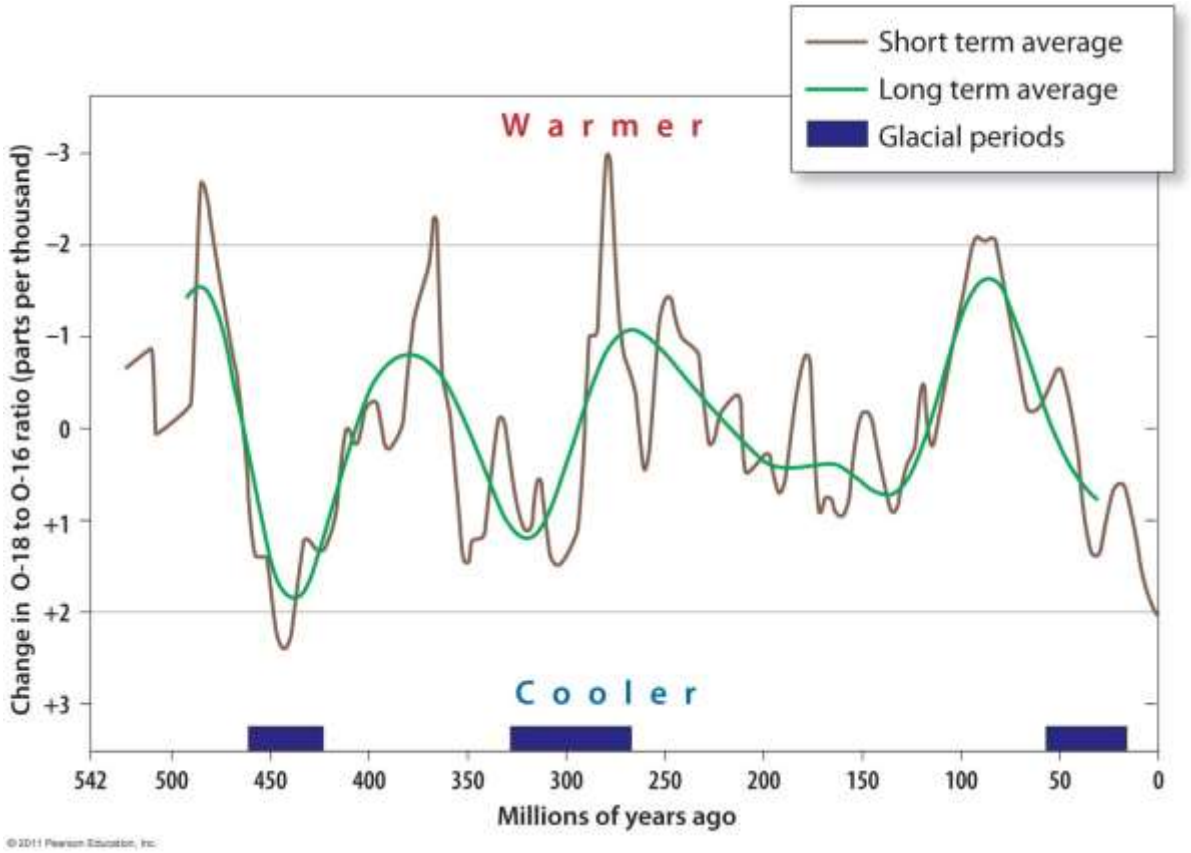


FIGURE 14-26 The Phanerozoic Oxygen Isotope Record of Seawater
The variation in the ratio of O-18 to O-16 is determined from measurements of oxygen isotopes in fossil marine shells and skeletons. A greater O-18 to O-16 ratio indicates colder periods.

Paleoclimatology—Studying Past Climates (cont.)

- **Atmosphere samples in ice cores**
  - Air is trapped in snow each year on ice sheets
  - Snow becomes compressed under the weight of new snow and turns into ice
  - Enclosed air becomes trapped in the ice as bubbles of ancient air
  - Bubbles can be analyzed for their content of greenhouse gases
  - Determine prehistoric atmospheric concentrations of methane and CO_2

Paleoclimatology—Studying Past Climates (cont.)

- **Sea level history**
  - Shifts from cold to warm climate marked a change from expanding permanent ice sheets to melting ice sheets.
  - Major **cold periods** make major continental-scale ice sheets
    - Trap tremendous volumes of water evaporated from the oceans
    - Lower sea level
- **Warm periods** melt the great ice sheets
  - Send tremendous amounts of water back to the oceans
  - Sea level rises

Atmospheric Gases Trapped in Ice at Vostok Station, Antarctica

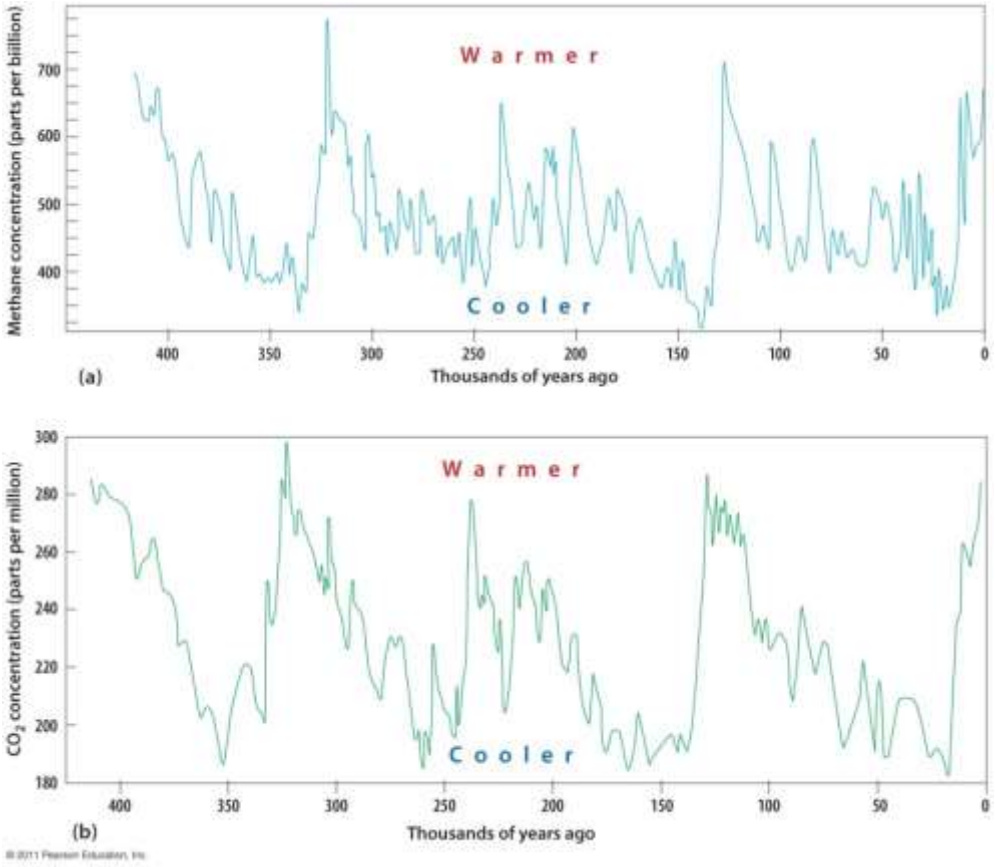
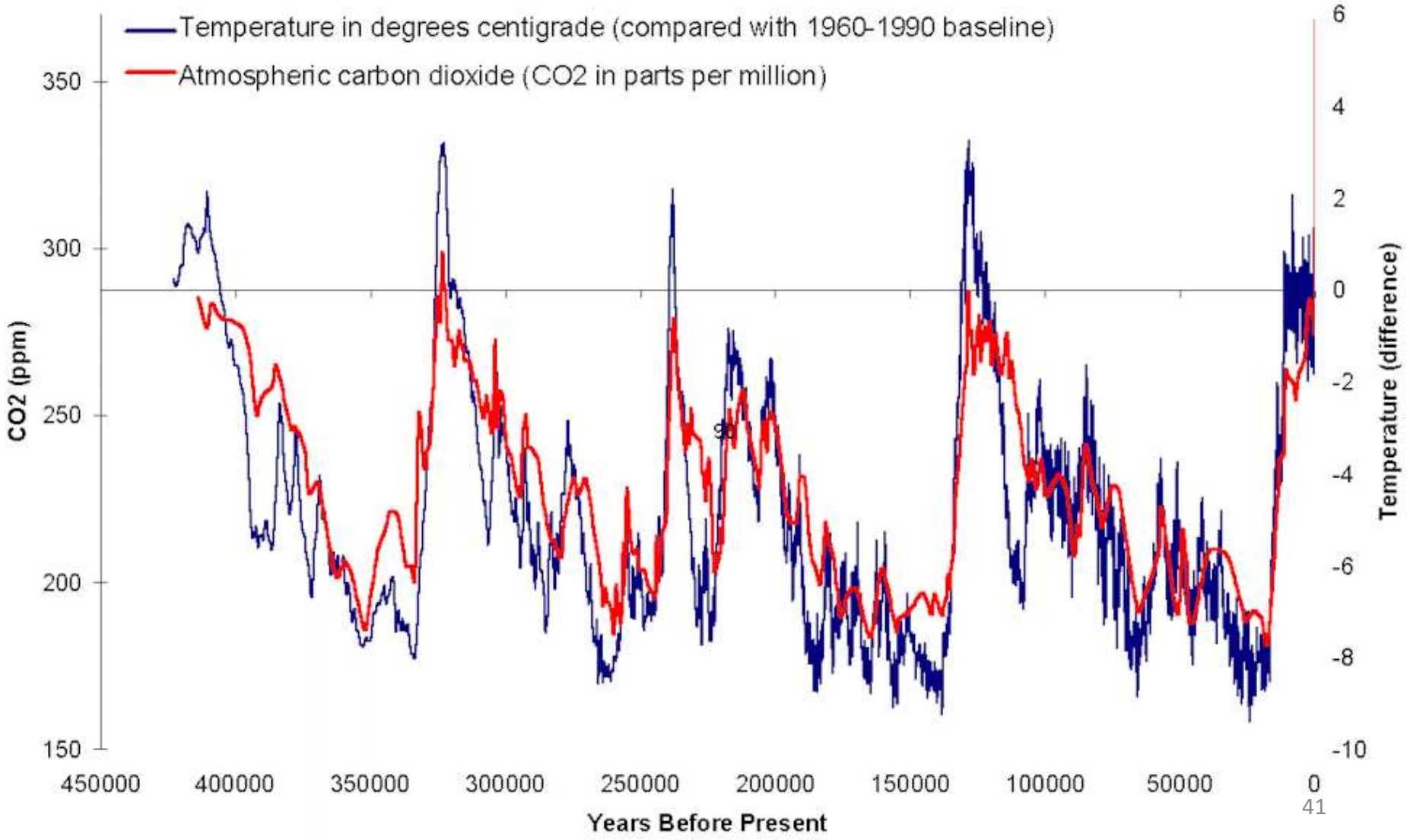


FIGURE 14-27 Atmospheric Gases Trapped in Ice at Vostok Station, Antarctica
Higher concentrations of methane **(a)** and carbon dioxide **(b)** in air bubbles trapped in ice cores indicate warmer interglacial times. Earth entered a warming interglacial period 20,000 years ago.

Temperature and CO_2



Matanuska Glacier, AK – Large boulder shields ice surface from solar radiation – Ice pedestal

Matanuska Glacier, AK – Solar Radiation heats dark rocks that melt through ice surface

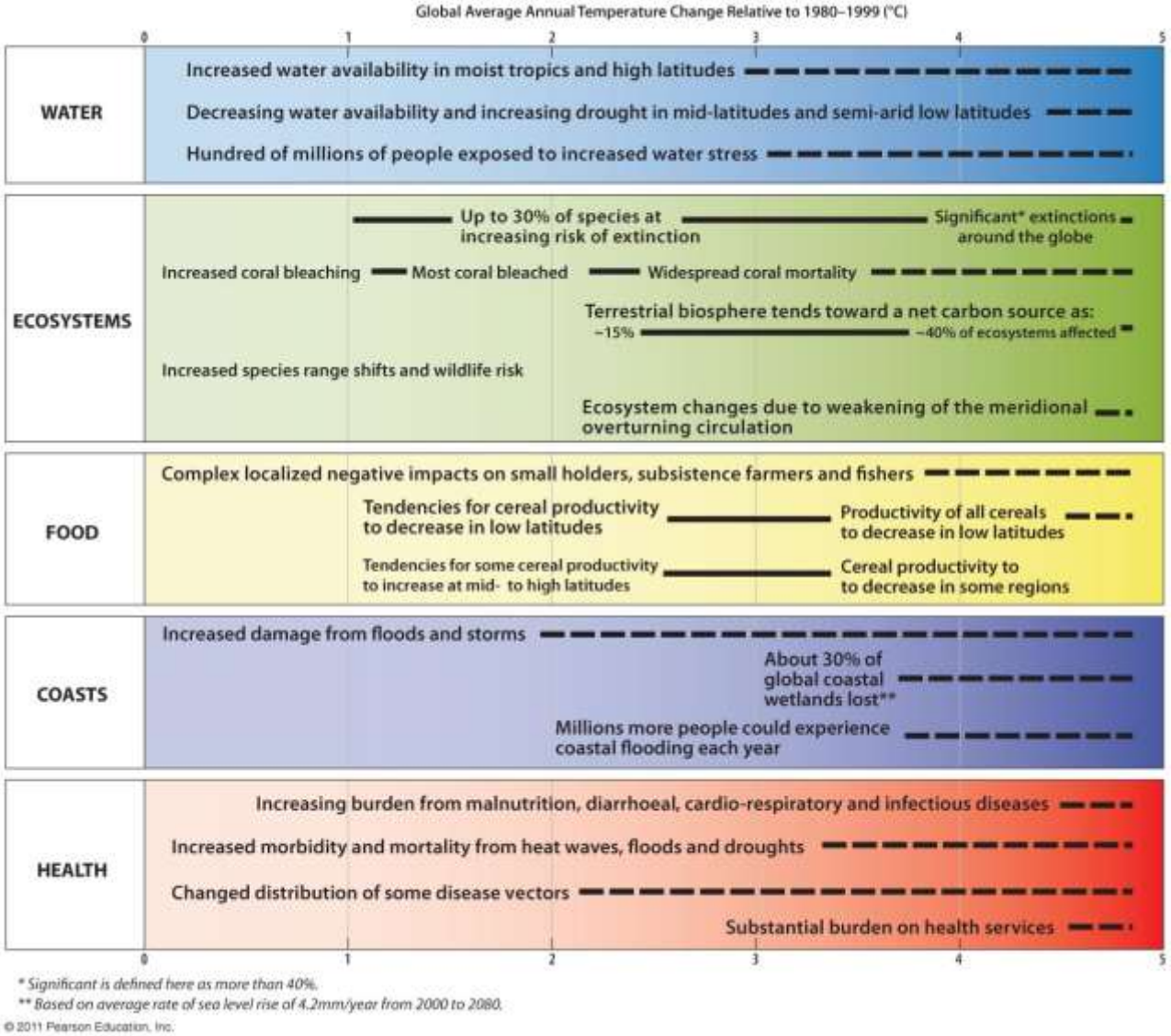
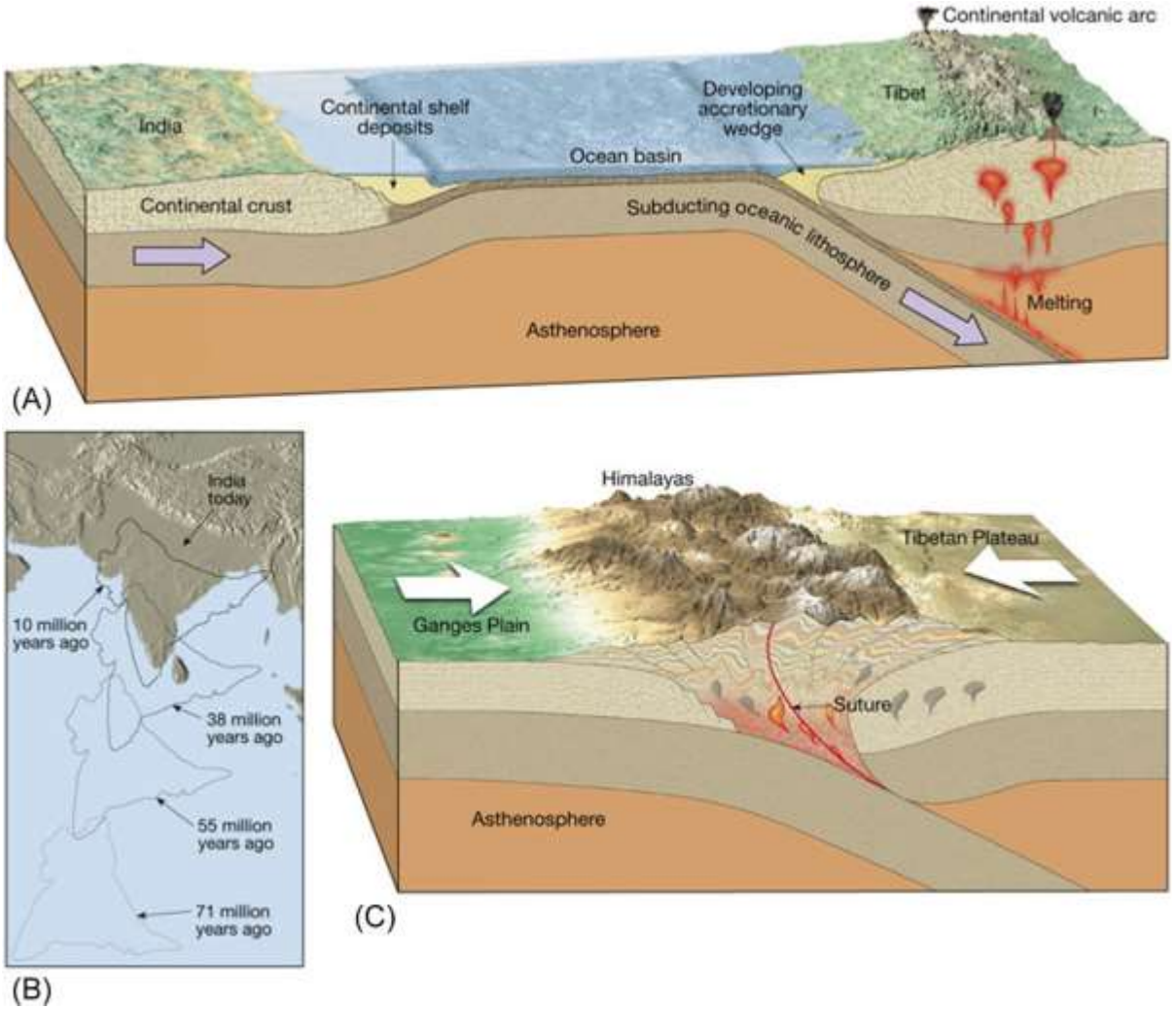


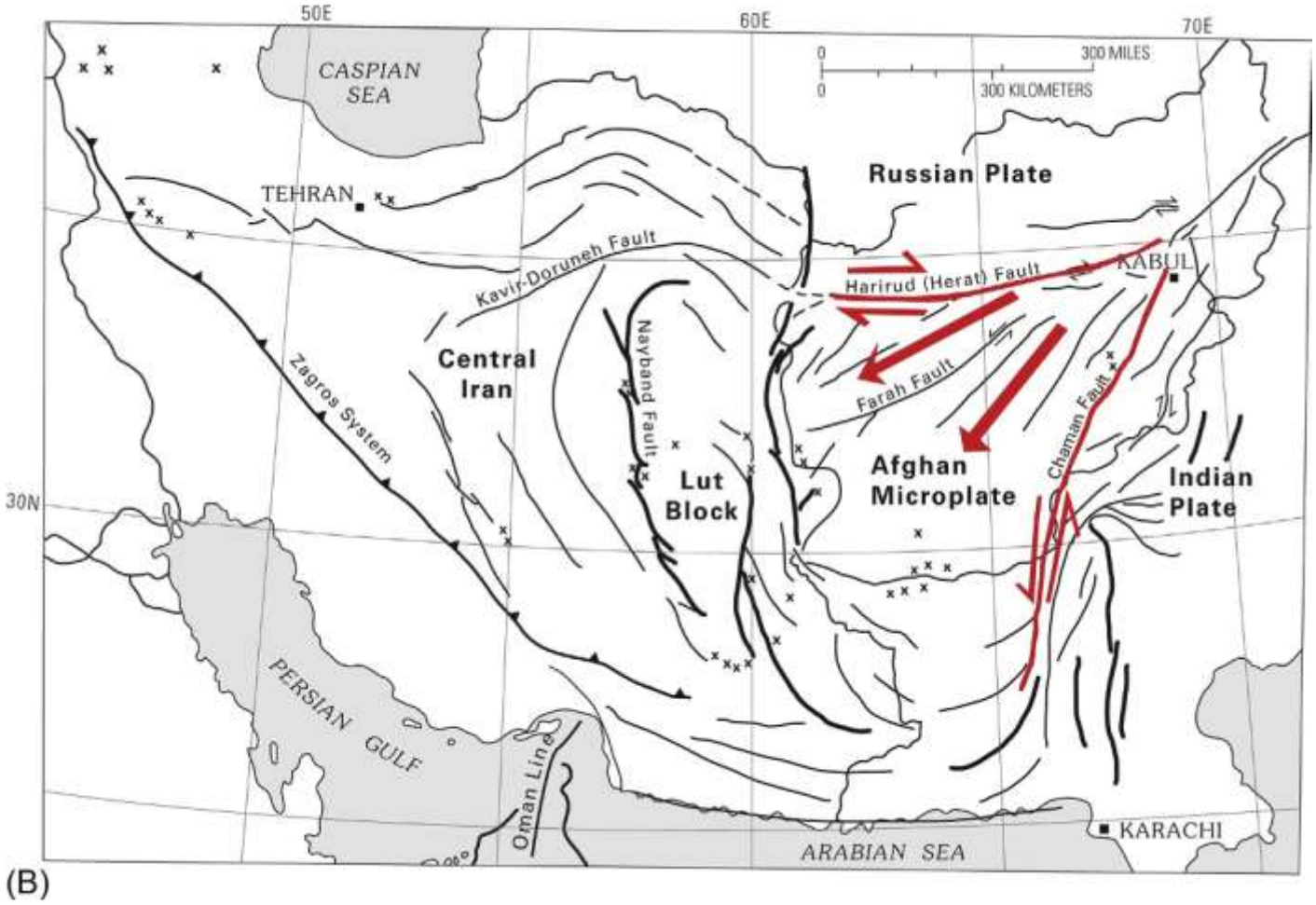
FIGURE 14-40 Examples of Impacts Associated with Different Amounts of Global Average Temperature Change Projected here by the IPCC in 2007. We can see some of these effects already with more severe droughts, wildfires, infectious diseases like COVID-19 perhaps?, increased floods, and coastal storms…

Indian and Eurasian Continental Collision = Himalayas



Indian and Eurasian Continental Collision = Himalayas

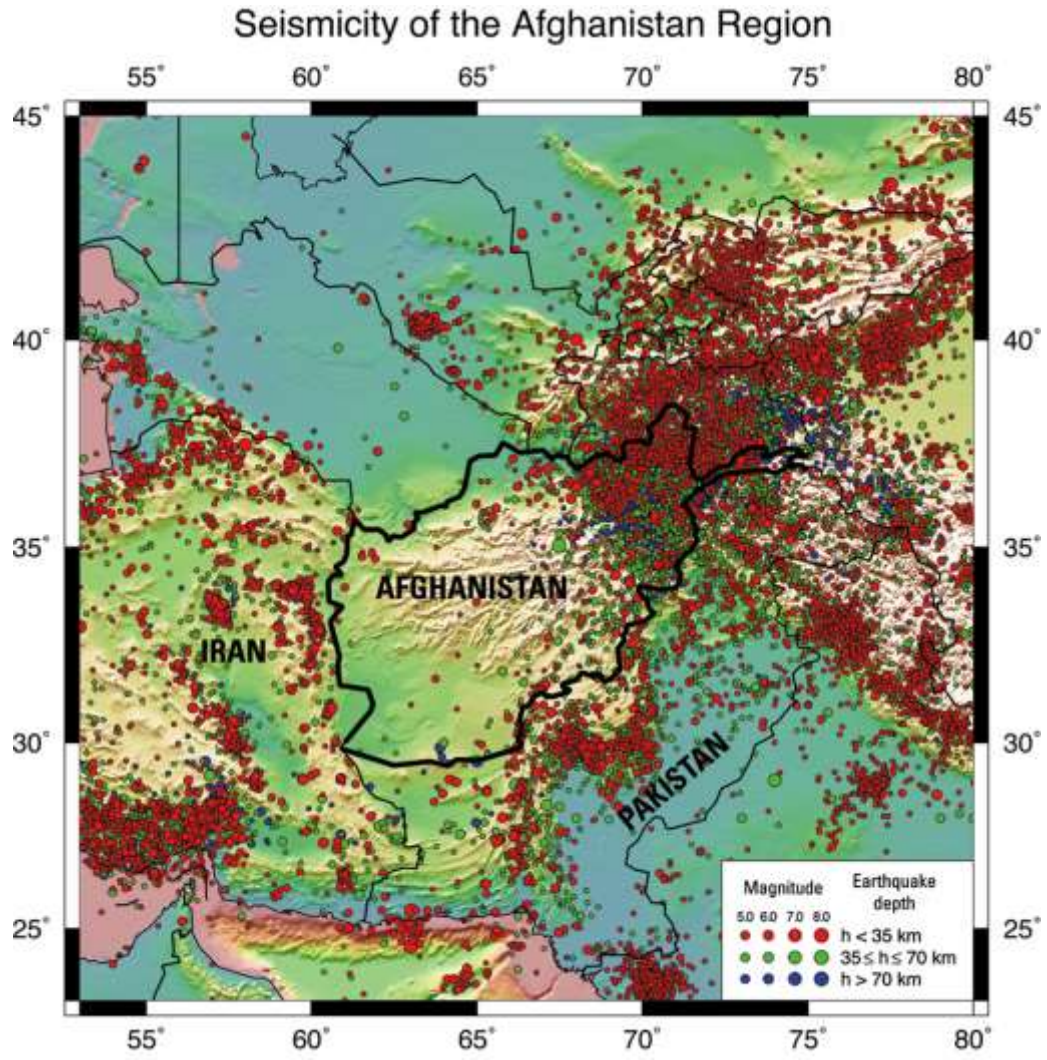
- (A) Ongoing continental collision between the India and Eurasia (Tibet) plates at some time prior to the ongoing plate-tectonic collision of the present time.
- (B) Progressive plate-tectonic migration of Indian subcontinent over the past 55 million years to impact with Eurasia, and force up the collisional mountains of the Hindu Kush and Himalaya.
- (C) Mountains of the Hindu Kush and Himalaya just southwest of the Tibetan Plateau suture between the two colliding plates.
    - These images were created by the Earthscope National Office, a National Science Foundation funded project. For more information, visit www.earthscope.org (accessed 11.07.15). (Per illustration publication rules on website).

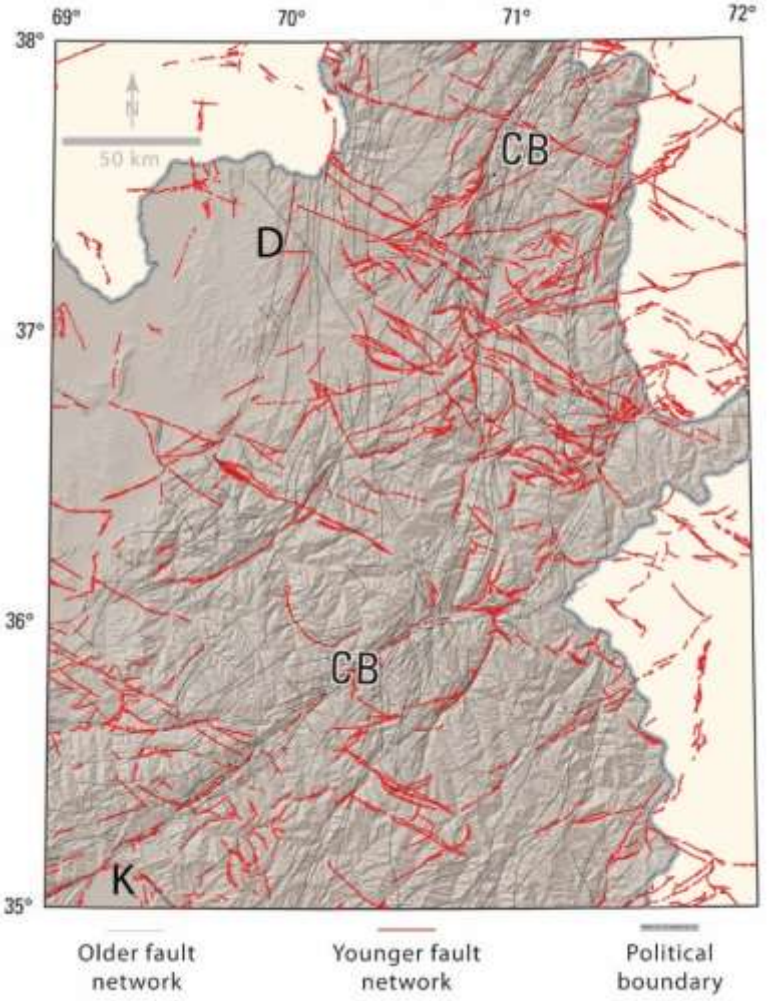


Faults of the Afghan Microplate

- (B) The Afghan Block, between the Hari Rud and Chaman faults, is being pushed to the southwest into the Lut Depression in Iran
  - (Modified from Whitney, J.W., 2006. Geology, water, and wind in the lower Helmand Basin, southern Afghanistan: U.S. Geological Survey Scientific Investigations Report 2006-5182, 40 pp.).

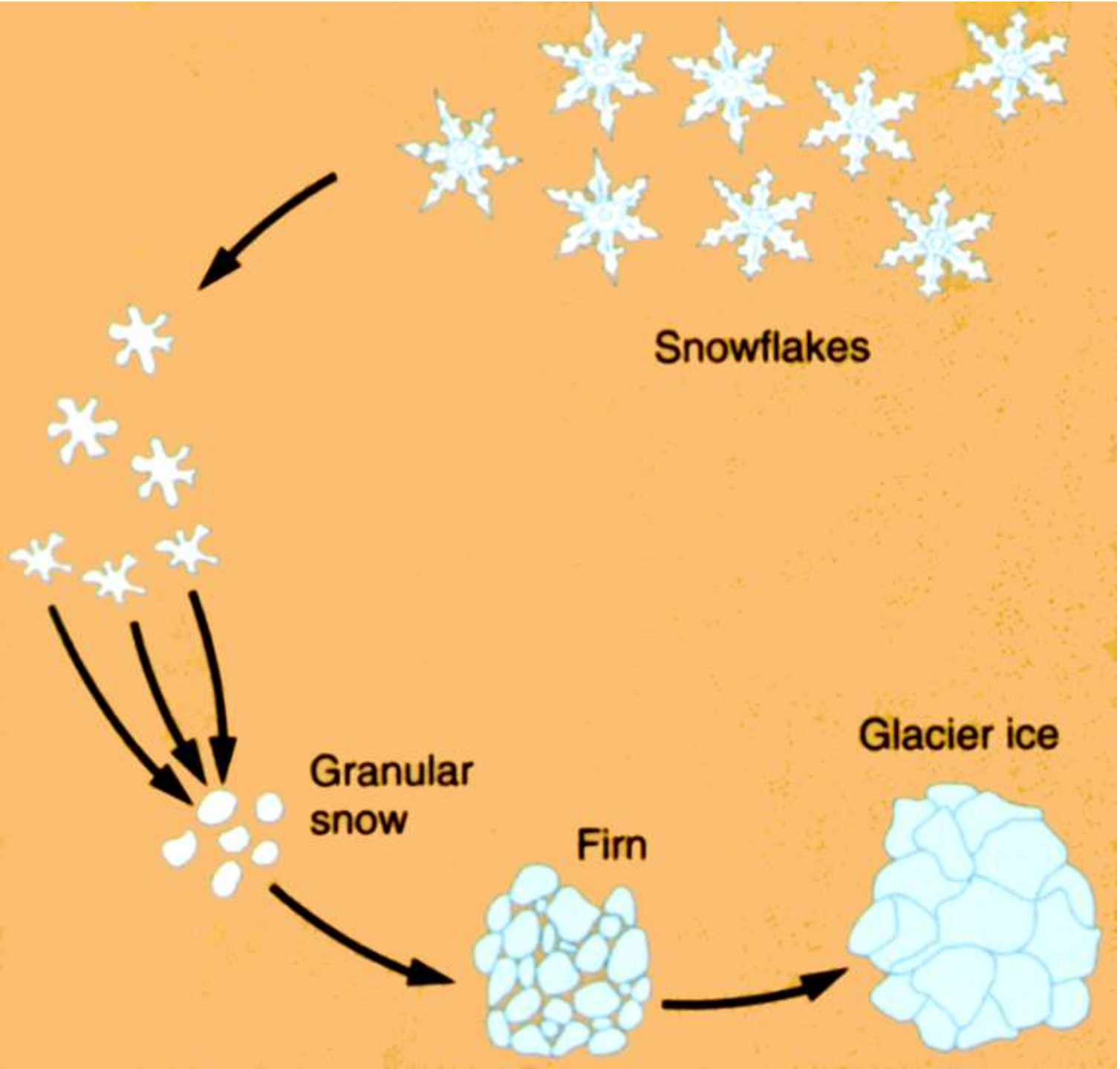
Highest magnitude & frequency of earthquakes in the world!





Glaciers

- Formation and Decay Processes
- Nomenclature
- Morphology and Glacier Types
- Glacial Movement
- Glacial Landforms
- Glacier Dynamics
- Glacial Hazards and Related Hazards



Snow to ice

Initial form of snow
(A)

After two weeks
(B)

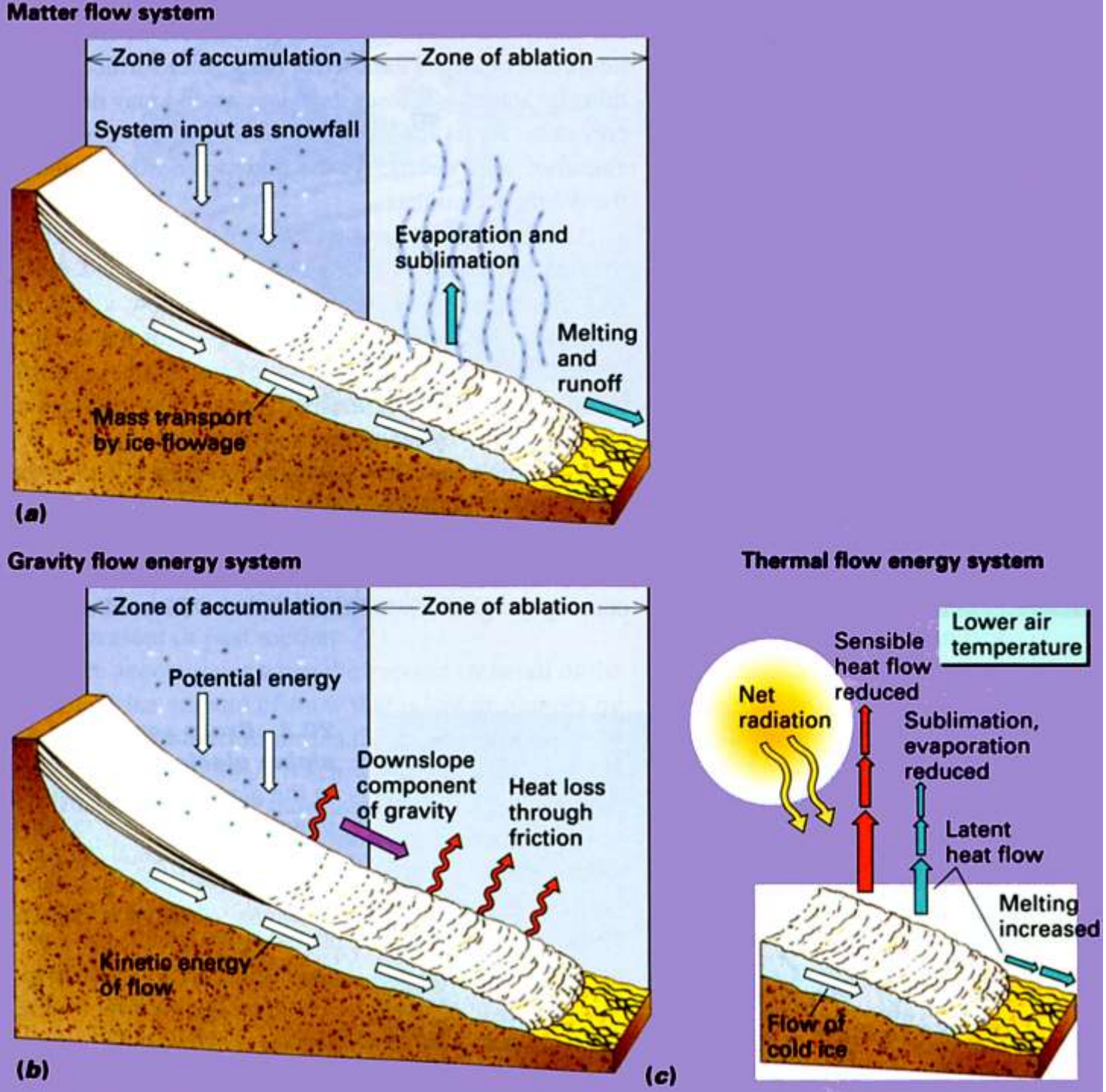
After seven weeks
(C)

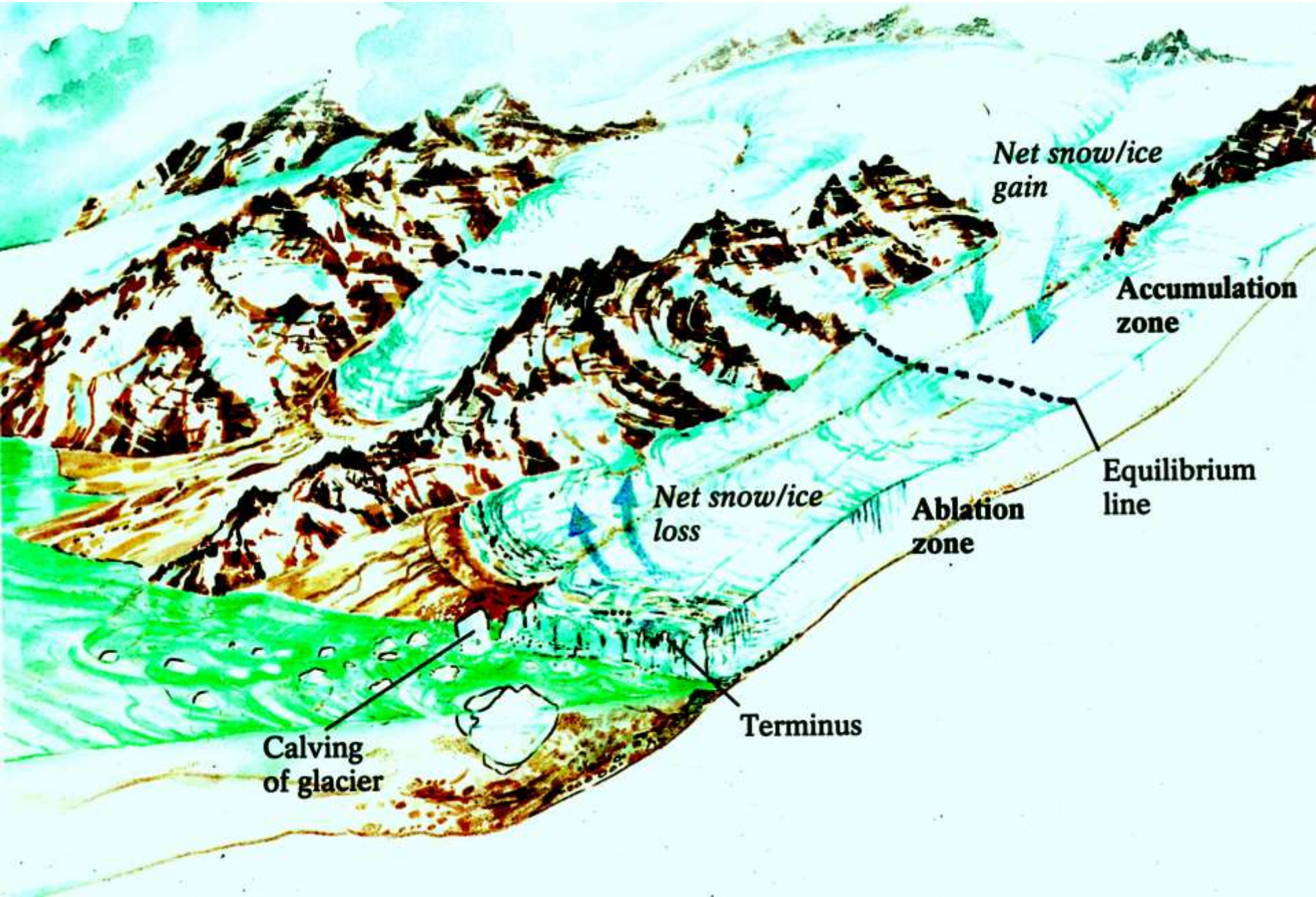
After eight weeks
(D)

Figure 9.1
Changes in the shape of snow crystal in the transition to firn.

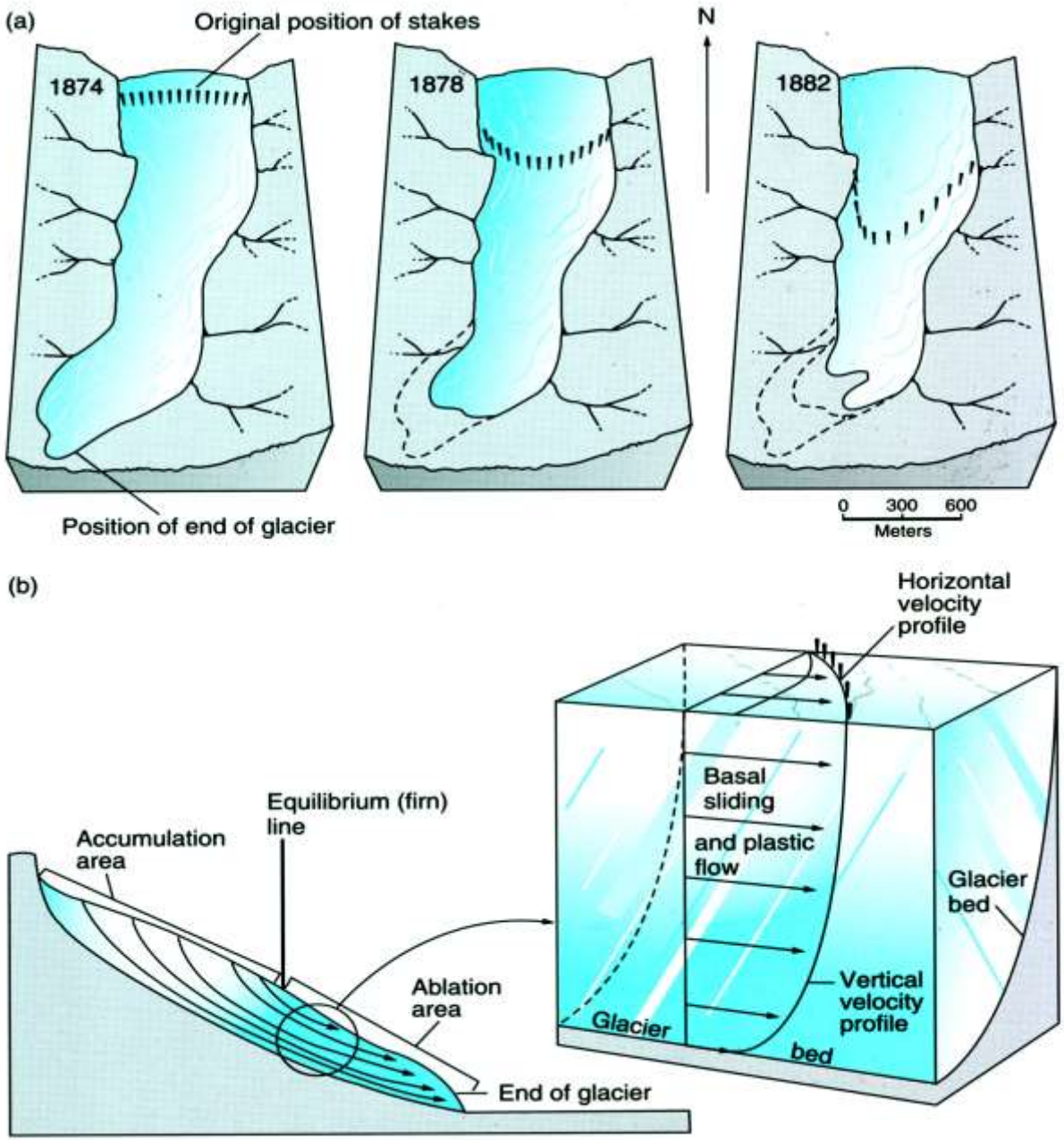
TABLE 9.1	Increasing Density of Snow During Transition to Ice.
Materials	**Density (gm/cc)**
New snow	0.05–0.07
Firn	0.4–0.8
Glacier ice	0.85–0.9

Powder snow recrystallizes from pressure to firn (corn snow, neve)


Matter flow system
Zone of accumulation
Zone of ablation
System input as snowfall
Evaporation and sublimation
Melting and runoff
Mass transport by ice flowage
(a)
Gravity flow energy system
Zone of accumulation
Zone of ablation
Potential energy
Downslope component of gravity
Heat loss through friction
Kinetic energy of flow
(b)
Thermal flow energy system
Lower air temperature
Sensible heat flow reduced
Net radiation
Sublimation, evaporation reduced
Latent heat flow
Melting increased
Flow of cold ice
(c)


Net snow/ice gain
Accumulation zone
Equilibrium line
Net snow/ice loss
Ablation zone
Terminus
Calving of glacier

Glacier movement



Extending & compressive flow

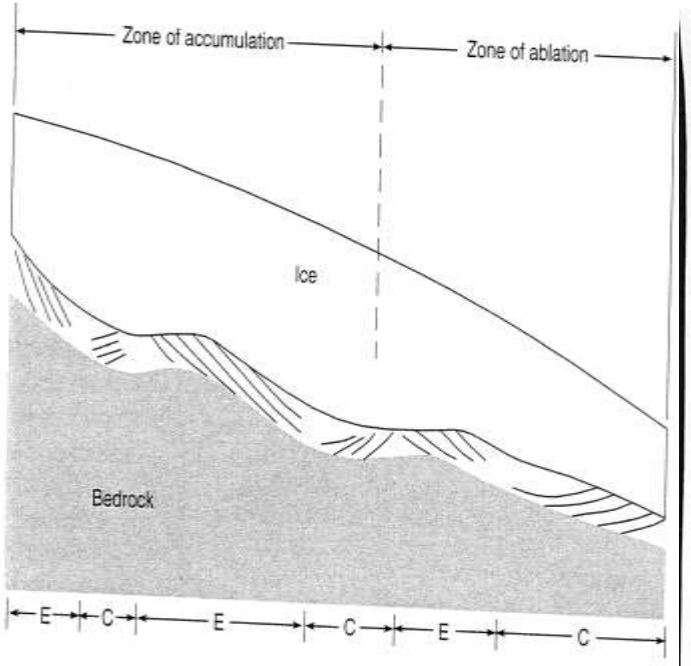


Figure 9.16
Longitudinal section of hypothetical glacier showing irregular bedrock profile and preferred slip planes within the ice. Zones of extending flow and compressive flow indicated by E and C.
(Nye 1952a)

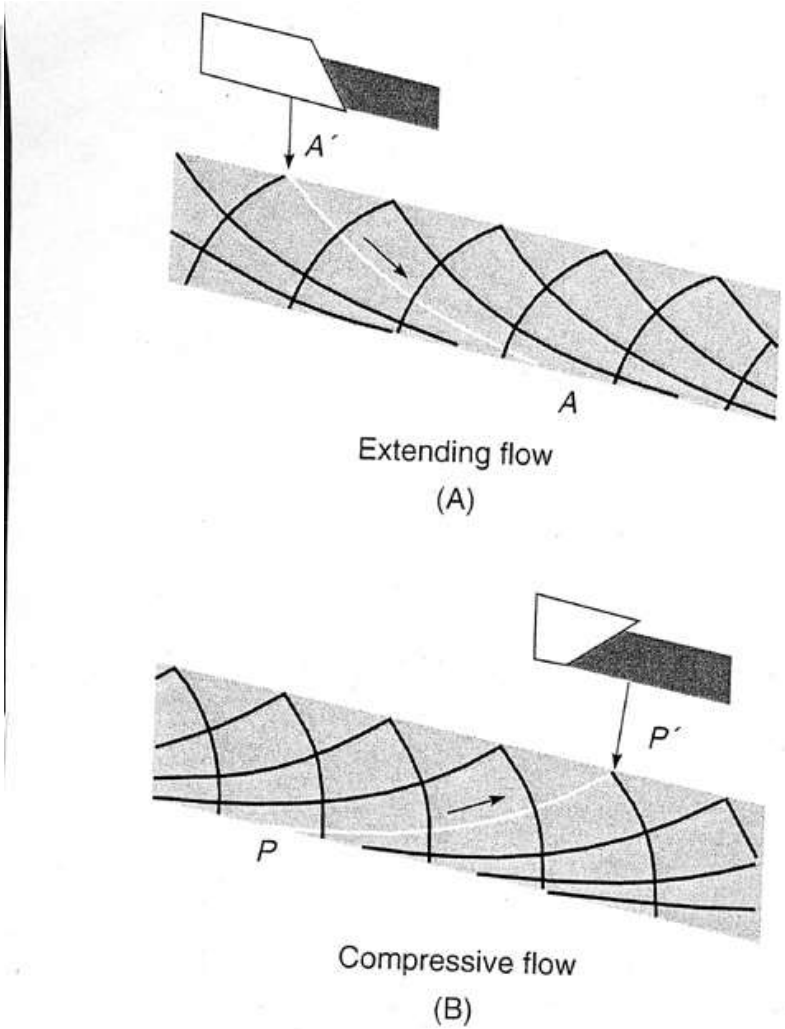


Figure 9.15
Potential slip planes under (A) extending and (B) compressive flow. The preferred downglacier slip paths will follow A-A' and P-P'.
(Nye 1952a)