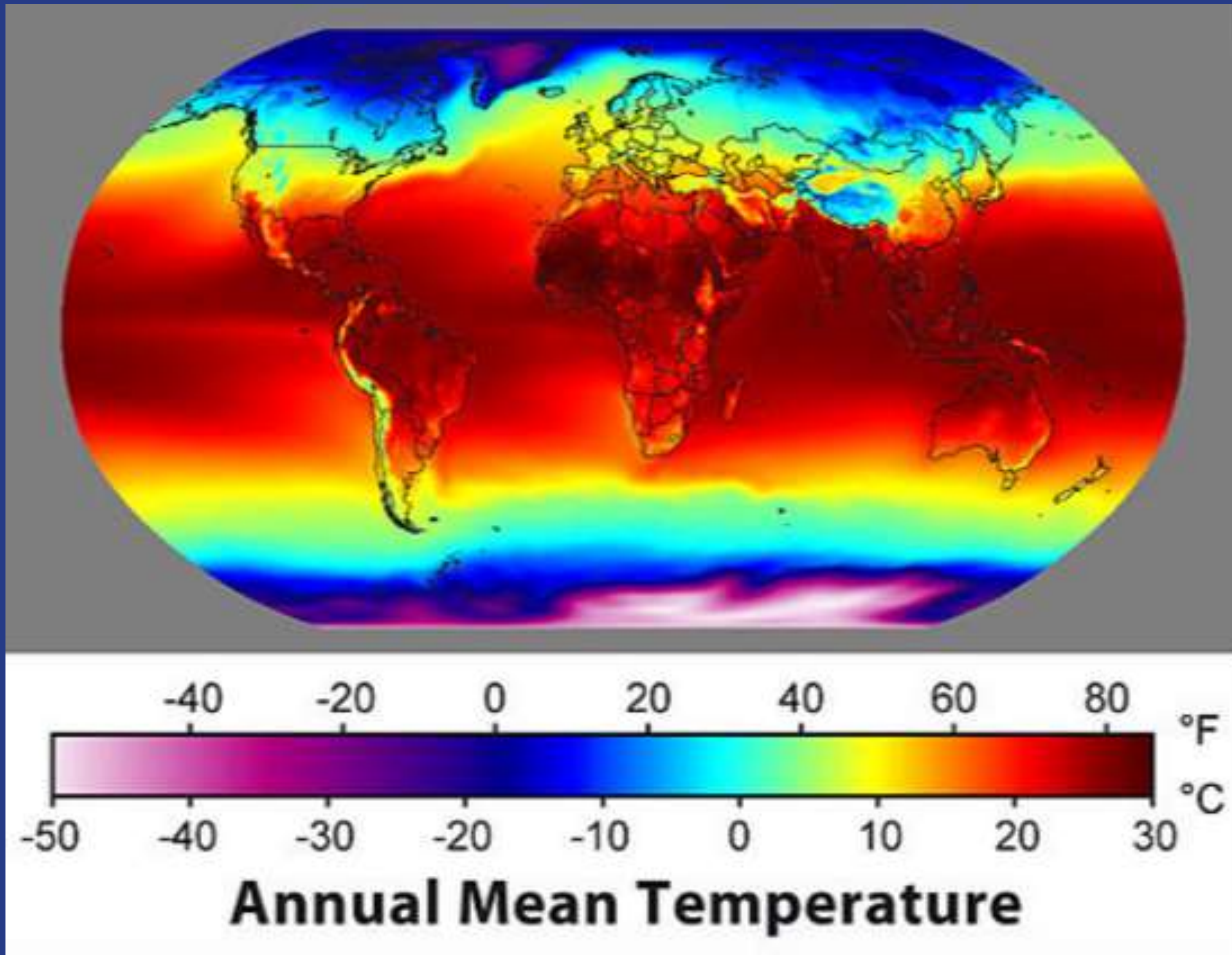
General Geology, Lesson 9 continued

Glacial landscapes and sediments

A. M. Celâl Şengör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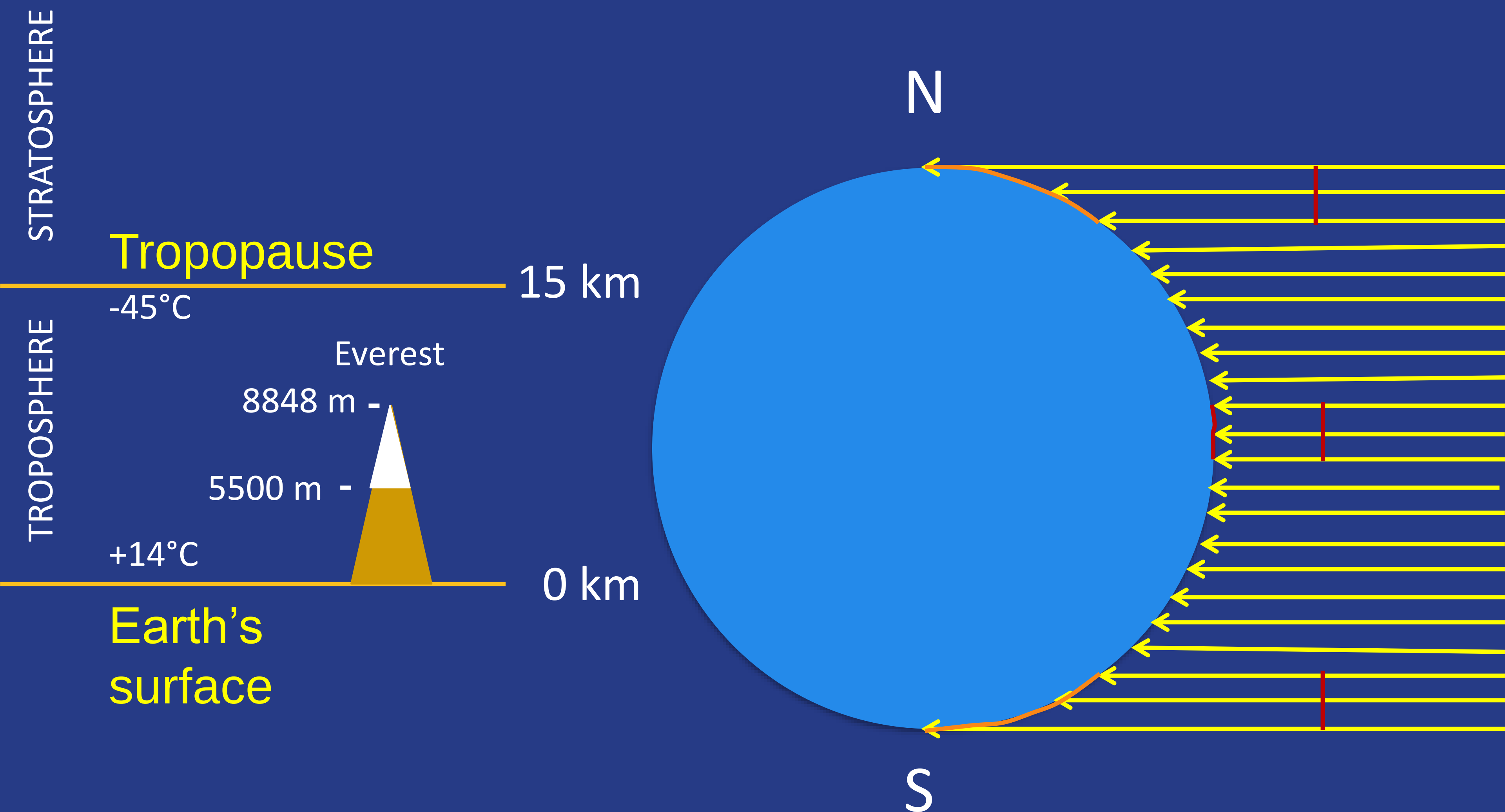
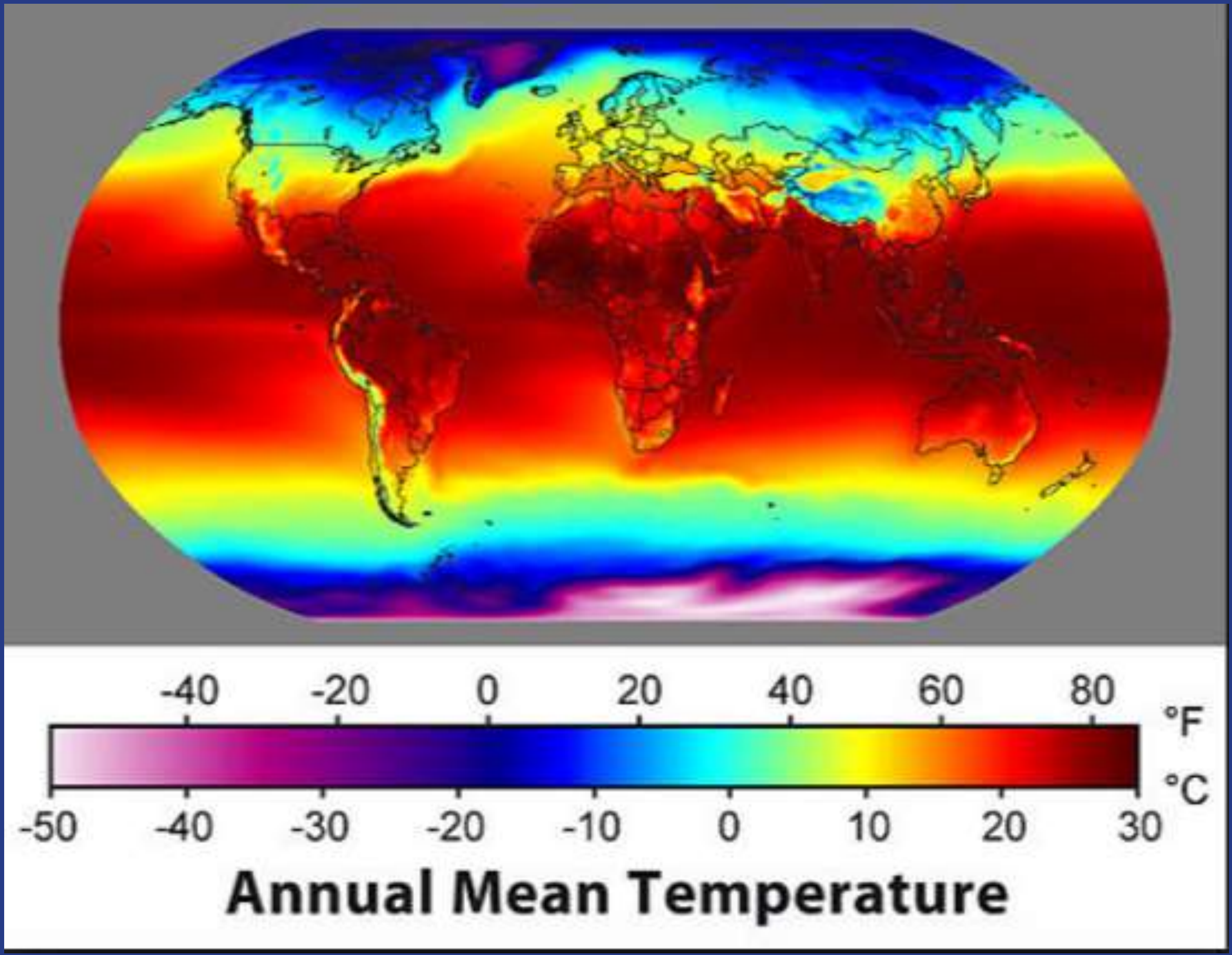
°F
°C
-50 -40 -30 -20 -10 0 10 20 30
Annual Mean Temperature



STRATOSPHERE
Tropopause
15 km
-45°C
TROPOSPHERE
Everest
8848 m
5500 m
+14°C
0 km
Earth's surface
N
S

Snowline at Everest, the Himalaya Mountains: Nepal and Xizang, People’s Republic of China

Snowline at Weisshorn, in the Central Alps, Switzerland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°F
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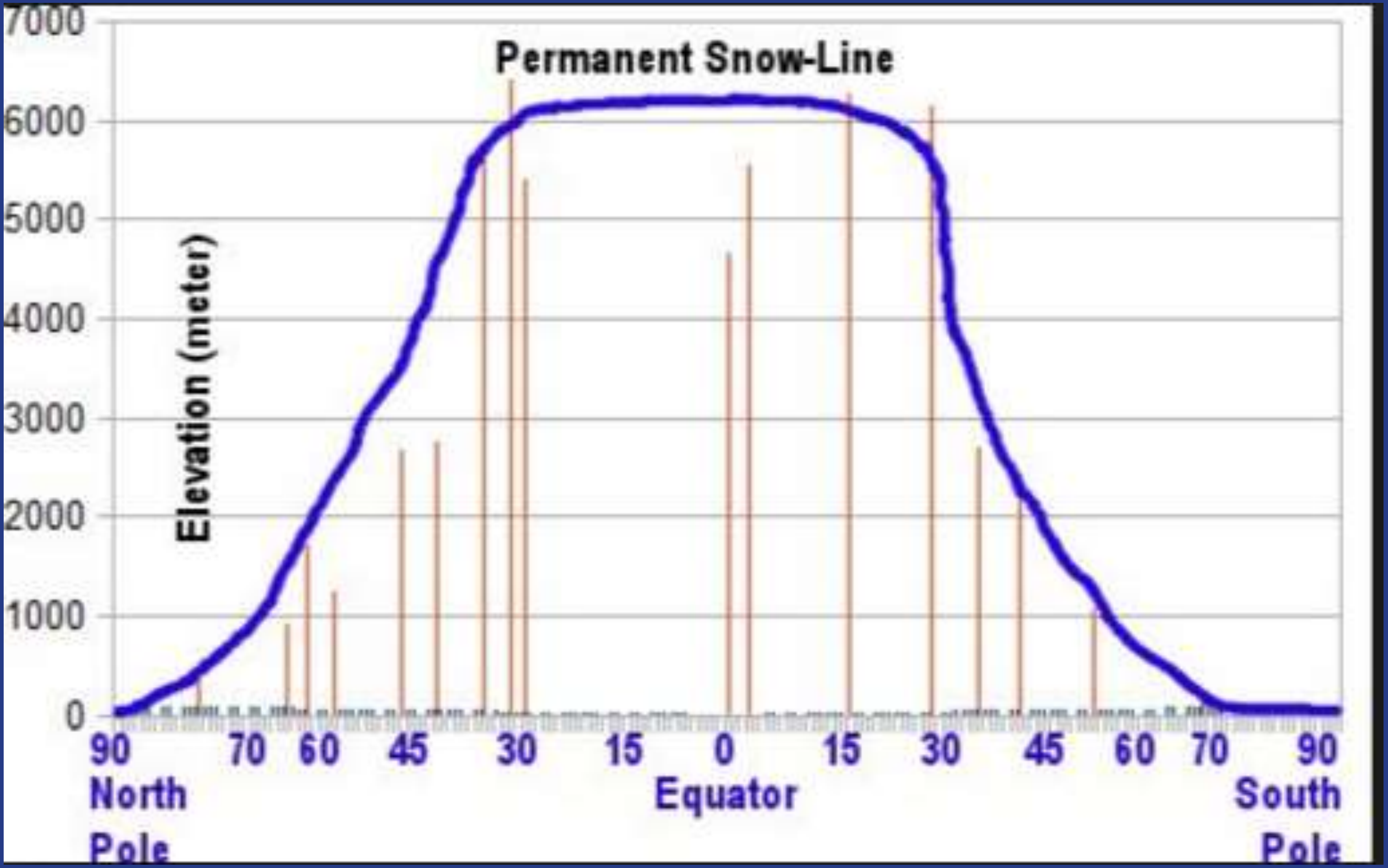
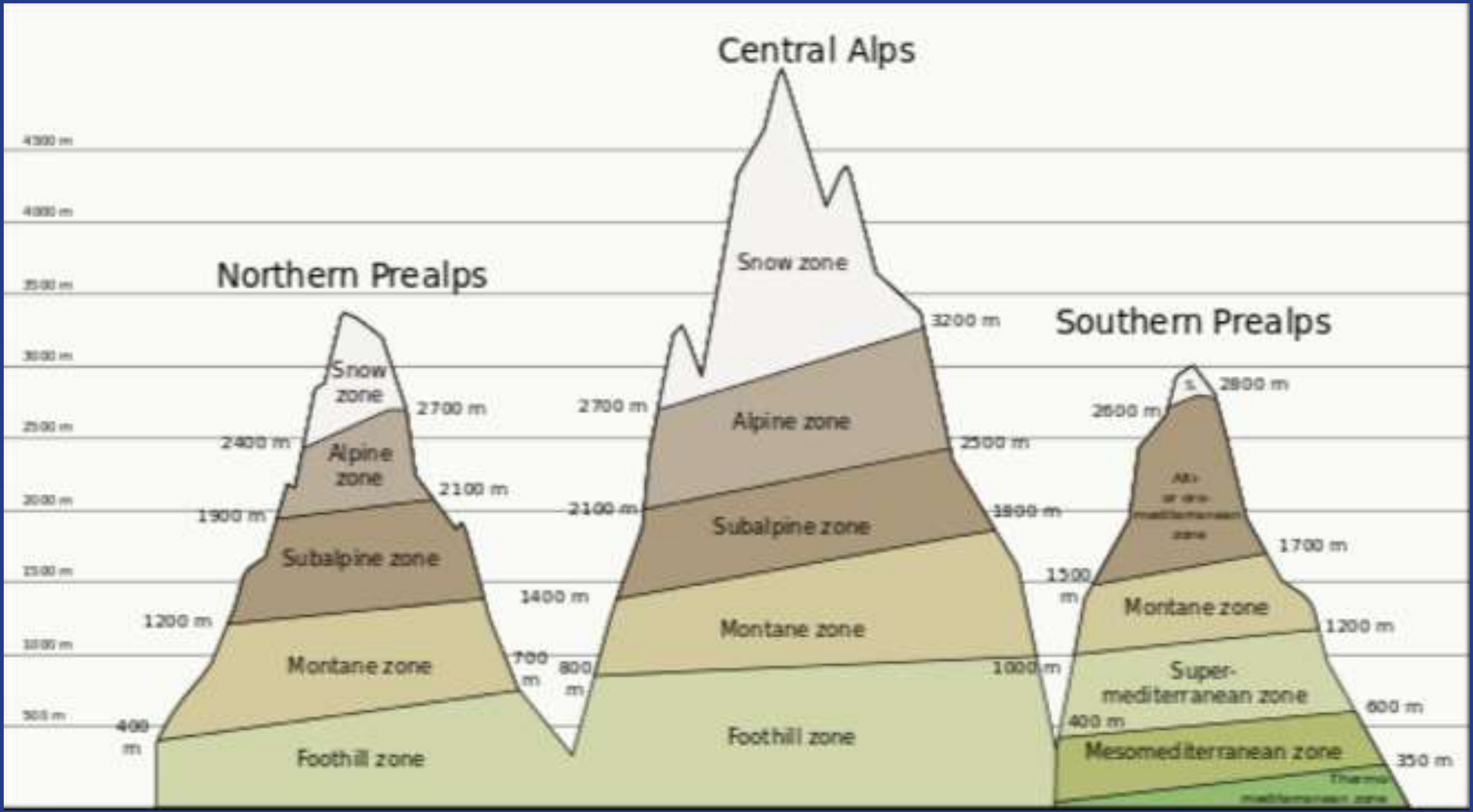
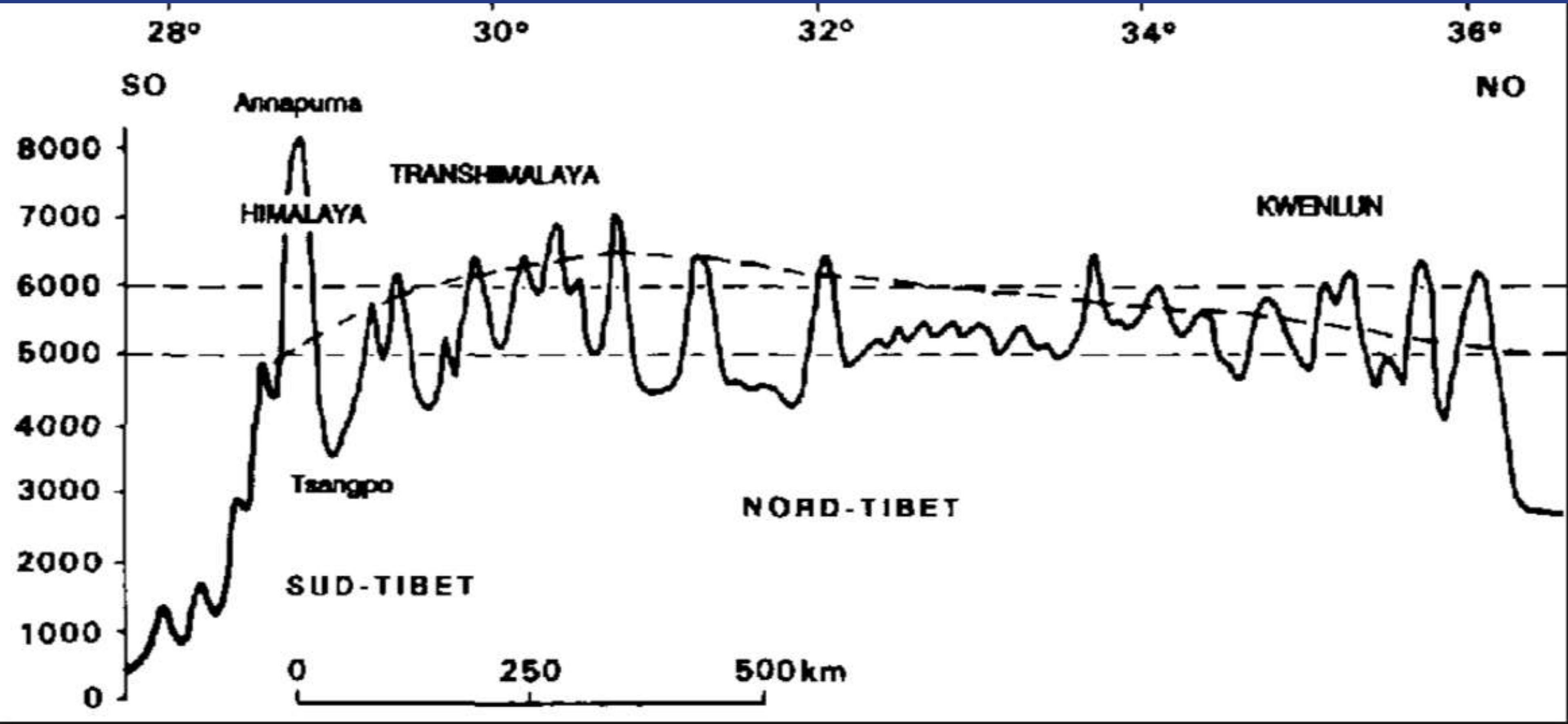
-50 -40 -30 -20 -10 0 10 20 30
Annual Mean Temperature



Variation of snowline elevation from pole to pole on earth.



The variation of elevation of the snowline in the Alps



The variation of the elevation of the snowline in the Himalaya and in Tibet (Qinghai-Xizang Plateau, People's Republic of China)

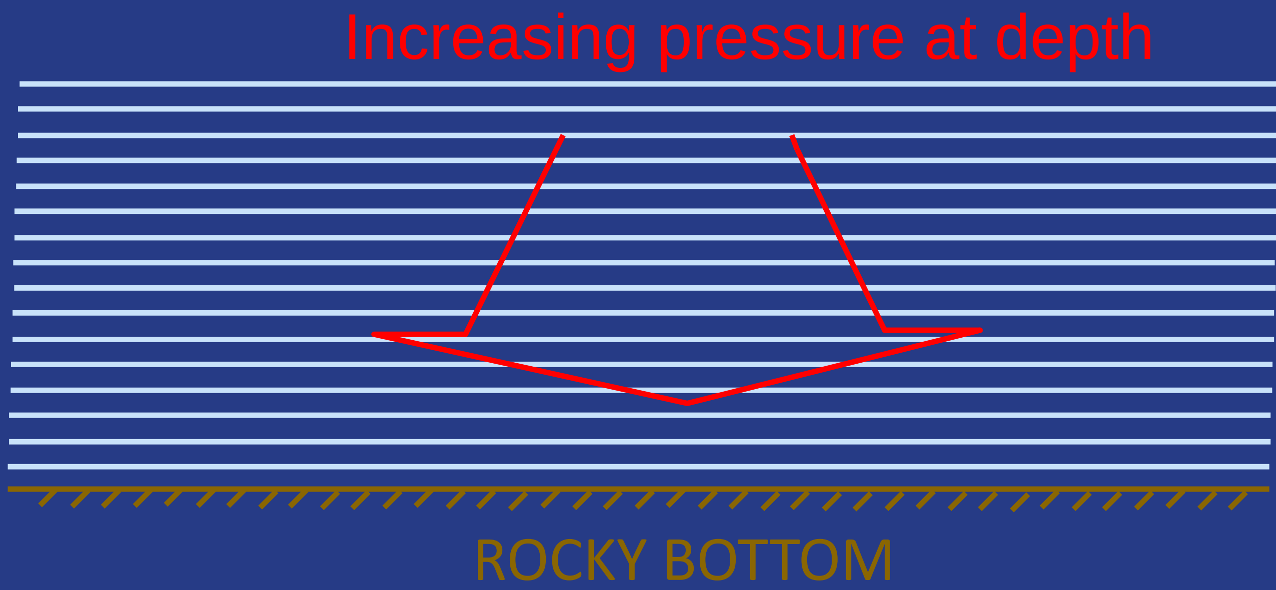
Factors influencing the elevation of the snowline:

Latitude (because it determines the average temperature of the region)

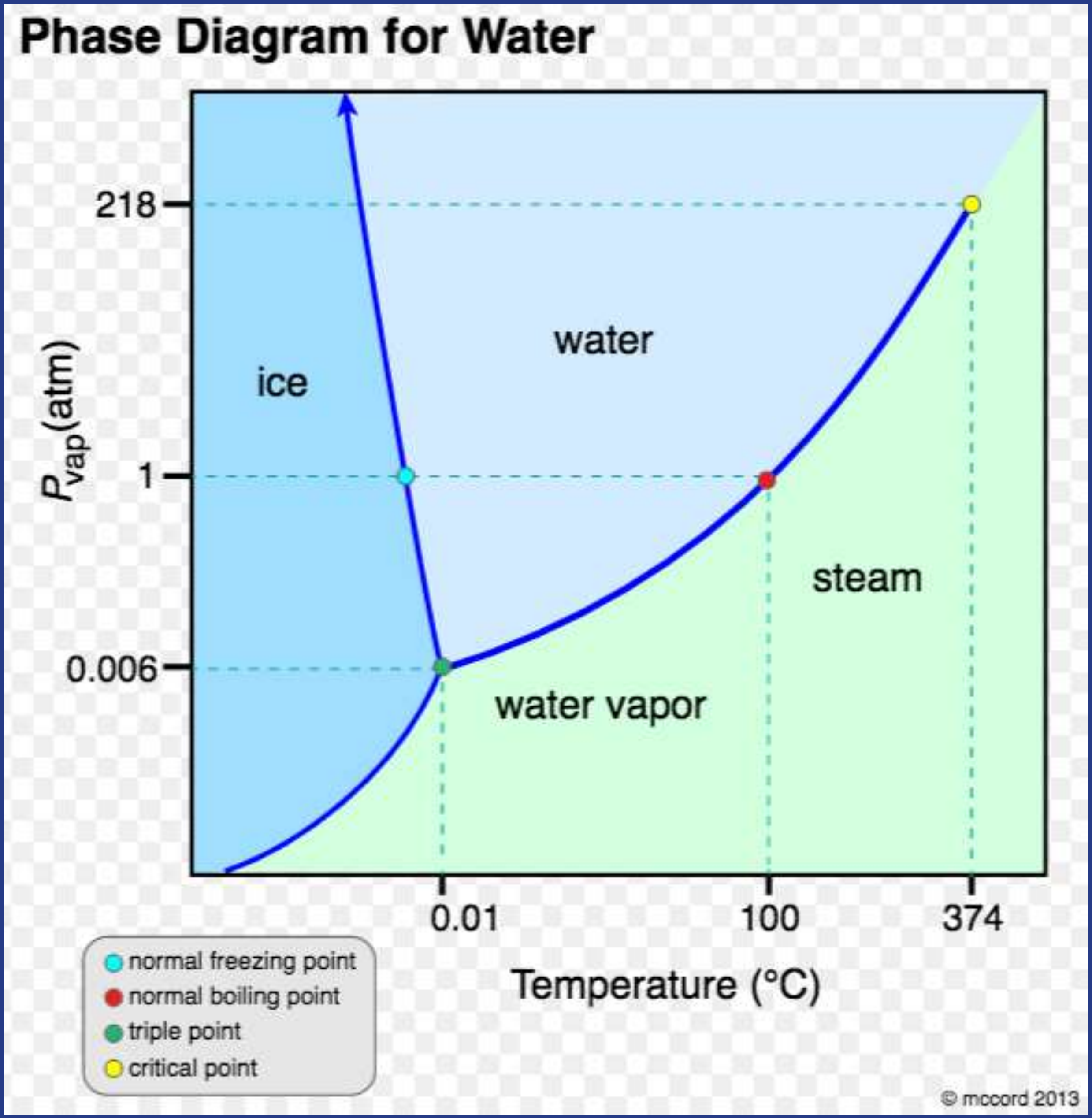
Facing of the slope (snowline is higher on slopes facing the equator: in the northern hemisphere slopes facing north have lower snowline than slopes facing south. In the southern hemisphere, slopes facing south have lower snowline than slopes facing north).

Availability of moisture (snowline is higher in dry regions than in wet regions).

Above the snowline, snow accumulates year after year and turns into ice.



Accumulated snow layers at Kilimanjaro, Africa

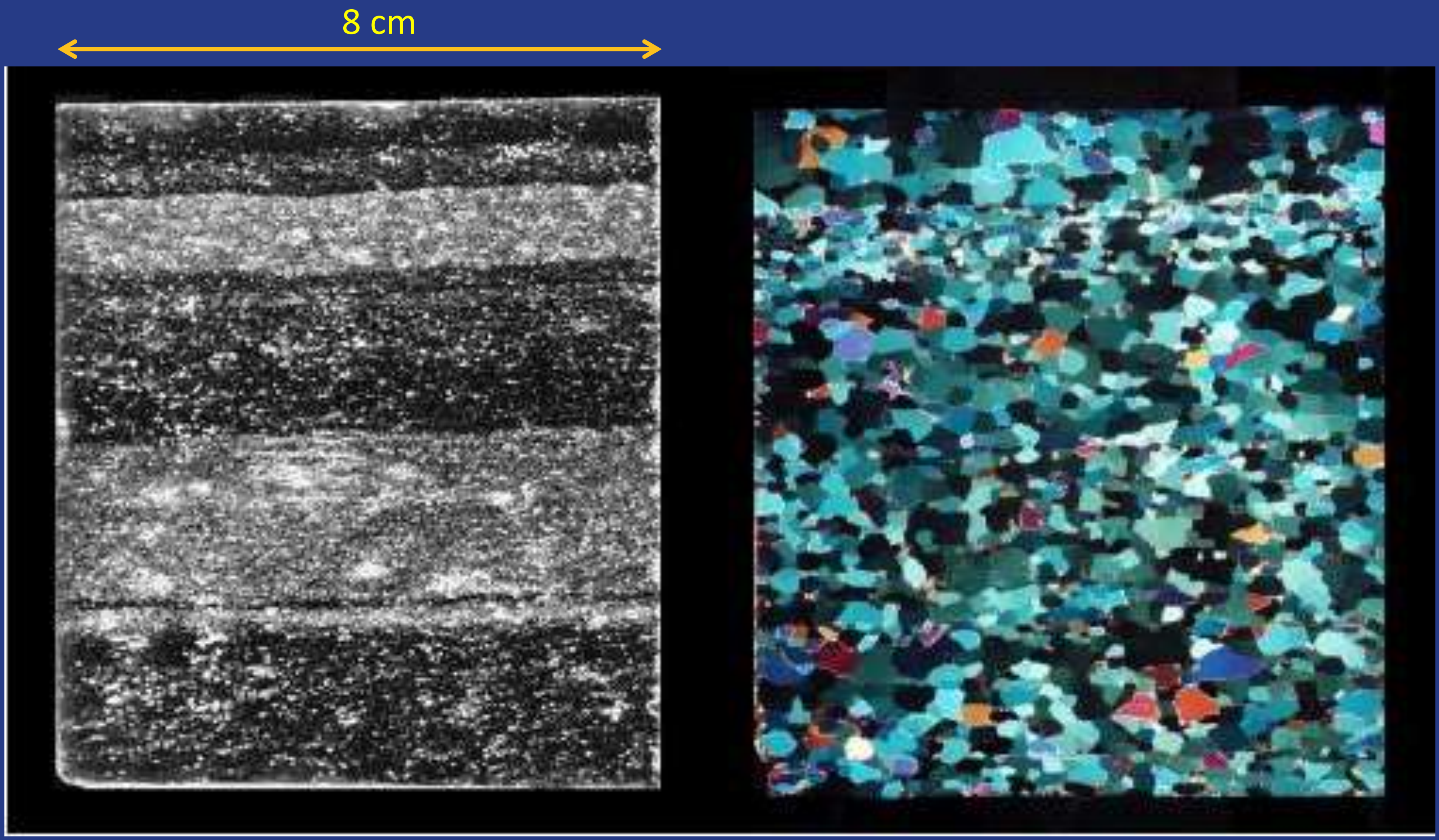


The phase diagram of H_2O

This is what ice crystals look like under a polarising petrographic microscope. The different colours result from different crystal orientations.

Ice under a few hundred metres of overburden

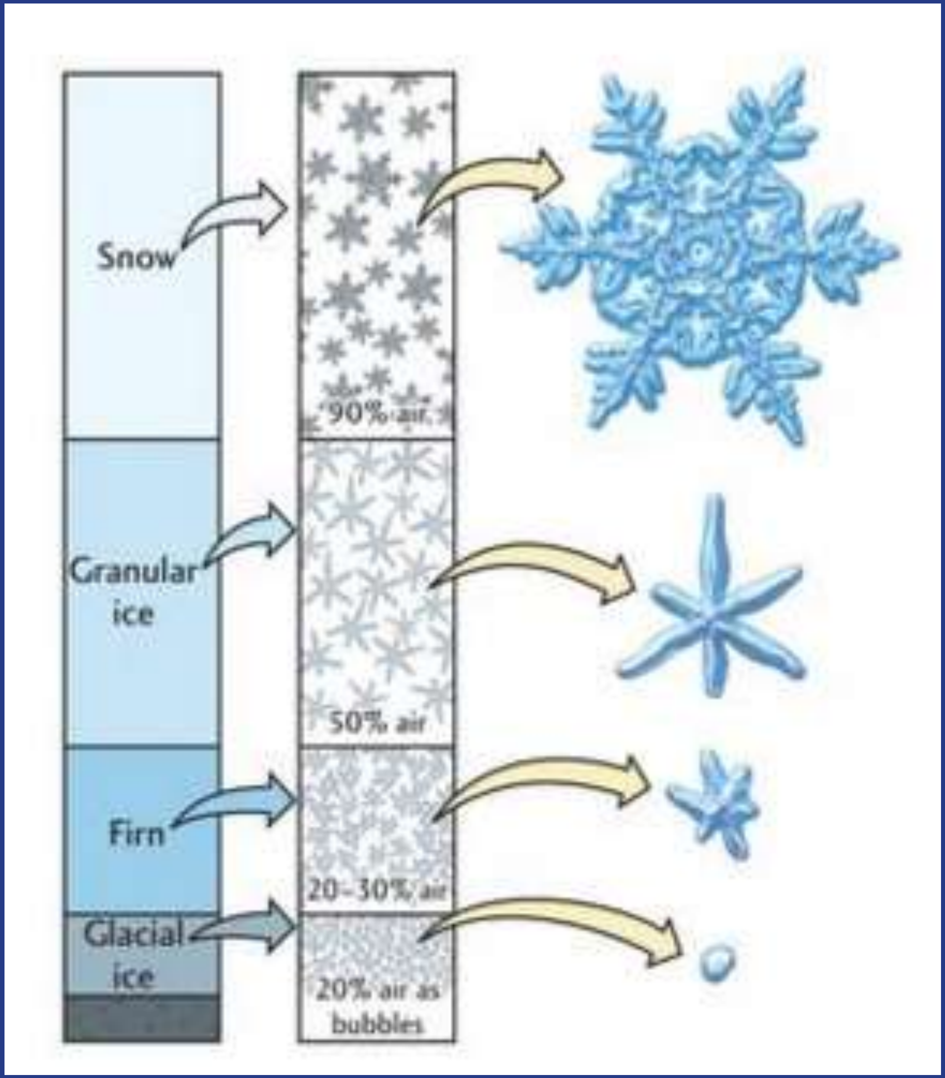
Ice under a couple of kilometres of overburden

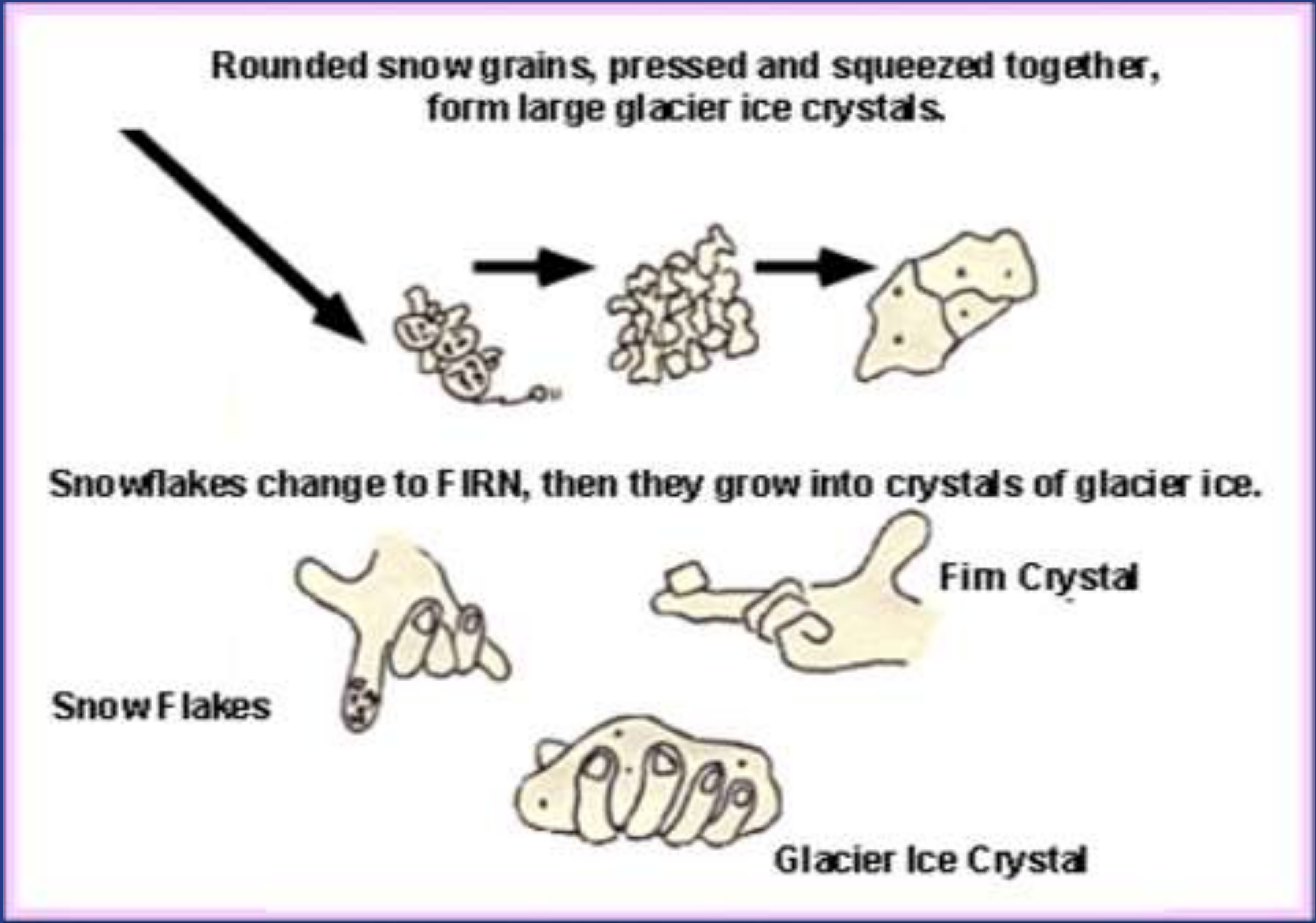


Ice layers defined by more and less dusty accumulations. The darker layers are the dustier accumulations. Note that the ice crystals in the dustier layers are smaller.

The amount of impurities and the crystal size dependent on those impurities in the ice layers determine their colour.

Ice crystlas evolve in the following way:





Firn, also called névé from the French, represents the small-crystal ice accumultion on the larger ice masses. As Firn gets lower because of further snow accumulation on top, it gets further compacted and gets completely metamorphosed into glacier ice.

Snow developing into firn and glacier ice with increasing depth. The blue colour of the glacial ice is commonly a result of the impurities in contains.

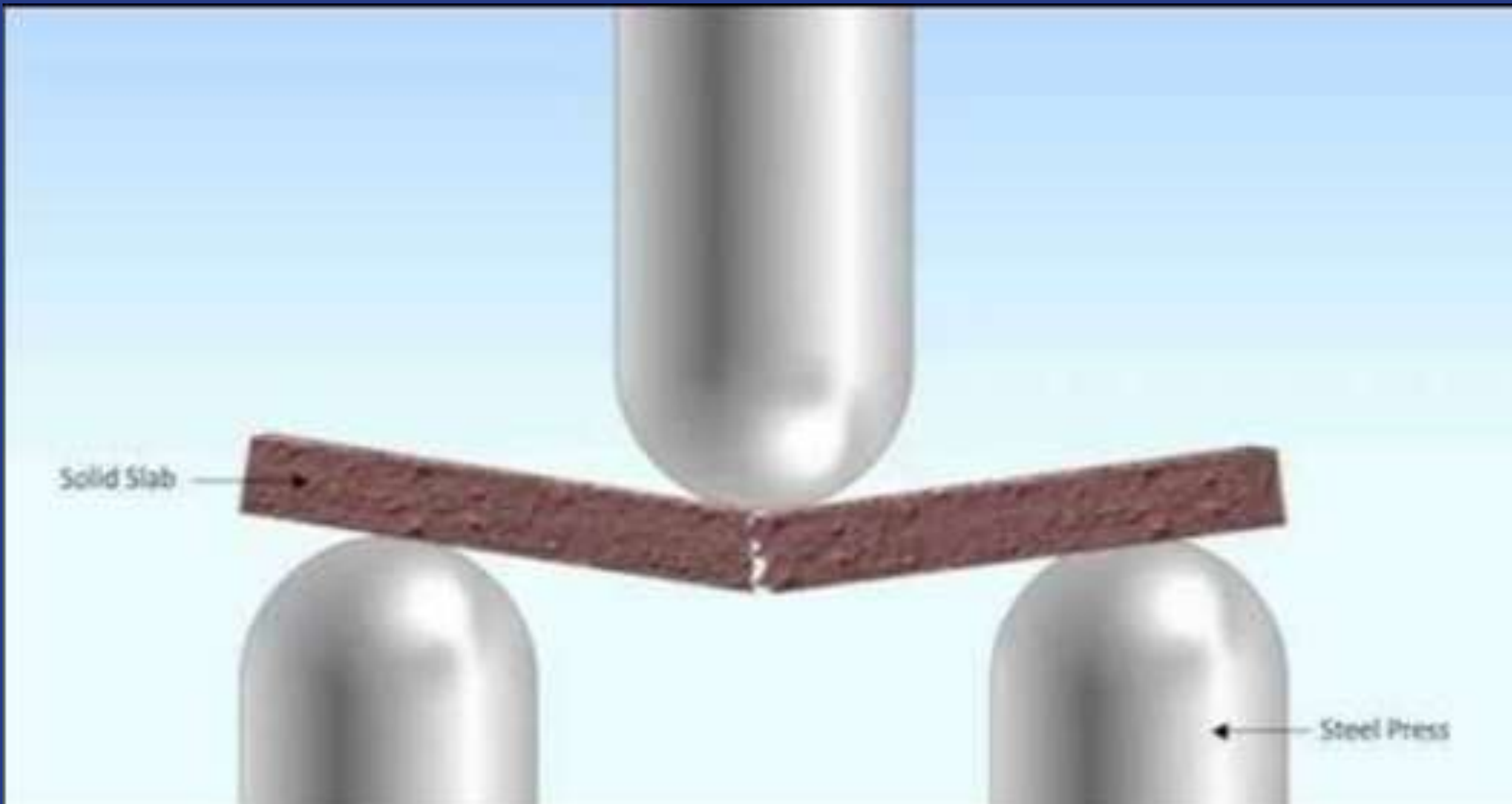
When ice accumulates and its volume becomes larger than its basin of accumulation it begins to flow outwards. Glacier ice flows by means of plastic deformation.

Solids deform under stress by three mechanisms:

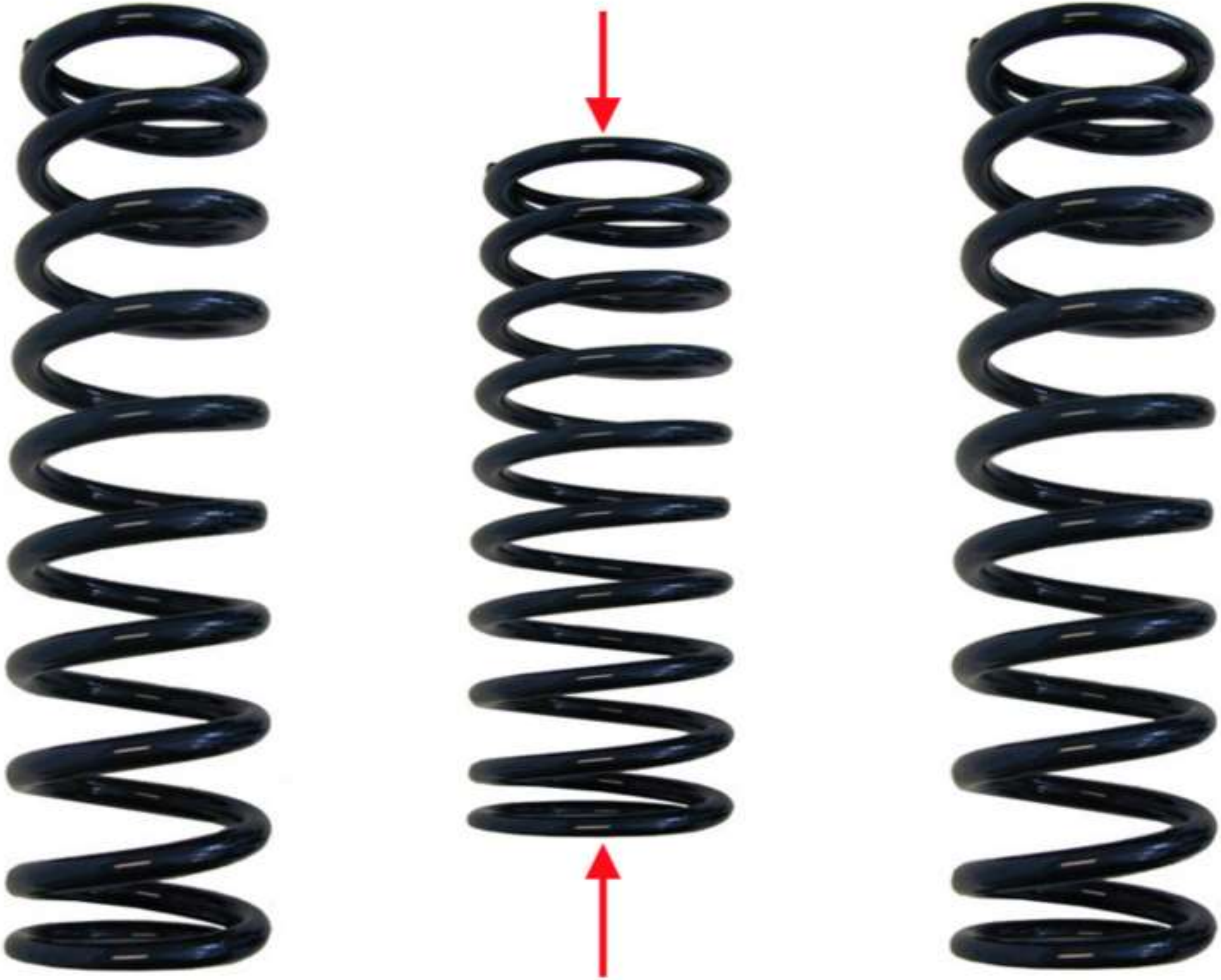
1. Brittle: by breaking under applied stress

2. Elastic: the material returns to its original shape when the applied stress is removed

3. Plastic: The material flows and remains deformed when the applied stress is removed.


Solid Slab
Steel Press

No applied force | While force is applied | α: reversible Elastic deformation




Plastic Deformation
Permanent change in shape

When ice begins flowing out of its basin of accumulation, it forms solid rivers of ice, called glaciers.

Franz Josef Glacier Fox Glacier

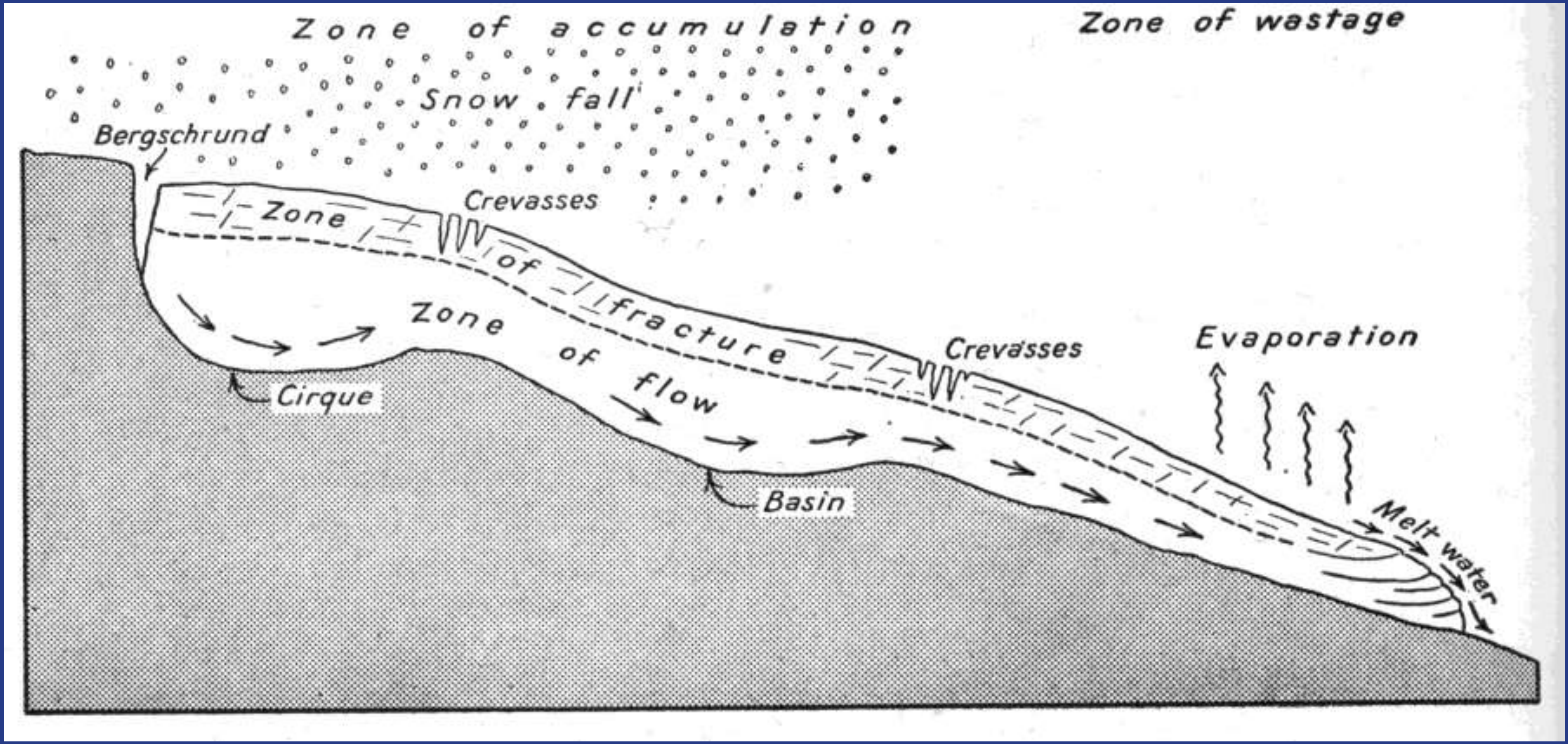
Franz Josef and Fox glaciers in New Zealand

The Baltoro Glacier, Karakorum Mountains, Baltistan, Pakistan/India frontier region

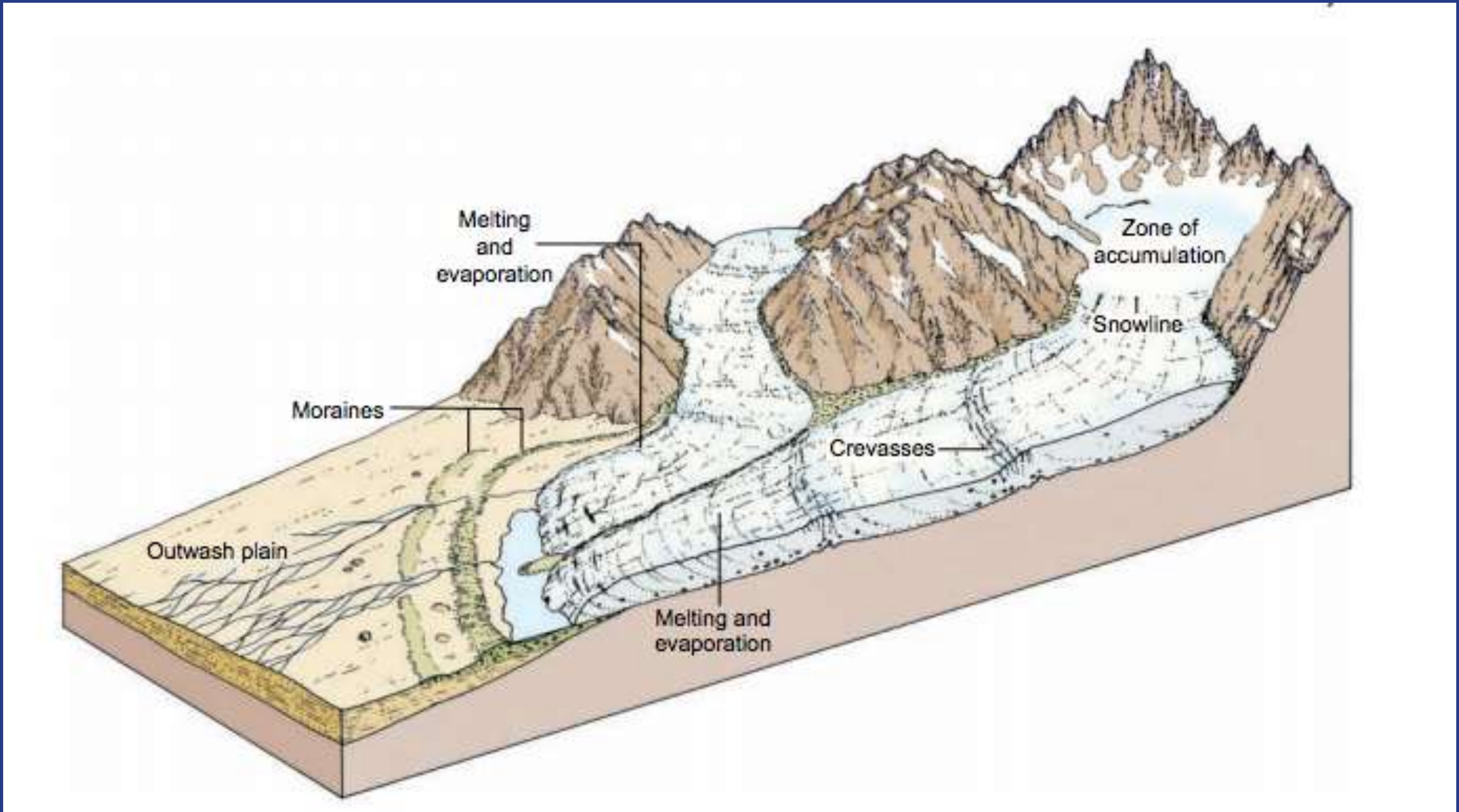
The Great Aletsch Glacier, The Alps, Switzerland

The birth place of the Great Aletsch Glacier

The present-day end of the Great Aletsch Glacier



Longitudinal profile of a glacier



A glacial system

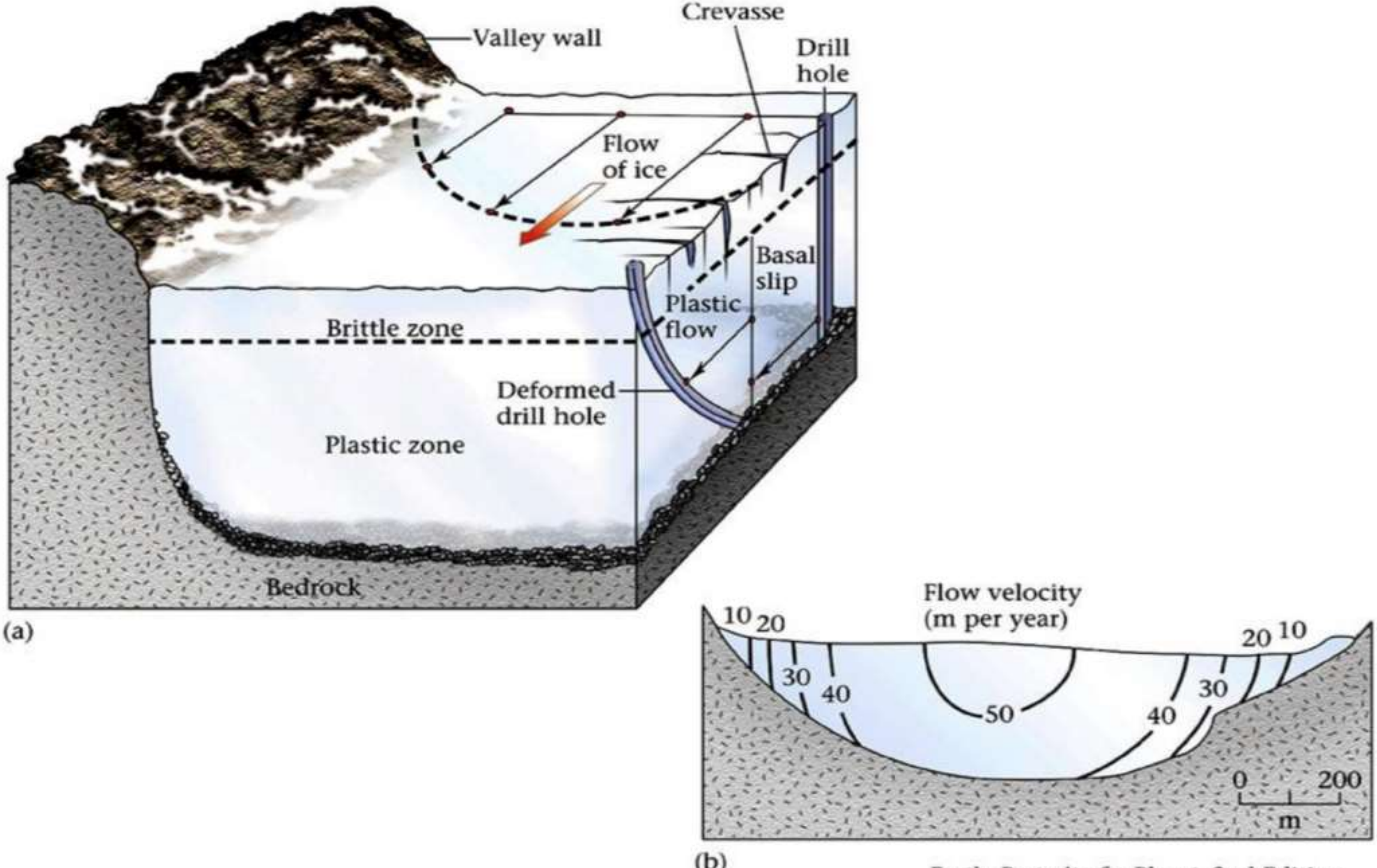


FIGURE 22.11

Earth: Portrait of a Planet, 2nd Edition
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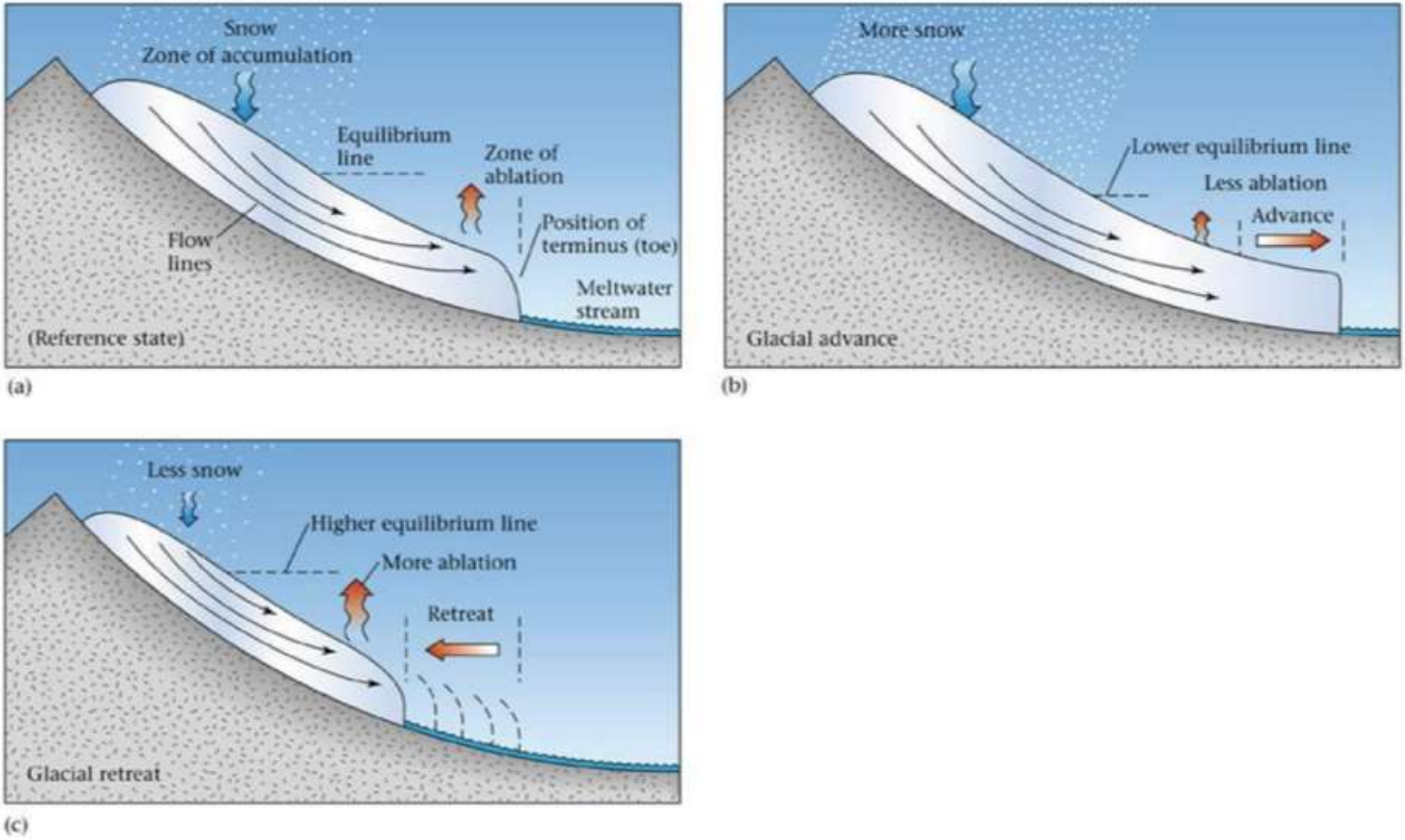
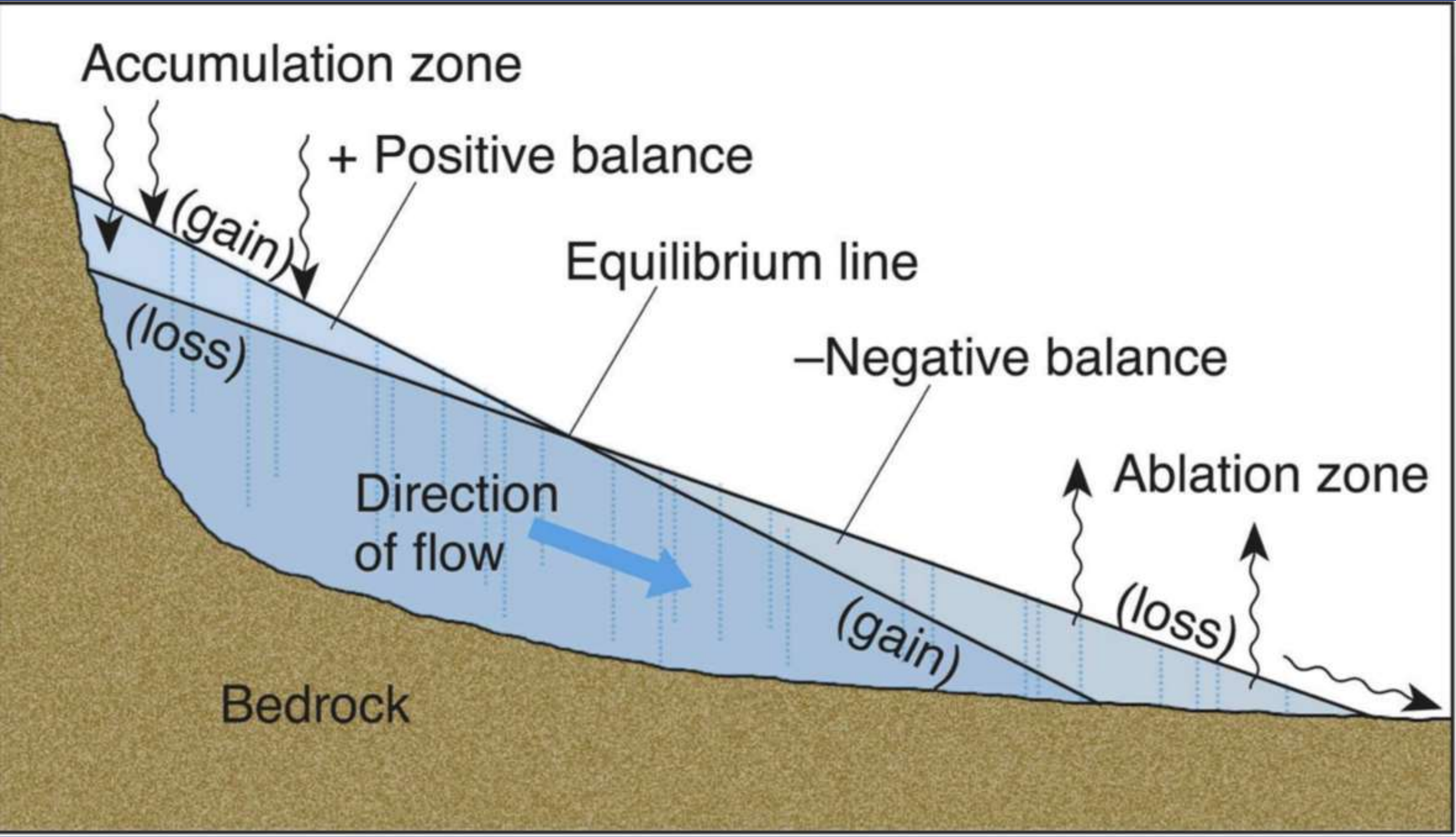
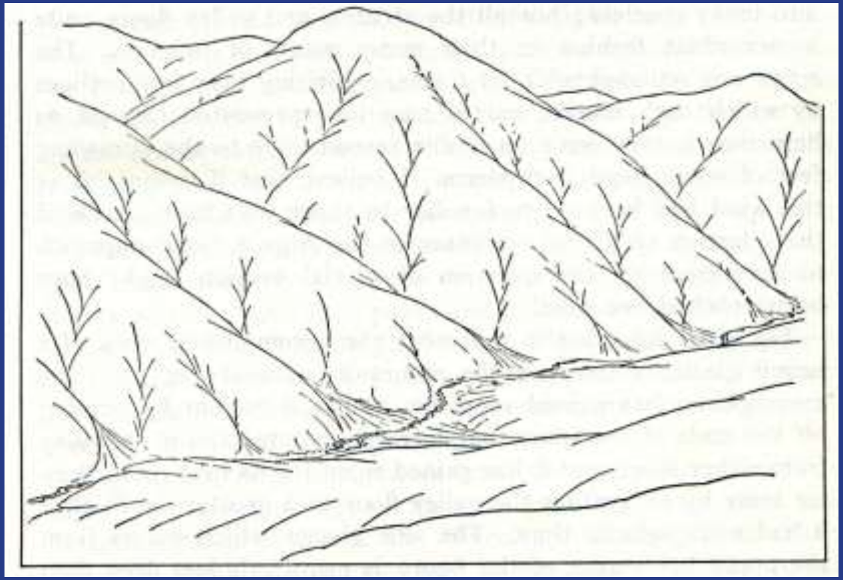
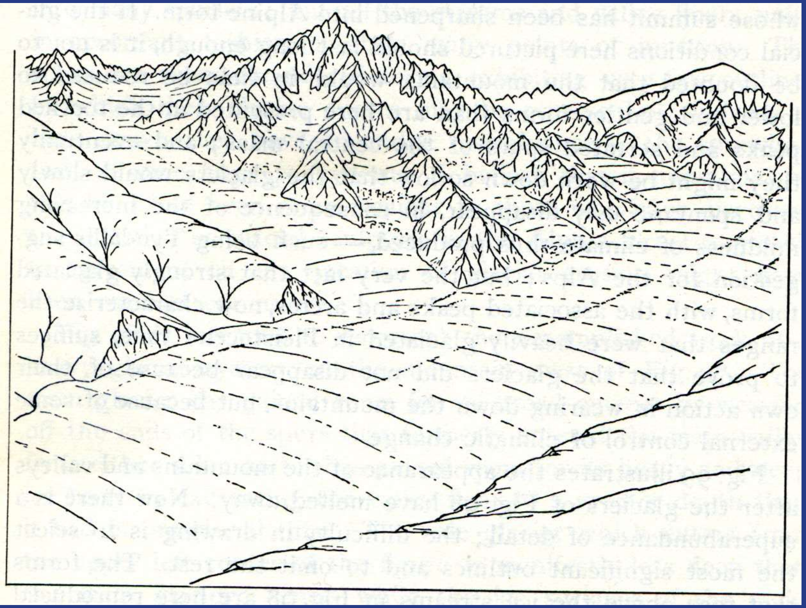
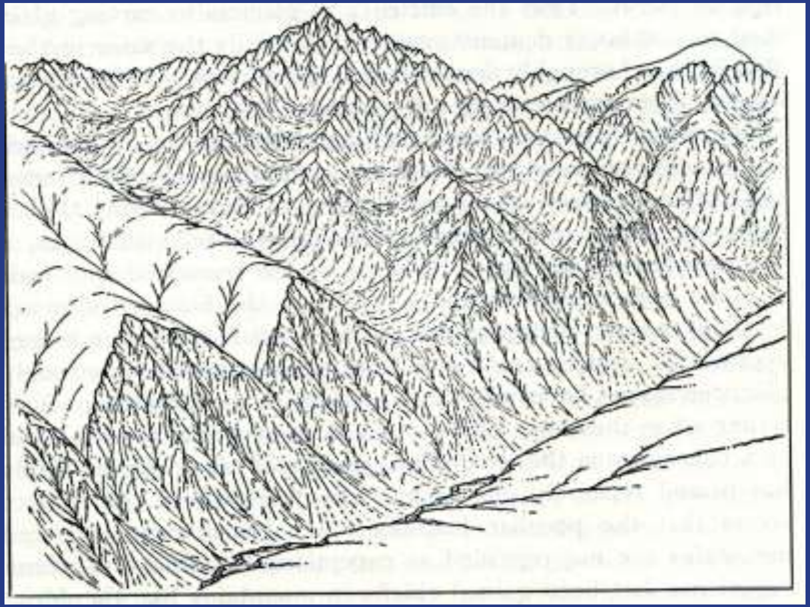
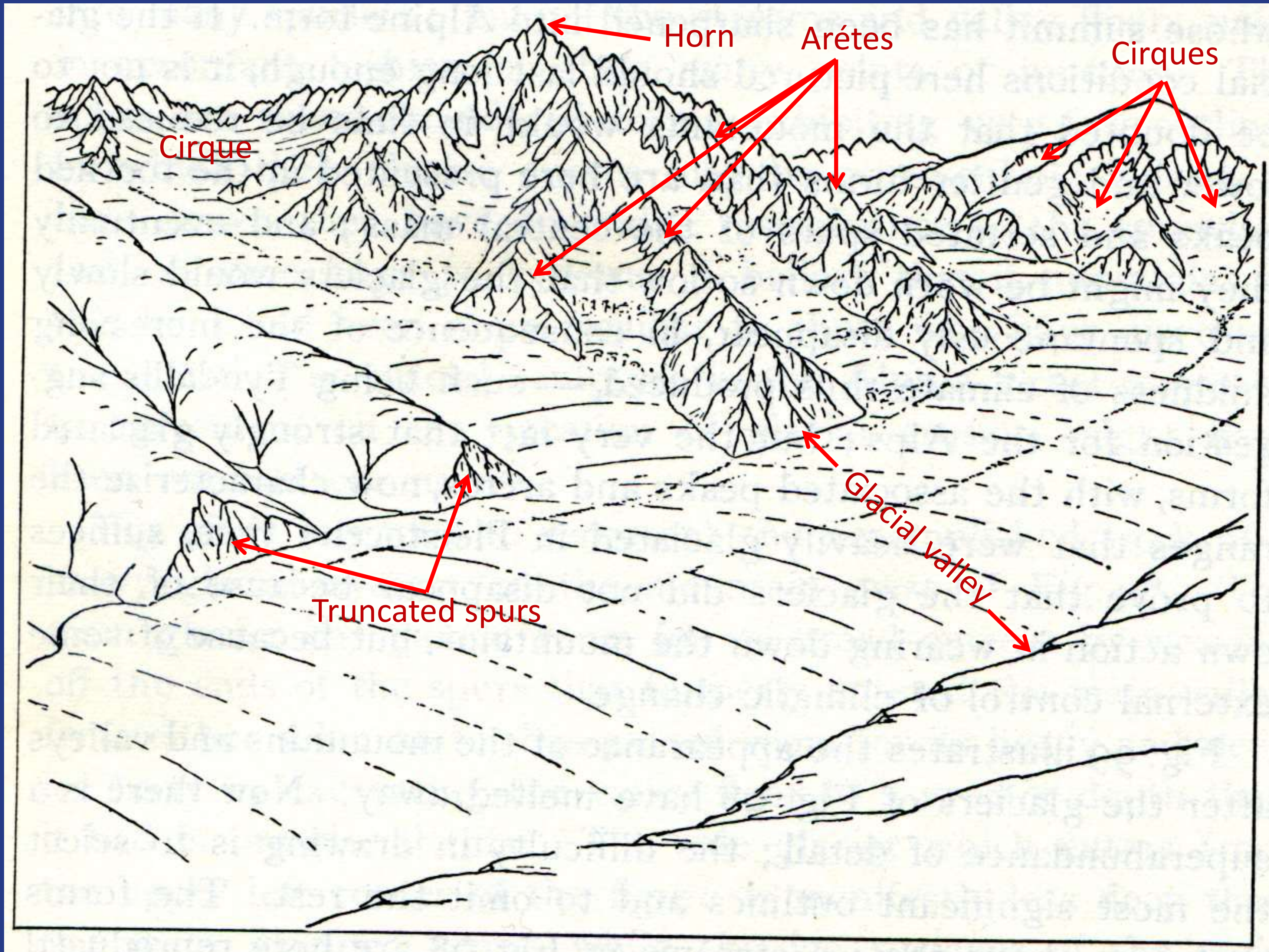


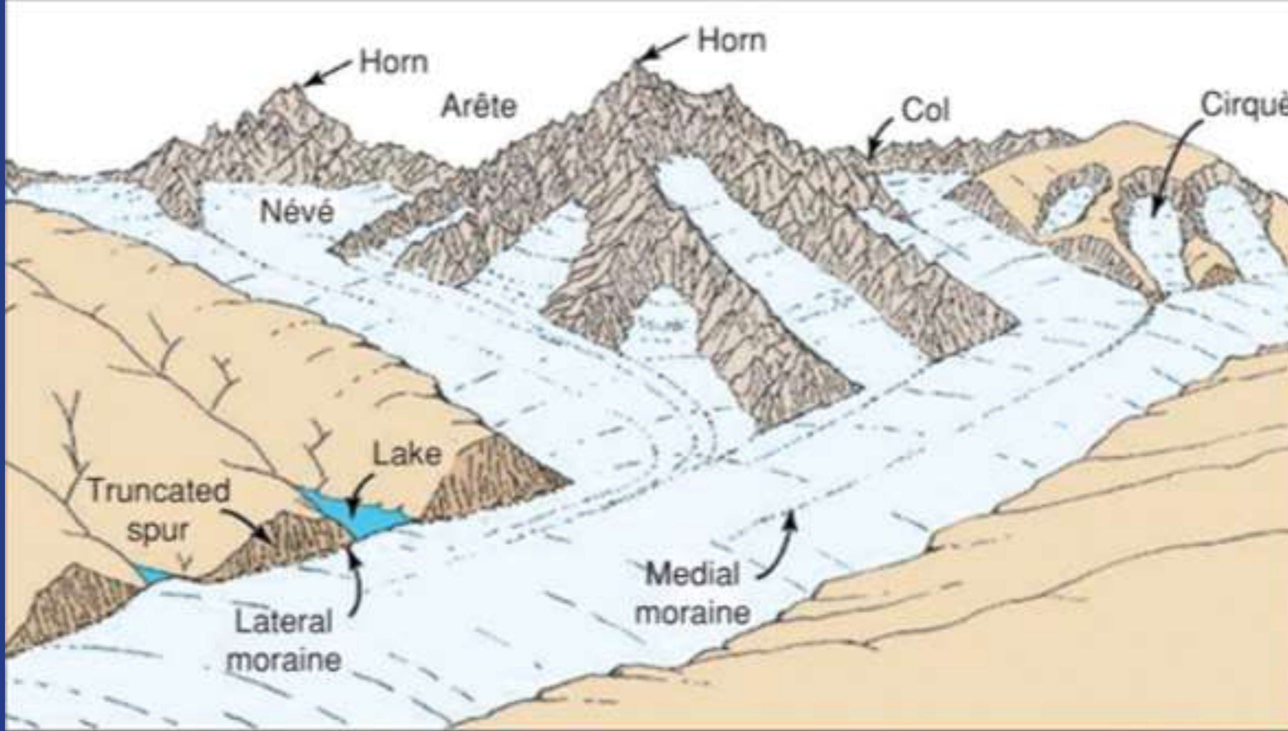
Stationary, advancing and retreating glaciers

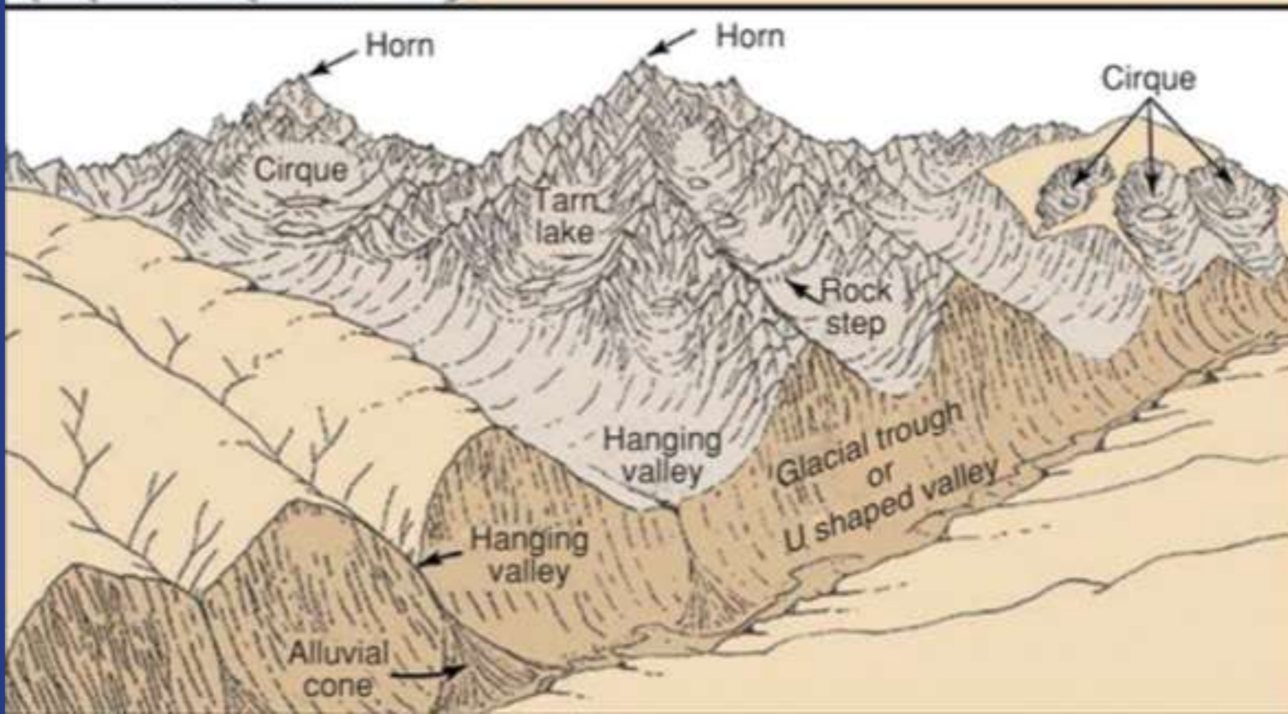

Accumulation zone
+ Positive balance
(gain)
(loss)
Equilibrium line
–Negative balance
Ablation zone
Direction
of flow
(gain)
(loss)
Bedrock

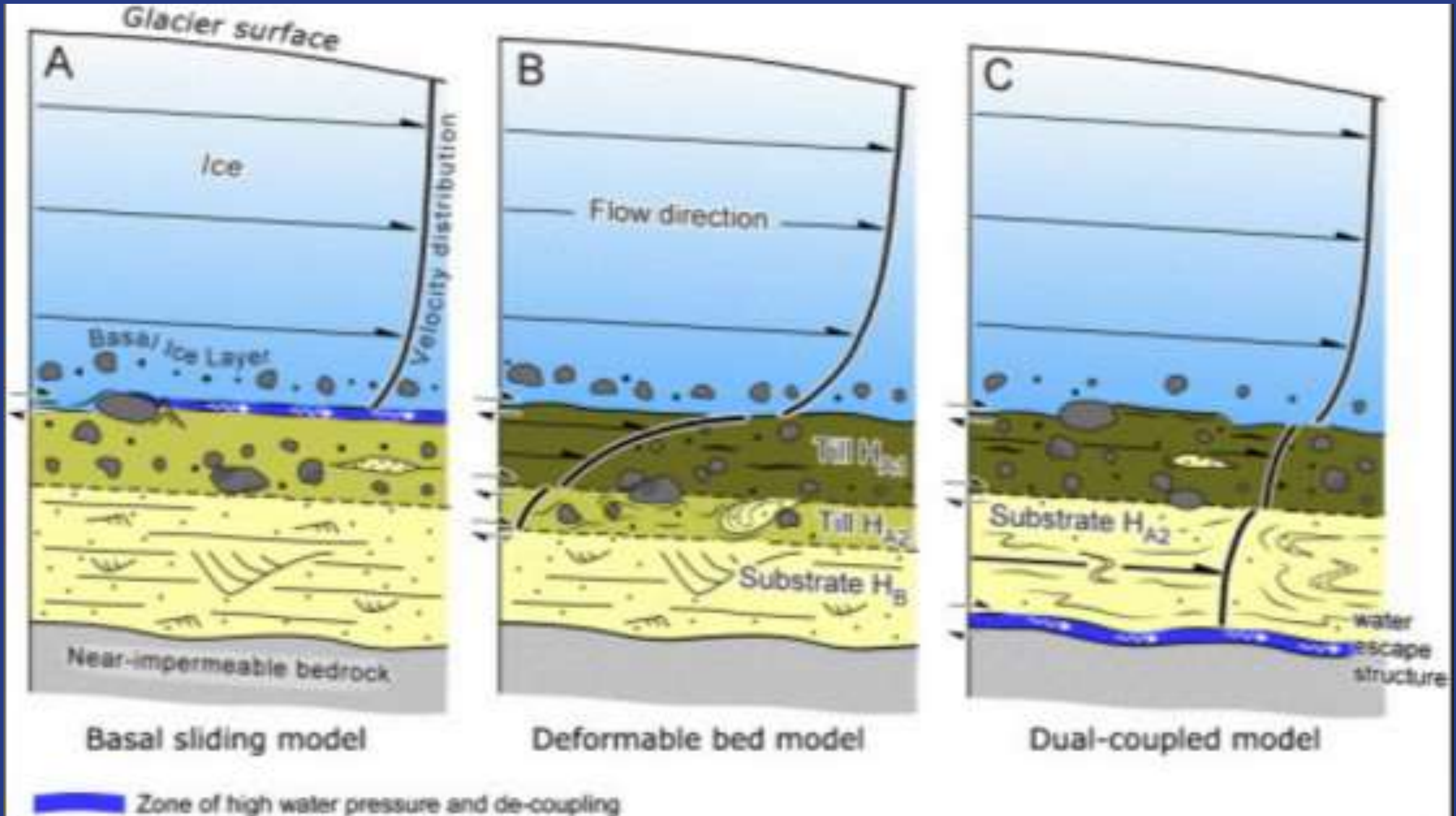




Evolution of glacial topography (after William Morris Davis)


Horn
Arétes
Cirques
Cirque
Glacial valley
Truncated spurs

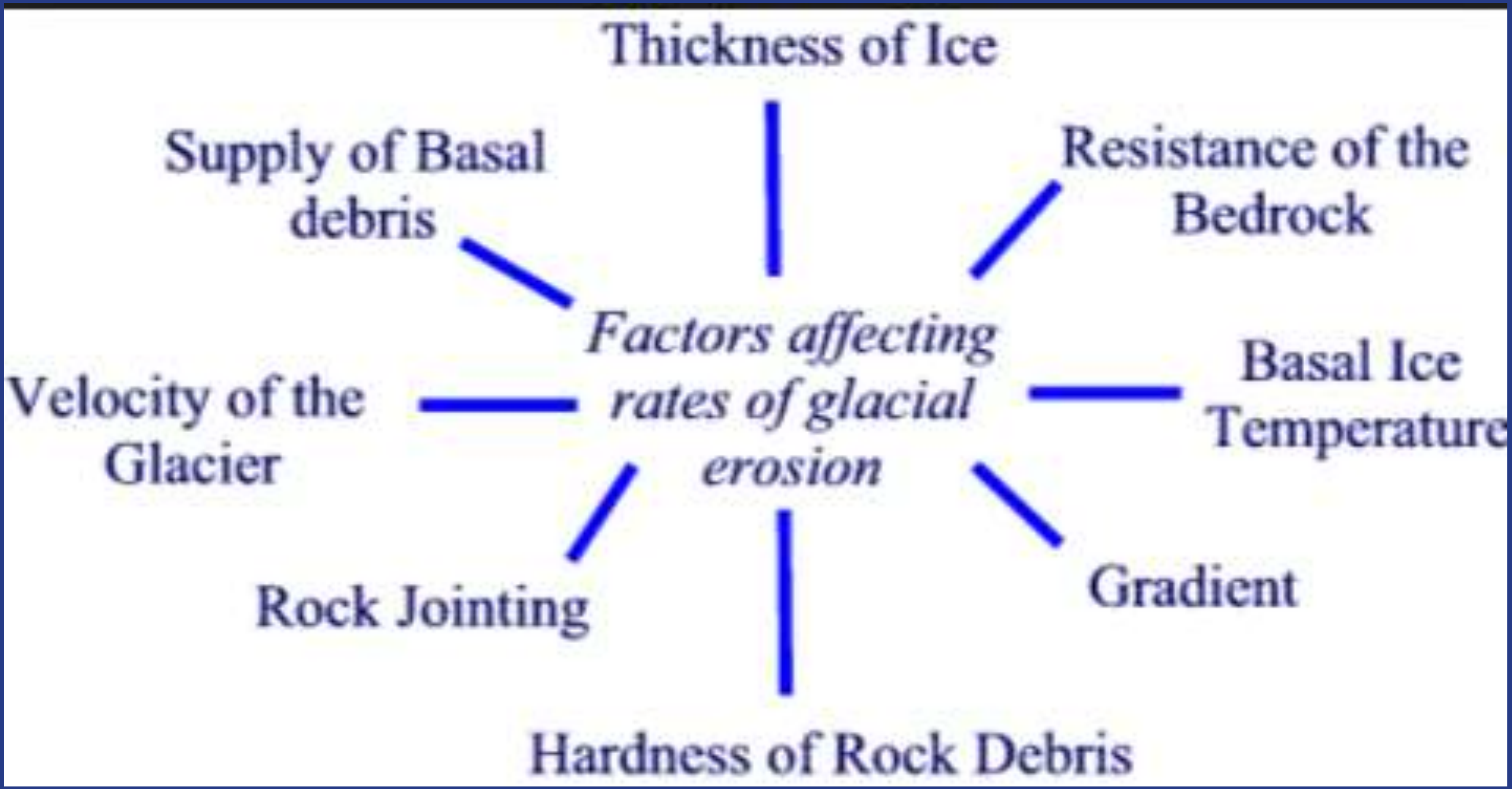

Horn
Horn
Arête
Col
Cirquè
Névé
Lake
Truncated spur
Medial moraine
Lateral moraine


Horn
Horn
Cirque
Cirque
Tarn lake
Rock step
Hanging valley
Glacial trough or U shaped valley
Hanging valley
Alluvial cone


Glacier surface
A
B
C
Ice
Velocity distribution
Flow direction
Basal Ice Layer
Till H_{A2}
Substrate H_B
Substrate H_{A2}
Near-impermeable bedrock
water escape structure
Basal sliding model
Deformable bed model
Dual-coupled model
Zone of high water pressure and de-coupling

Erosion by Glaciers (cont.)

- Alpine glaciers erode mountain slopes into horseshoe shaped basins called **cirques**
  - Melting forms cirque lake (**tarn**)
- Erosion of two or more cirques erodes intervening rock
  - **Horns :pointy peaks made by trios**
  - **Arêtes: long serrated ridges by pairs**
  - **Cols: passes through the arêtes**


Thickness of Ice
Supply of Basal debris
Resistance of the Bedrock
Factors affecting rates of glacial erosion
Velocity of the Glacier
Basal Ice Temperature
Rock Jointing
Gradient
Hardness of Rock Debris

V U

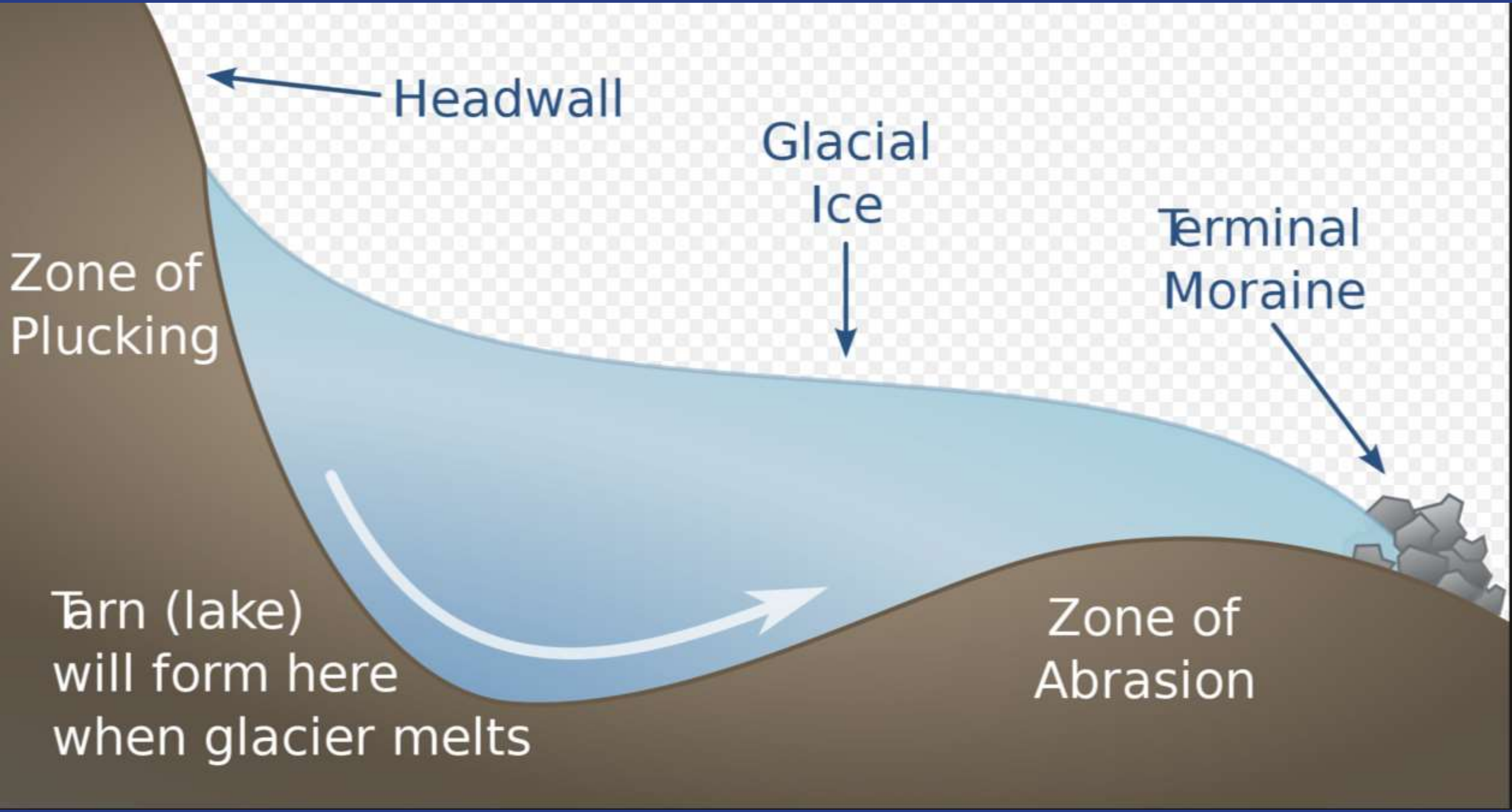
Fluvial valley Glacial valley

A typical V-shaped fluvial valley with its stream

A typical U-shaped glacial valley after the disappearance of the glacier.

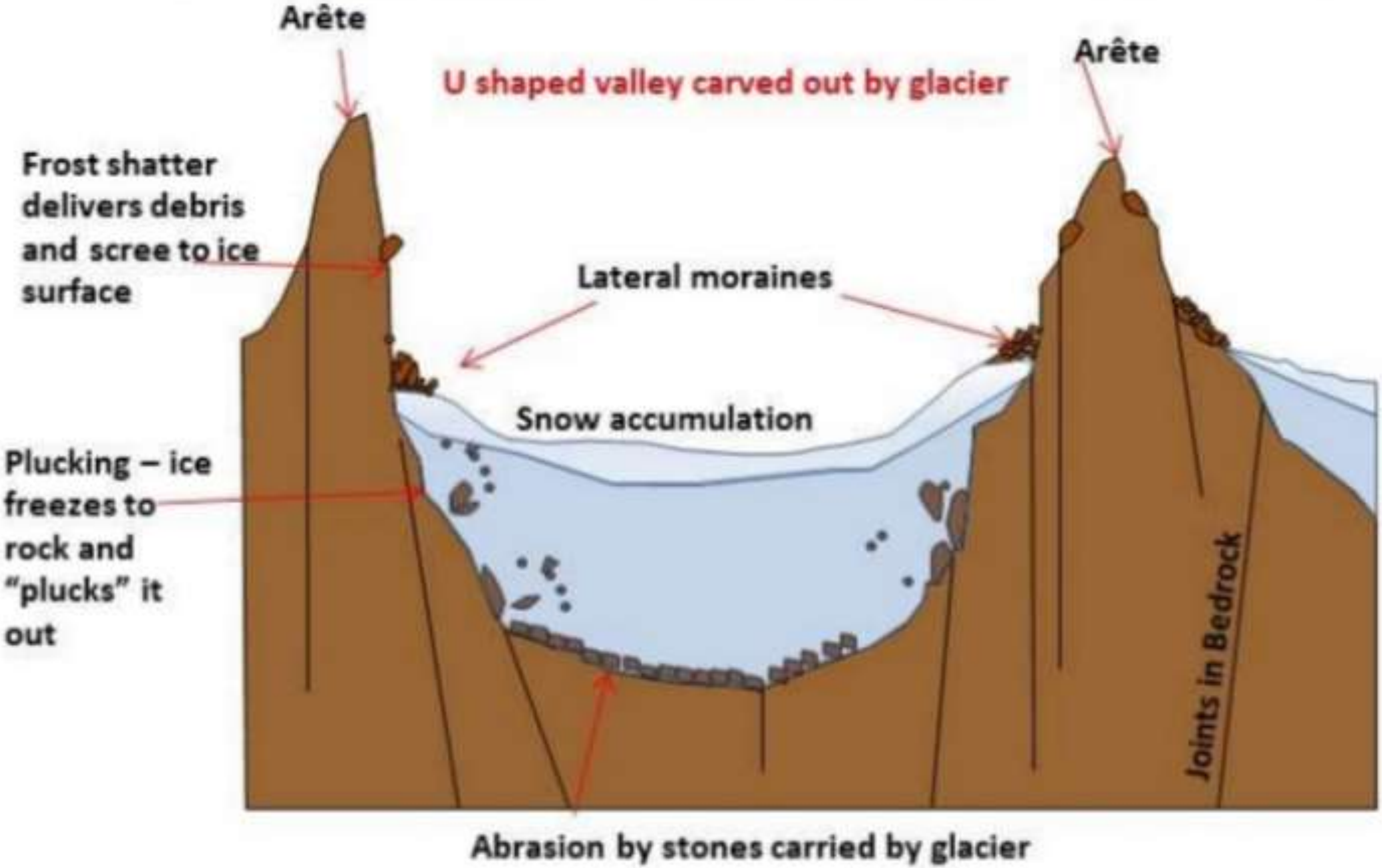
The glacial valleys of Vorarlberg, Austrian Alps

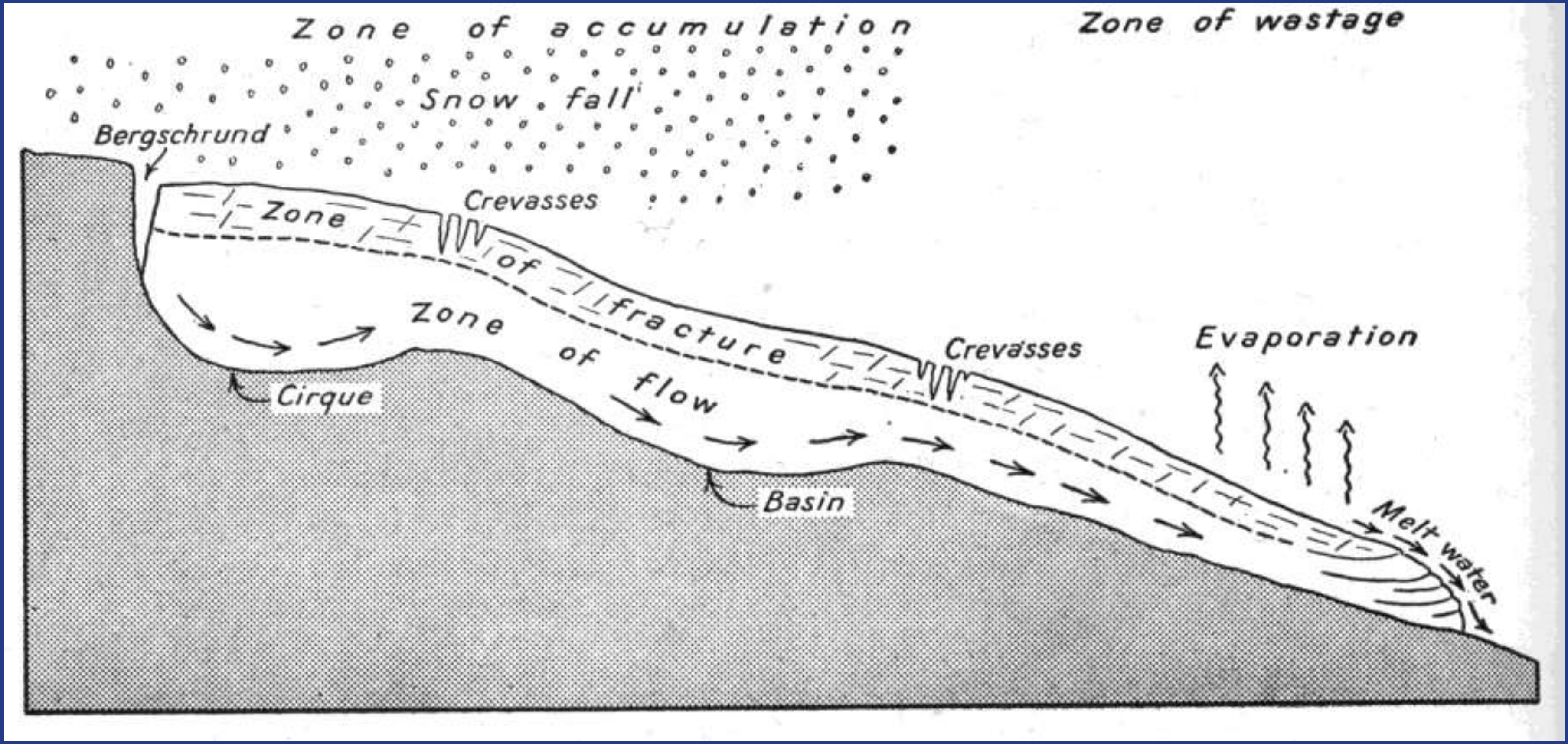

Tarn



Origin of a tarn, i.e., a lake formed in
a cirque vacated by a glacier

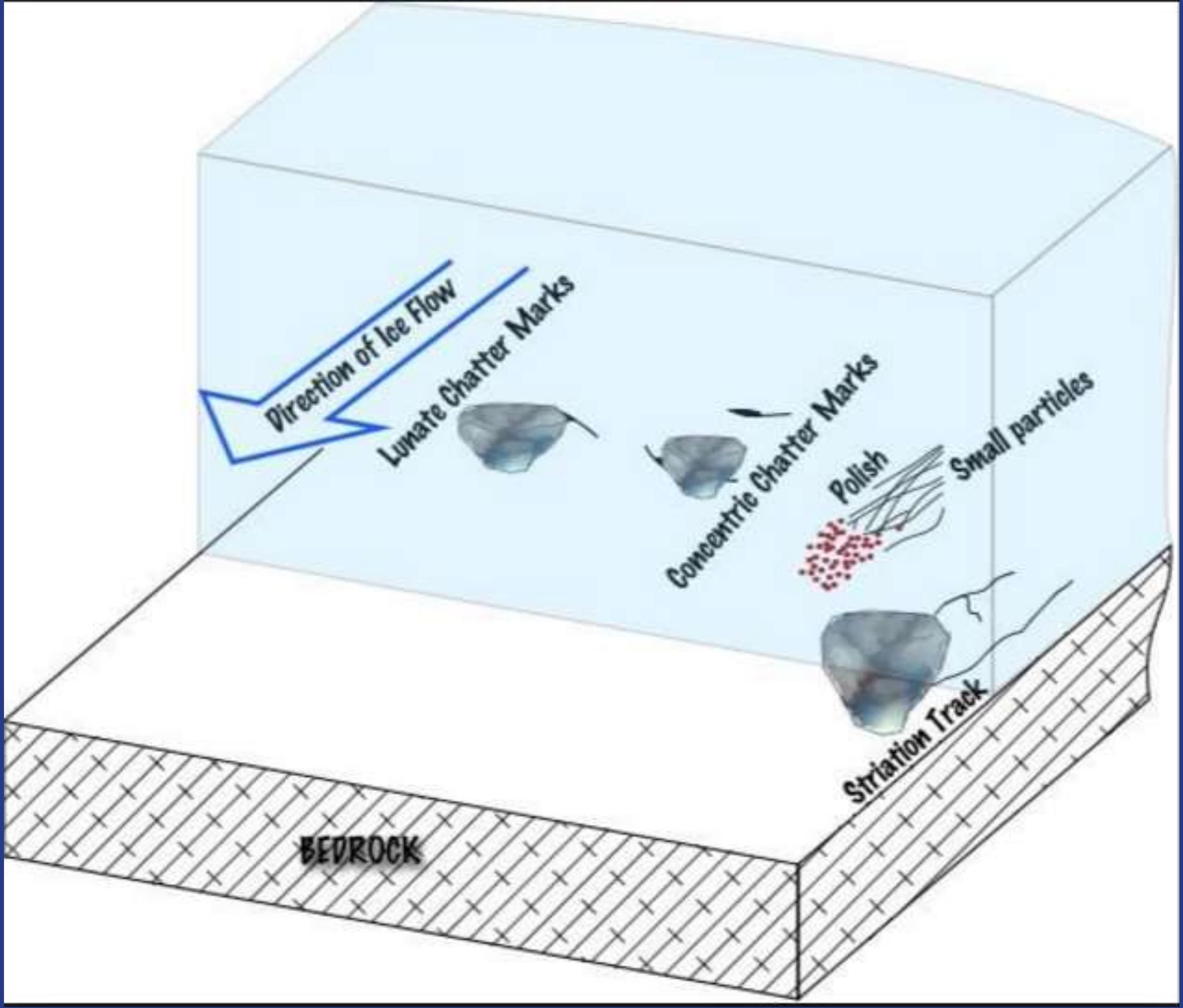
The formation of U-shaped Valleys



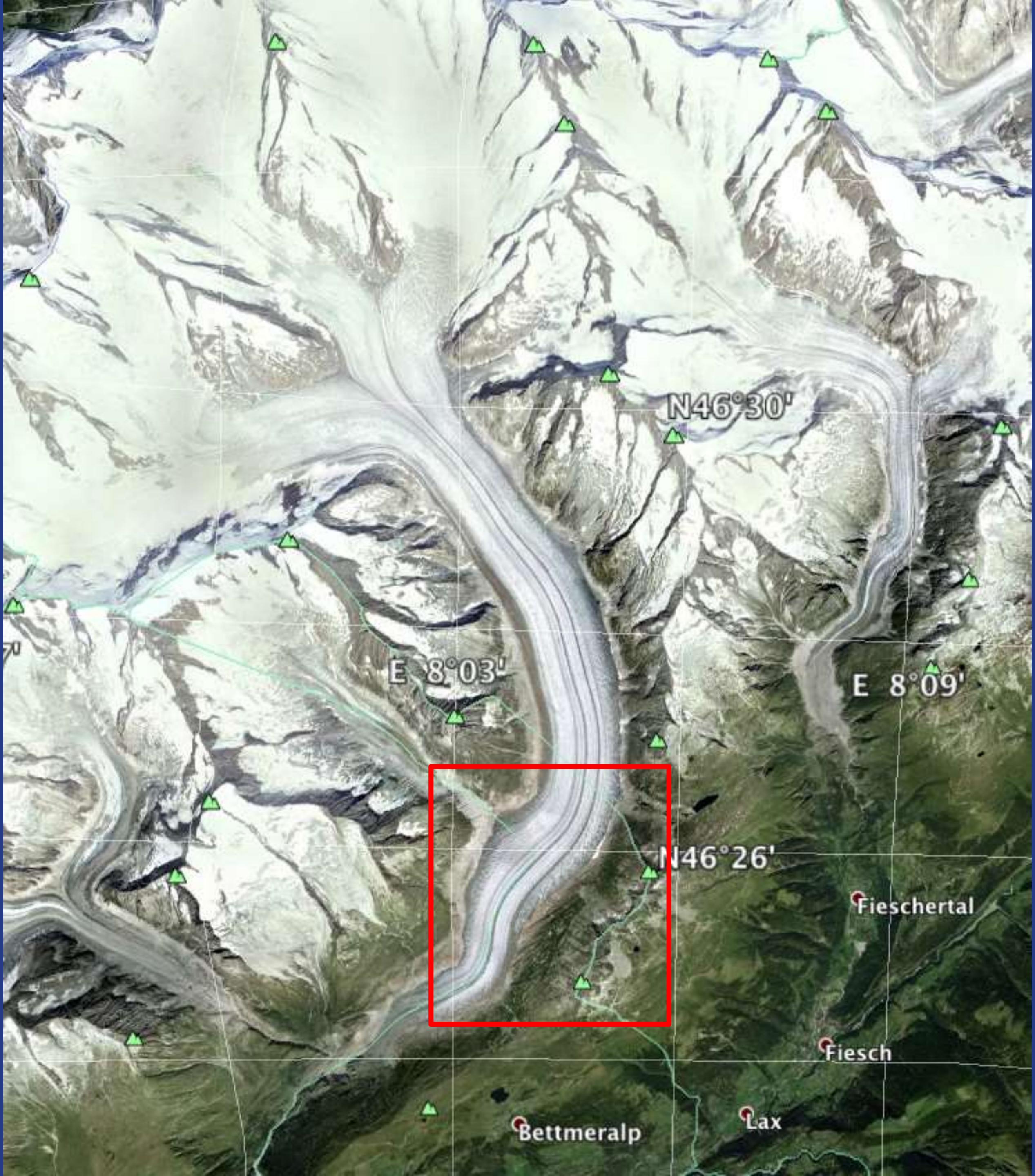


Longitudinal profile of a glacier

Striated walls of a glacial valley, Rocky Mountains, USA



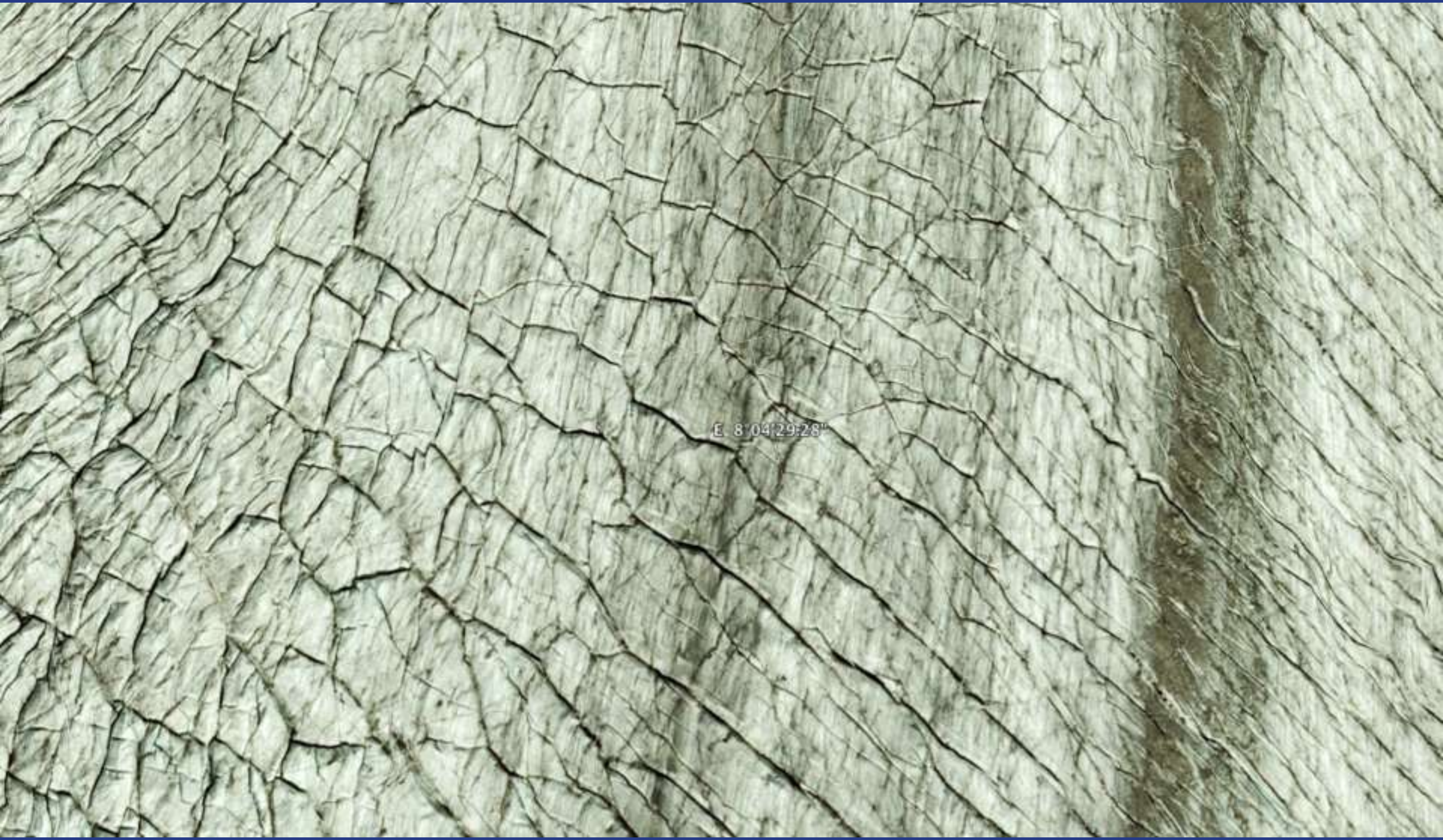
The origin of glacial striations and chatter marks by the tools carried by the glacier



N46°30'
E 8°03'
E 8°09'
N46°26'
Fieschertal
Fiesch
Lax
Bettmeralp


E 8°03'
E 8°04'12"
© 2016


N46°26'24"
E 8°04'30"
E 8°03'54"
N46°25'58.08"



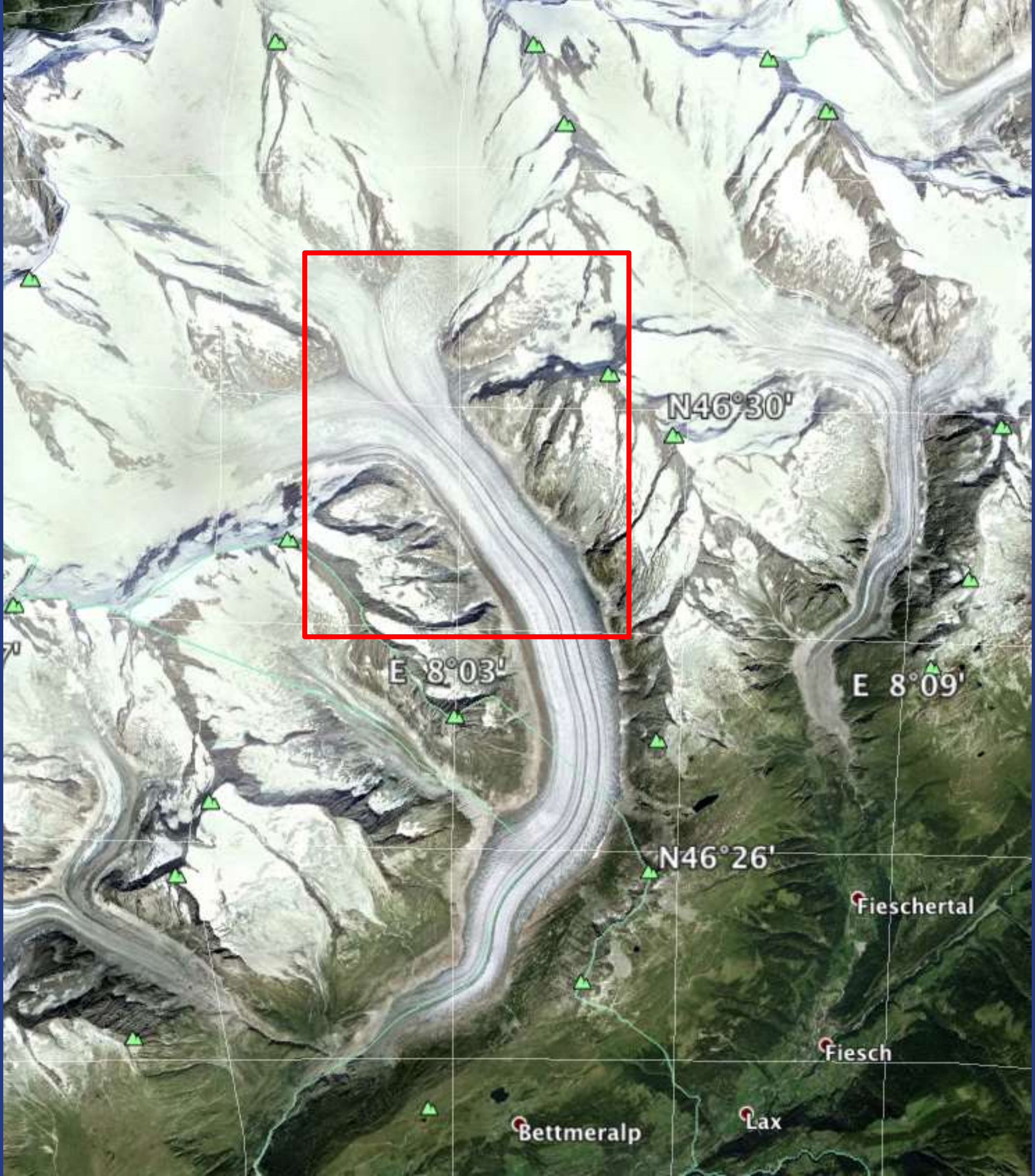
The various crevasses on the Aletsch Glacier, Alps, Switzerland

The crevasses of the Glacier d'Argentiere, Chamonix, France

A glaciologist measuring the glacier crevasse depth,
Northern Cascades, USA

Glacier crevasses

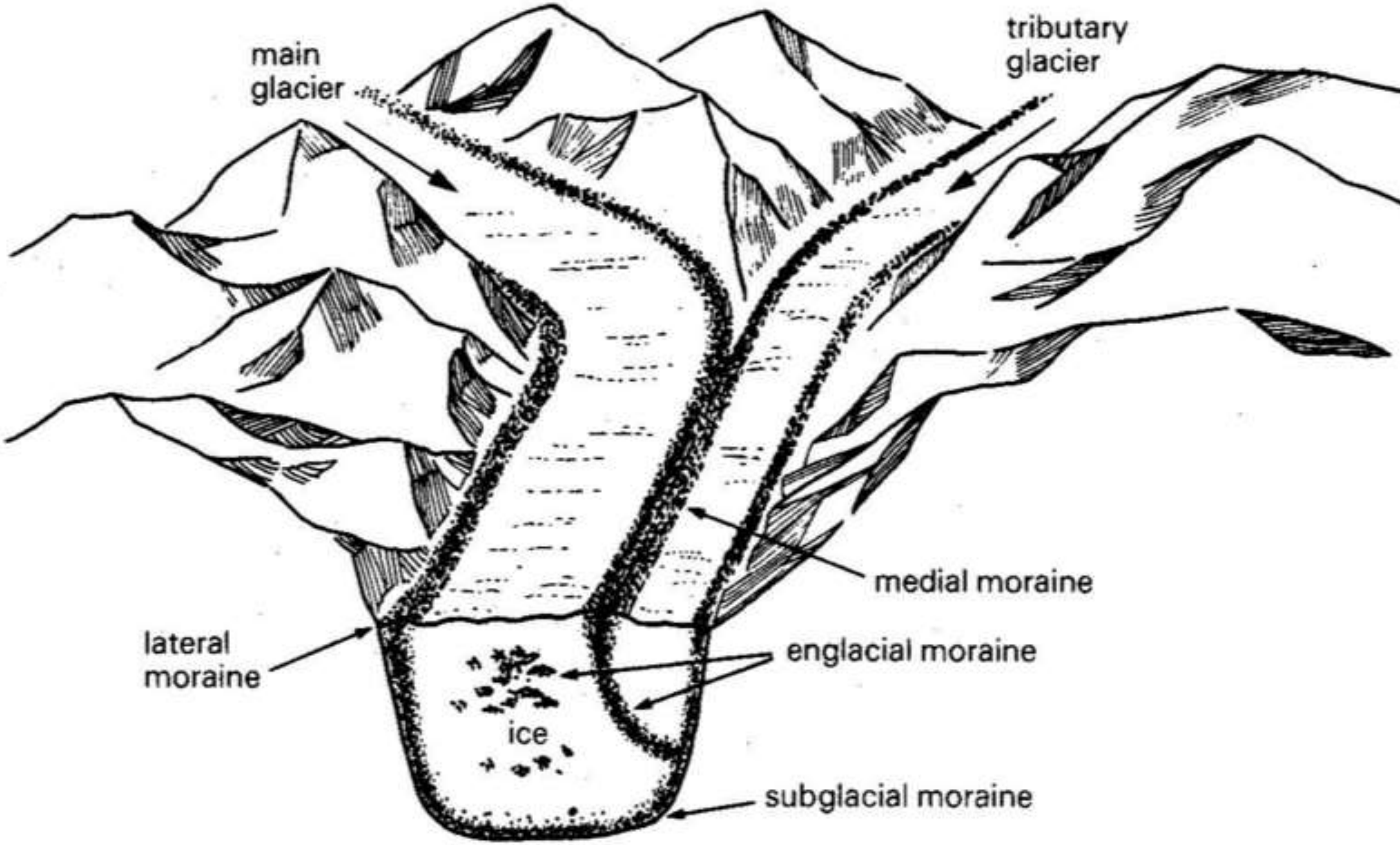
Glacier crevasses


N46°30'
E 8°03'
E 8°09'
N46°26'
Fieschertal
Fiesch
Lax
Bettmeralp

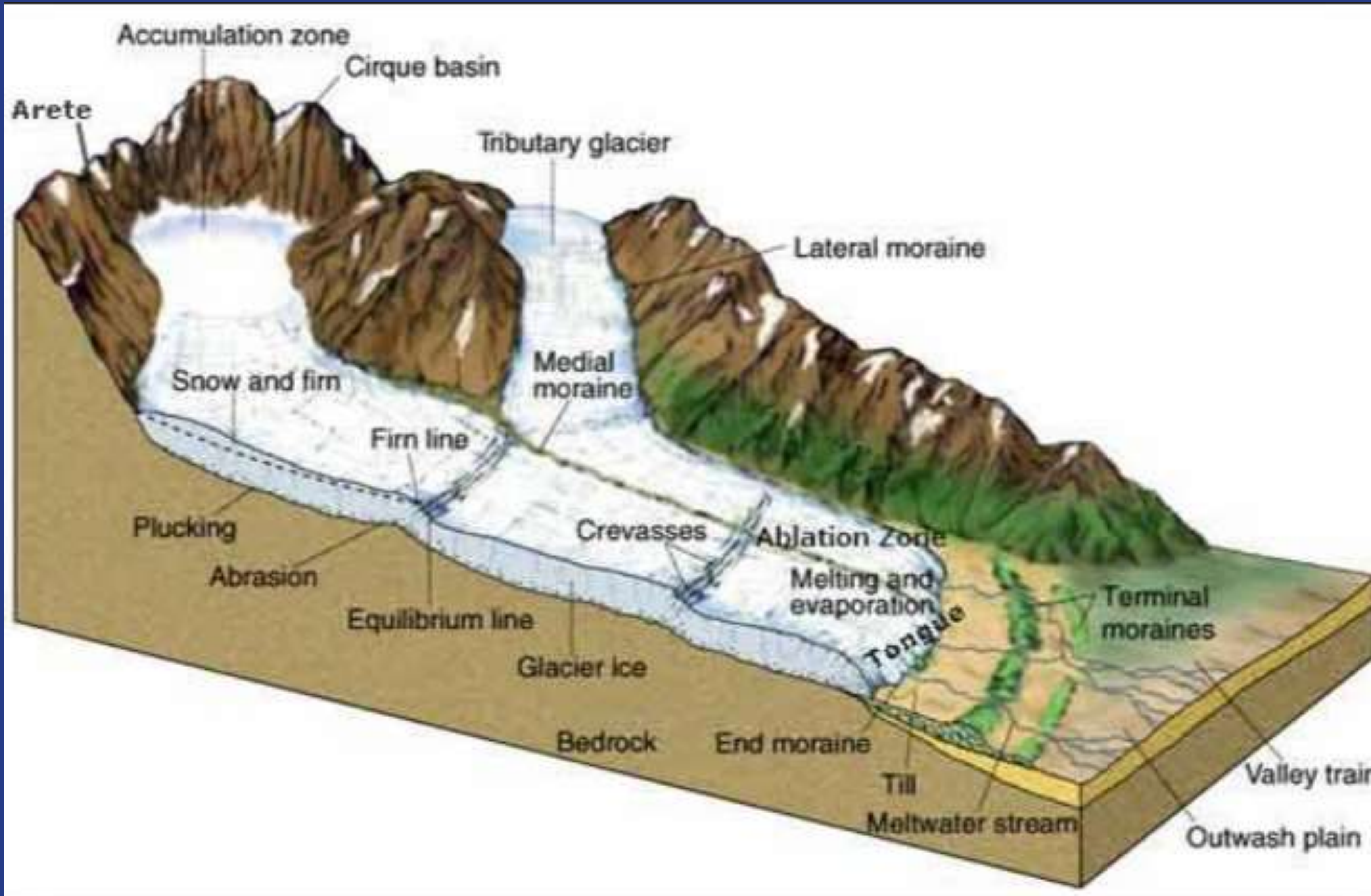

N46°30'54"
N46°30'18"
N46°29'42"
E 8°03'
E 8°04'12"
E 8°01'48"
°00'36"
N46°29'6"
N46°28'30"
© 2016 Google


E 8°01'53.76"

Moraines of a valley glacier



Lateral moraines of two glaciers combining to create a train of medial moraines: Yukon, Alaska, USA

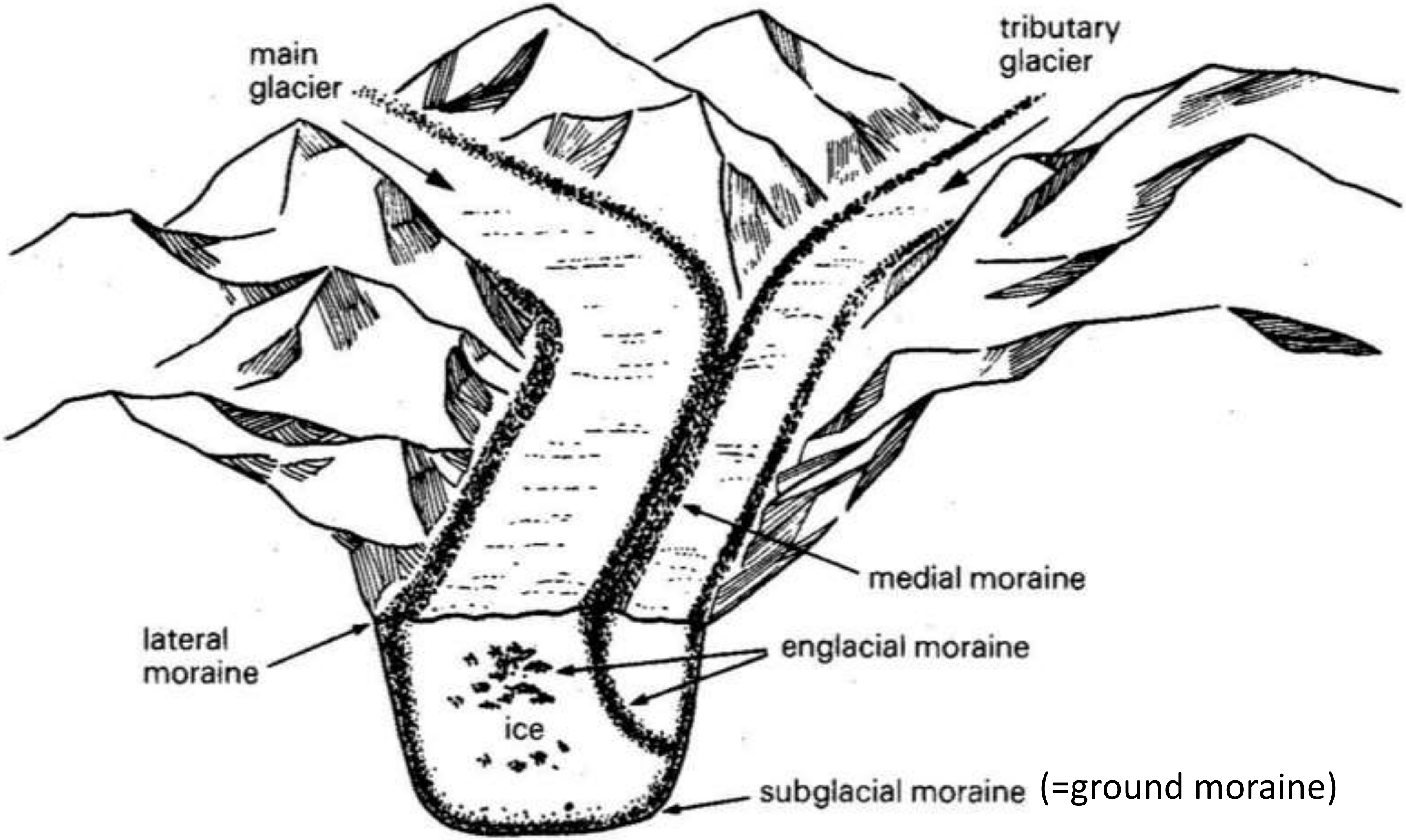


Accumulation zone
Cirque basin
Arete
Tributary glacier
Lateral moraine
Medial moraine
Snow and firn
Firn line
Plucking
Abrasion
Crevasses
Ablation Zone
Melting and evaporation
Tongue
Terminal moraines
Equilibrium line
Glacier ice
Bedrock
End moraine
Till
Meltwater stream
Valley train
Outwash plain

A terminal moraine of unknown locality (probably Scandinavia).

Lateral and terminal moraines of about 11-12,000 years from the tepey Valley, Belledonne Massif, The French Alps.

Moraines of a valley glacier




N46°30'54"
N46°30'18"
N46°29'42"
E 8°03'
E 8°04'12"
E 8°01'48"
N46°29'6"
N46°28'30"
© 2016 Google

Medial moraines of the Kenikott Glacier, Wrangell Mountains, St. Elias National Park, Alaska, USA

A closeup view of the medial moraines of the Kenikott Glacier, Alaska

Some terminological tips:

Moraine: a landform made up of till

Till: debris that has fallen onto the glacier and/or created by the glacier and carried by it atop or within or at the bottom of it. Till is a sediment.

Tillite: indurated till. Tillite is a sedimentary rock.

Coarse till adjacent to the Shearman Glacier, Alaska, USA

Finer-grained tills created by two different glacial advances.
Northern Ontario, Canada

Tillite of the Ghaub Formation, Namibia, Africa (photo by Paul Hoffman)

The FitzRoy Tillite Formation, Falkland Islands, South America

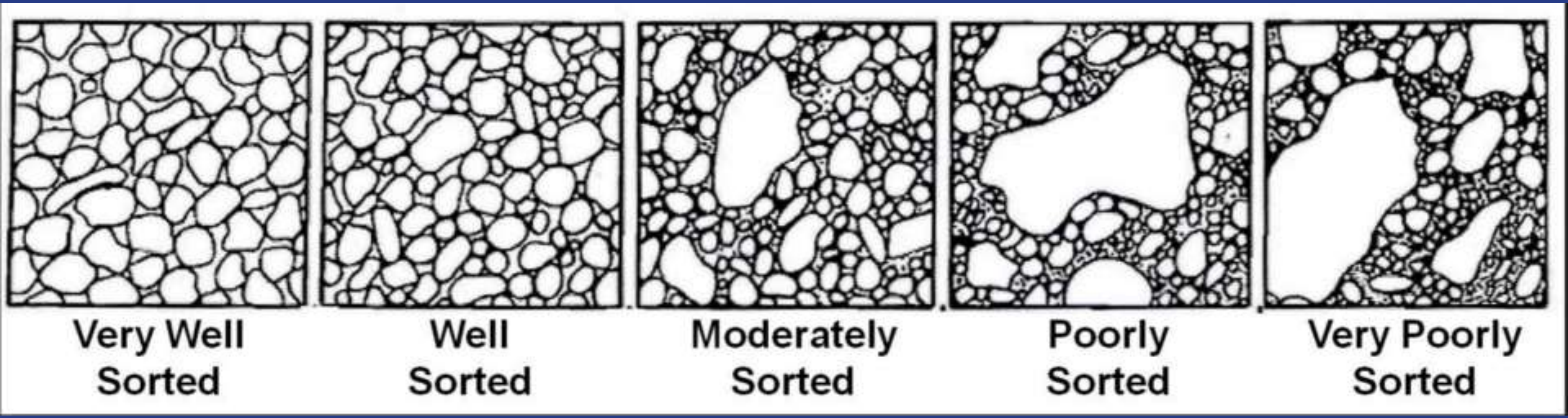
Tillites are very badly-sorted sedimentary rock.

Sorting: Separation of similar size particles during sedimentation.

In a well-sorted rock, all grains are of a similar size. In a badly-sorted rock they are of widely different sizes.

A well-sorted clastic sedimentary rock (sandstone)

A badly-sorted clastic sedimentary rock (tillite)



Terminology of sorting in clastic sedimentary rocks

In valley glaciers (also known as “Alpine glaciers”), the tills are rarely preserved as tillites, because the post-glacial erosion in mountains is vigorous.

The widespread tillites we see in the world were formed from the tills of continental glaciers also known as ice caps and ice sheets.

This brings us to the topic of glacier types and the ice ages.

Alpine Glaciers

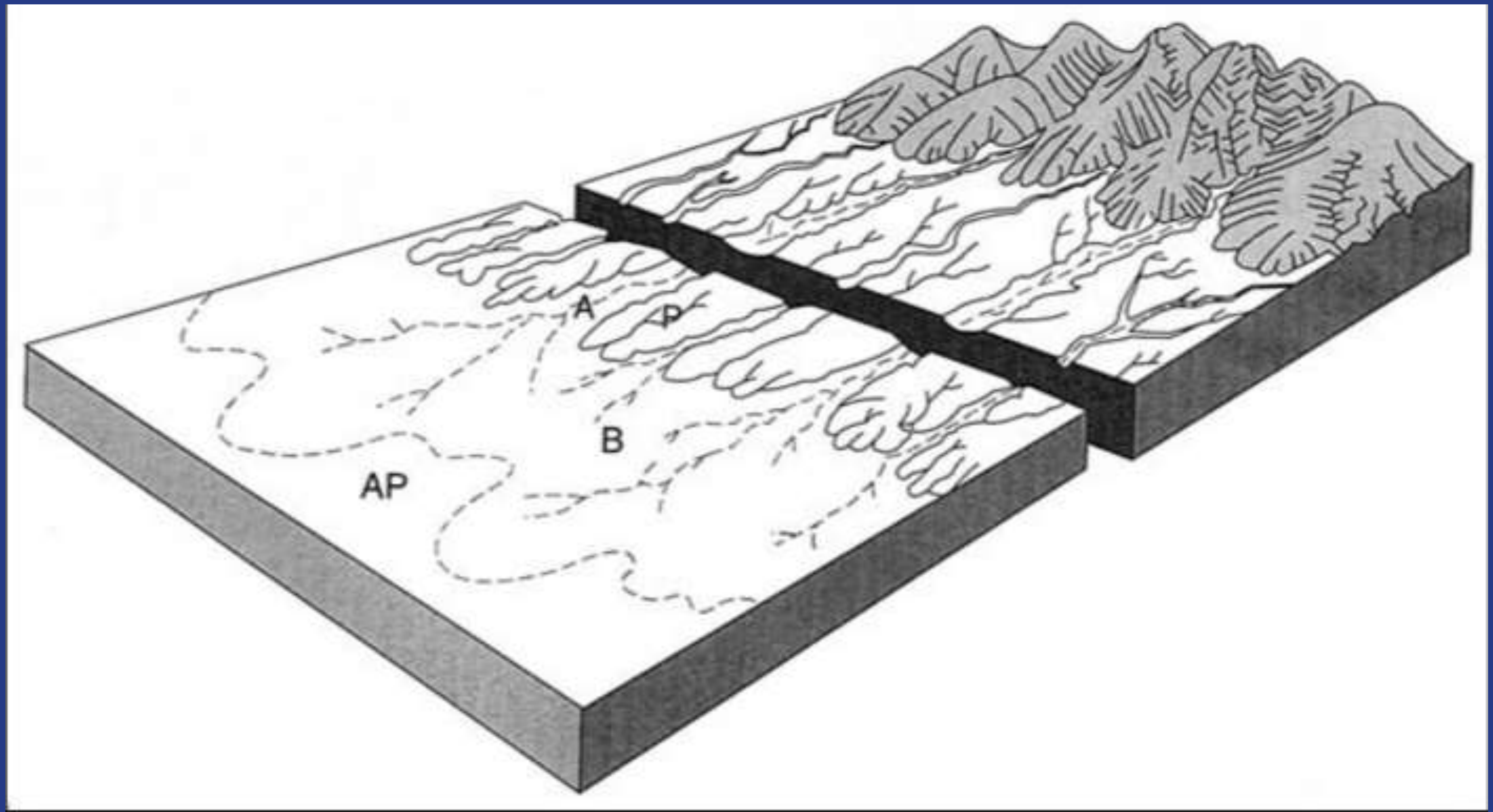
- Are confined by surrounding mountains

Types:

- Cirque Glaciers – erode basins in mountainsides
- Valley Glaciers – flow into preexisting stream valleys
- Icecaps – form on mountaintops

Piedmont glaciers

The word piedmont is built from the two French words: *pied*, meaning foot and *mont* meaning mount, mountain. Piedmont means a mountain foot plain or a mountain apron plain.



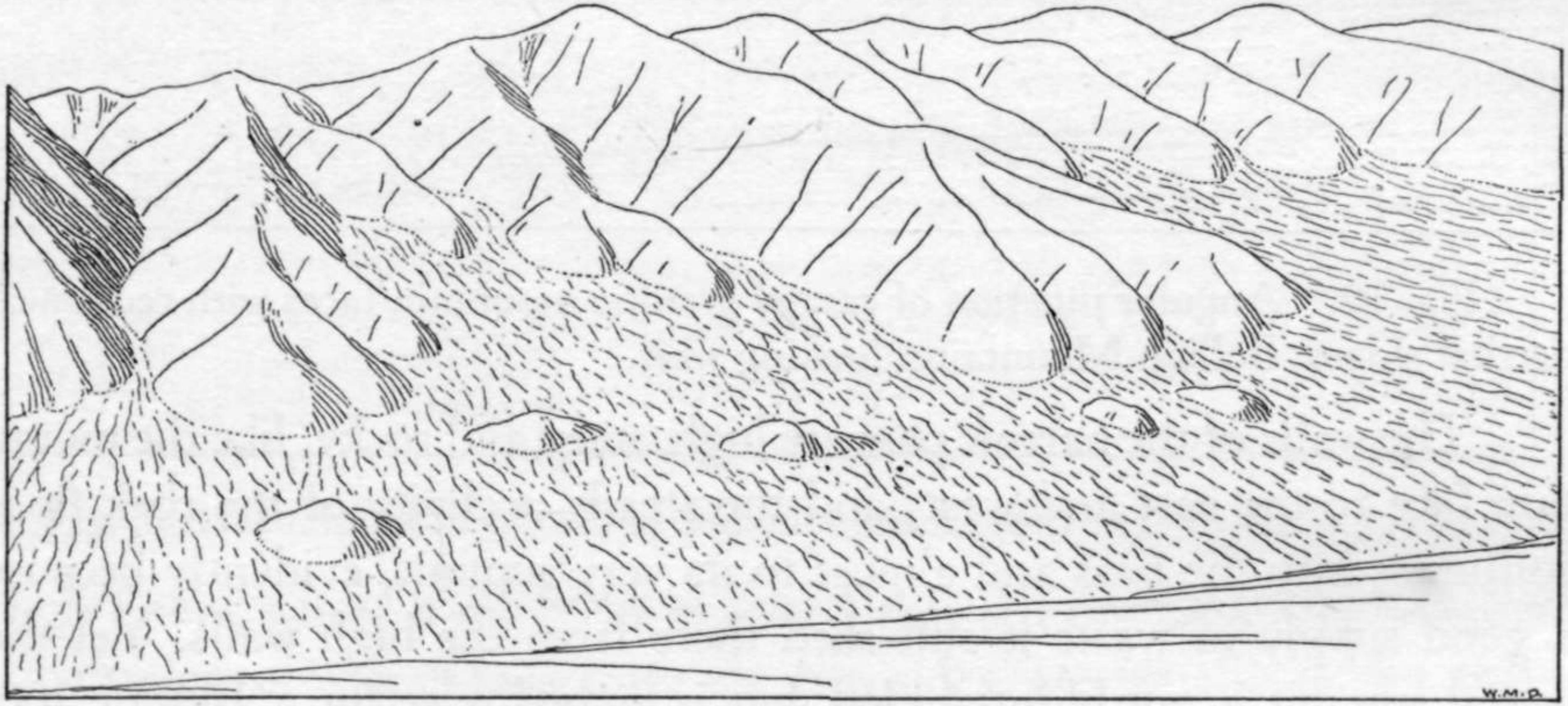
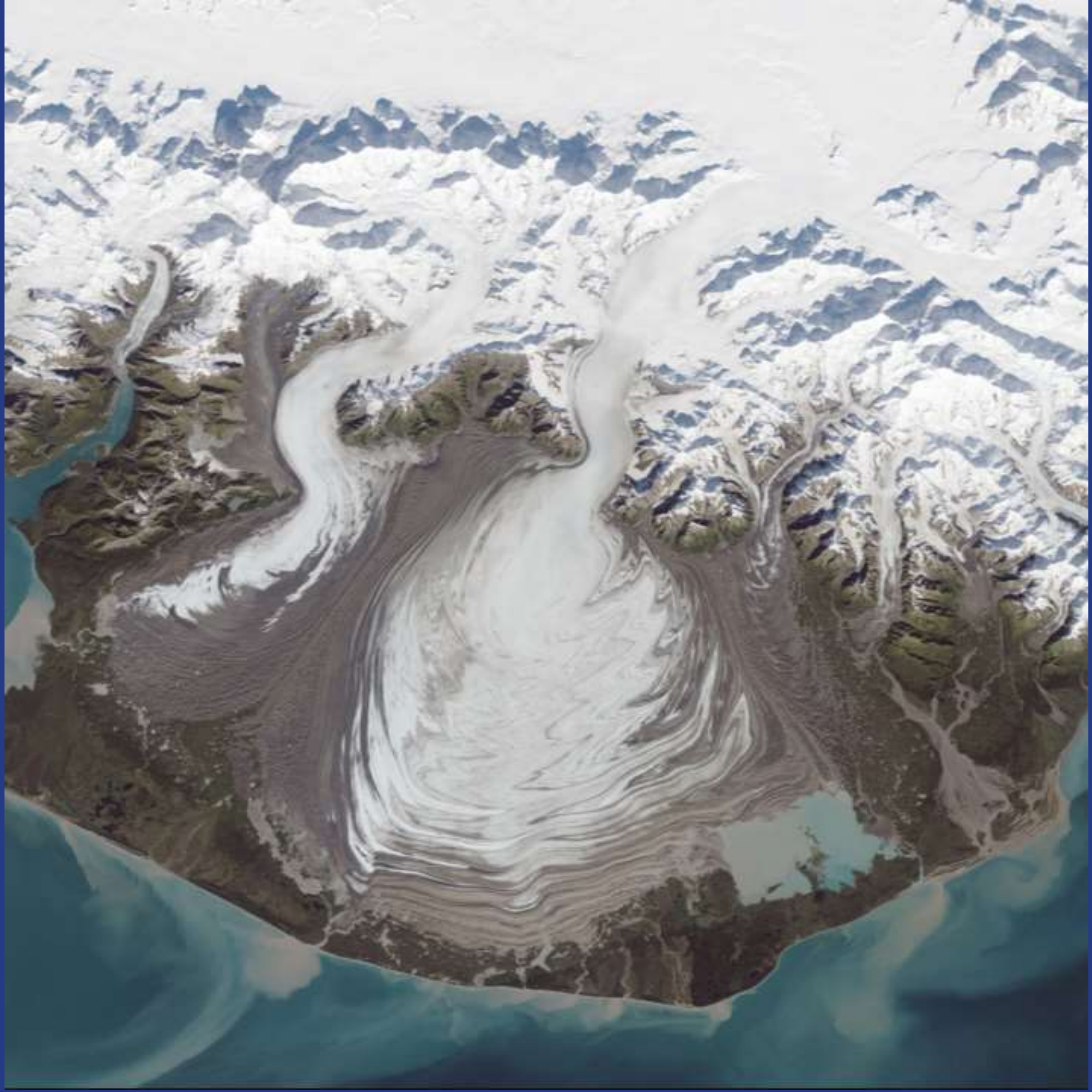


Fig. 12. The Paradise Mountains, looking southwest.

A piedmont plain from the Mohave Desert, California, USA

Piedmont glaciers form when a glacier emerges from its U-shaped valley onto a piedmont plain. This is a group of piedmont glaciers from the Axel Heiberg Island, Canadian Arctic



The Malaspina Glacier, Alaska, USA. One of the most spectacular piedmont glaciers in the world

The tongue of the Malaspina piedmont glacier, Alaska, USA.
Notice the terminal moraine ridges

The terminal moraines of a piedmont glacier on the Byot Island, Nunavut, Canadian Arctic

If there is insufficient melting of the piedmont glaciers to keep their growth in check, they become enlarged and eventually coalesce into continental ice caps and ice sheets. In the preset-day world, continental ice caps and ice sheets exist in Antarctica, Greenland, Iceland and on Novaya Zemlya island in the Russian Arctic.

If an ice mass covers less than 50,000 km^2, it is known as an ice cap or plateau glacier. If it covers more than 50,000 km^2, it is known as an ice sheet.

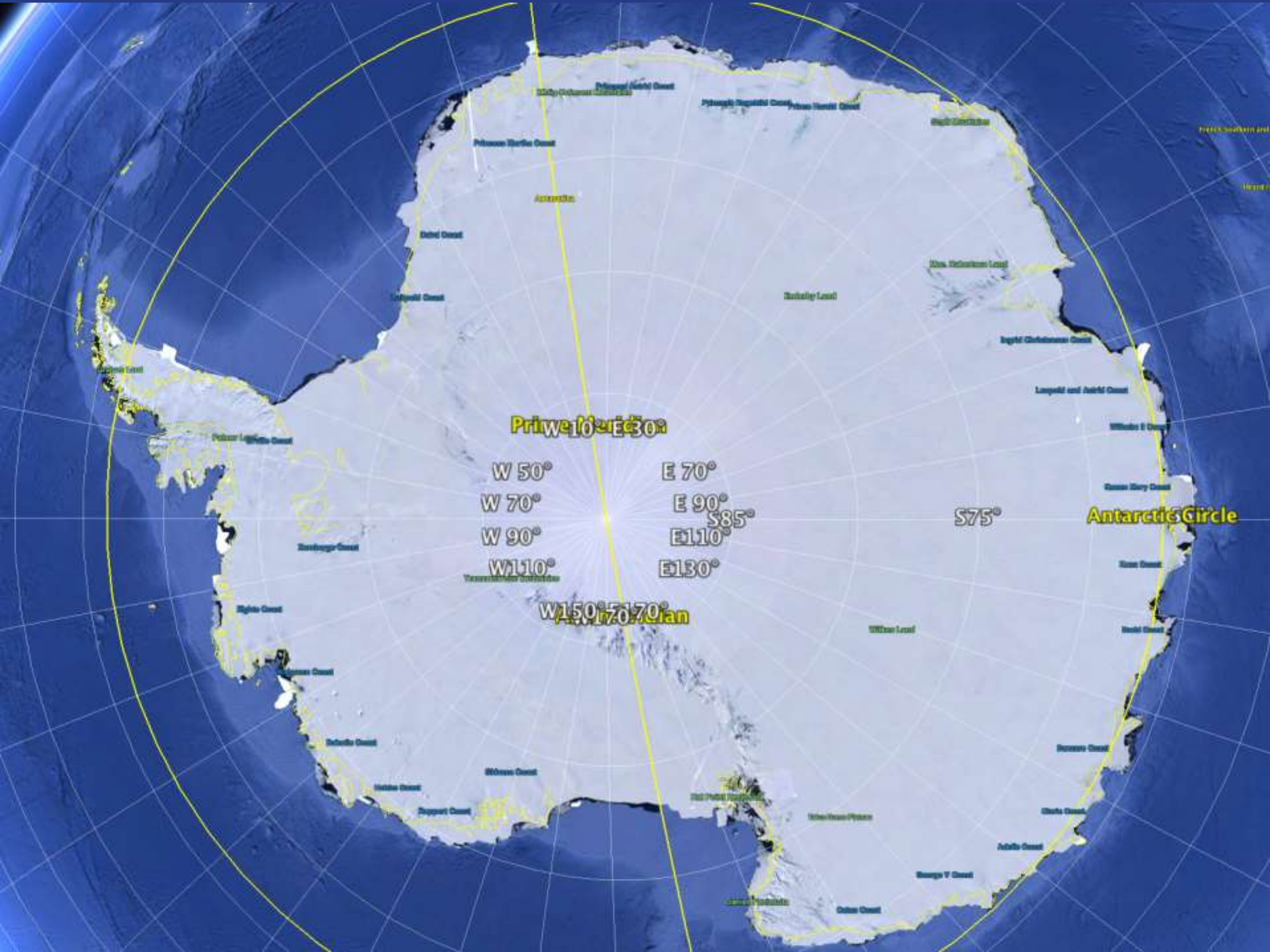
Glacial ice covers some 10 to 11 % of all land on our planet.

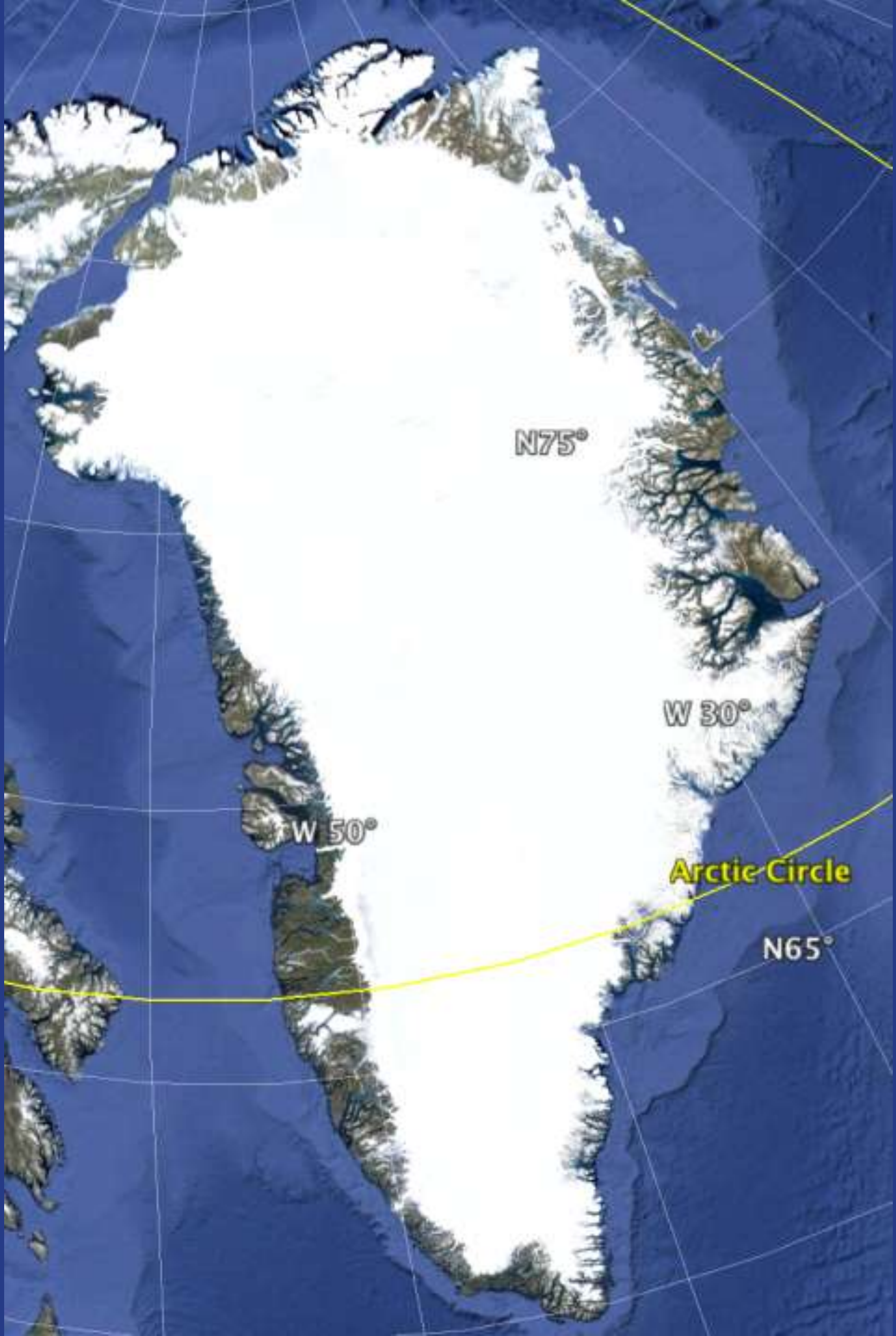
Of this 14 million square kilometres lies on Antarctica and makes up the Antarctic ice sheet. It contains 30 million cubic kilometres of ice.

The Greenland ice sheet covers 1.7 million square kilometres.

If all of Antarctic ice sheet melts the world-wide sea-level would rise by about 60 m. If all of the Greenland ice sheet melts, the world wide sea-level would rise by 7 metres.

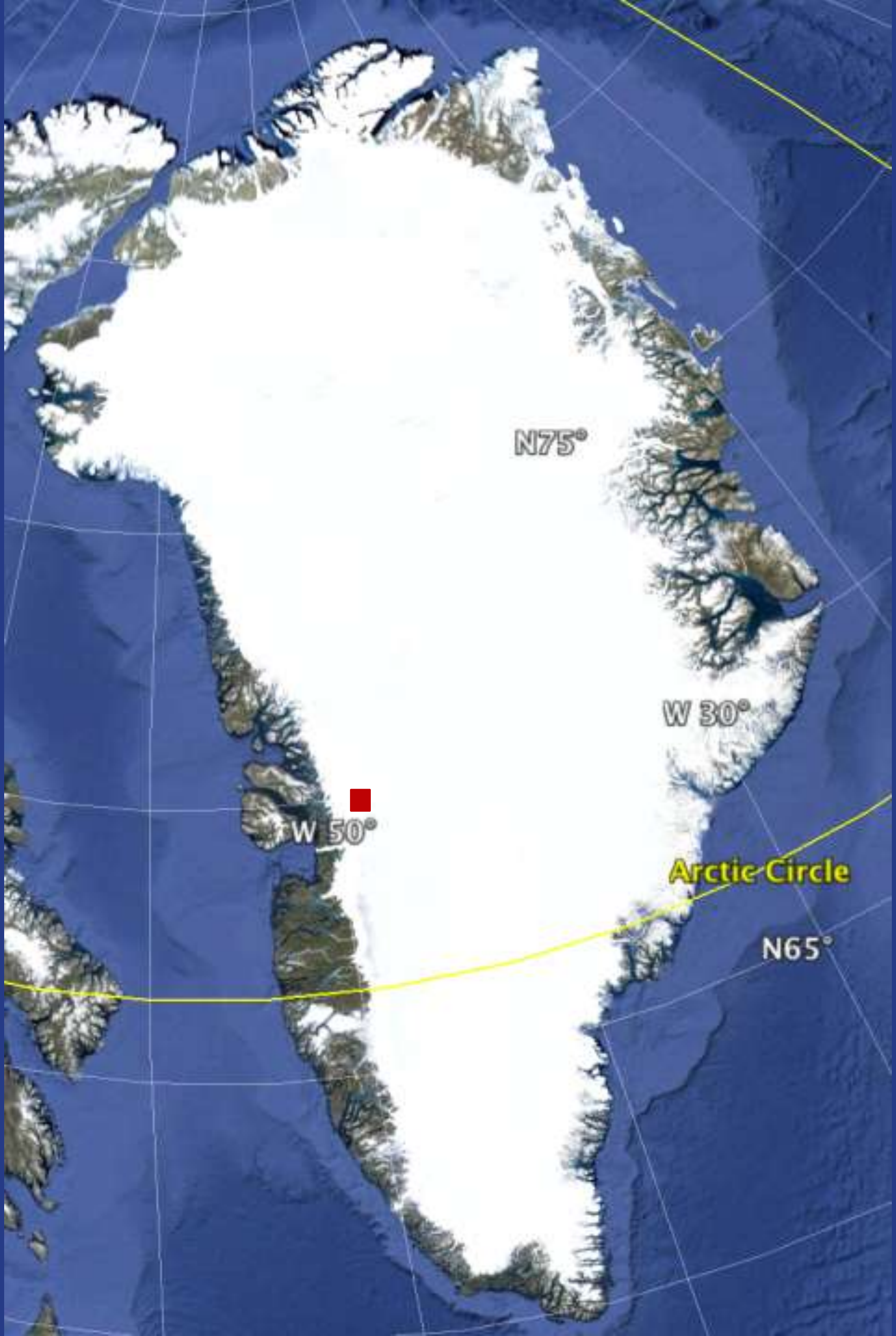
Ice on earth makes up some 1.7% of all the H_2O in the hydrosphere, but it accounts for 68.7 % of all fresh water in the hydrosphere.

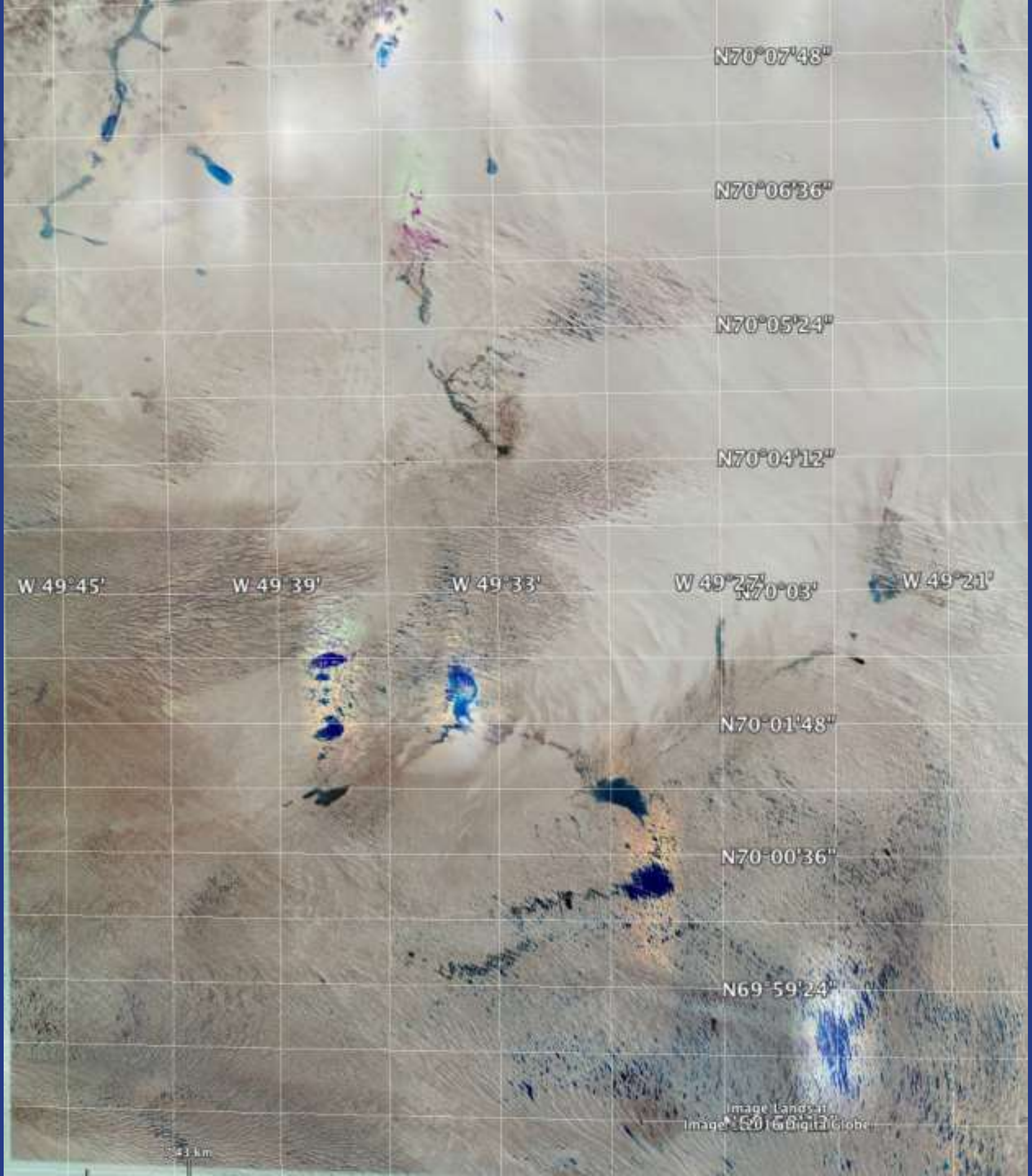

W 50°
E 70°
W 70°
E 90°
S85°
S75°
Antarctic Circle
W 90°
E110°
W110°
E130°


N75°
W 30°
W 50°
Arctic Circle
N65°


N67°
Arctic Circle
W 22°30'
W 17°30'
W 12°30'
N65°
N63°

N71°
E 67°30'
N73°
E 62°30'
E 57°30'
N75°
E 52°30'


N75°
W 30°
W 50°
Arctic Circle
N65°


N70°07'48"
N70°06'36"
N70°05'24"
N70°04'12"
W 49°45'
W 49°39'
W 49°33'
W 49°27'
N70°03'
W 49°21'
N70°01'48"
N70°00'36"
N69°59'24"
Image Landsat

Crevasses on the Greenland ice sheet

Crevasses, Greenland ice sheet

Crevasses near the edge of the Greenland ice sheet

The crevasses show that the ice sheets are in motion. Also at their edges they move outward and flow onto then sea creating sea ice and the ice shelves. Where the glaciers calve and the ice sheets break, icebergs form

This is the calving front of the world’s fastest melting glacier in Greenland: the Gyldenlove Glacier


18:44
~4000 m


18:48

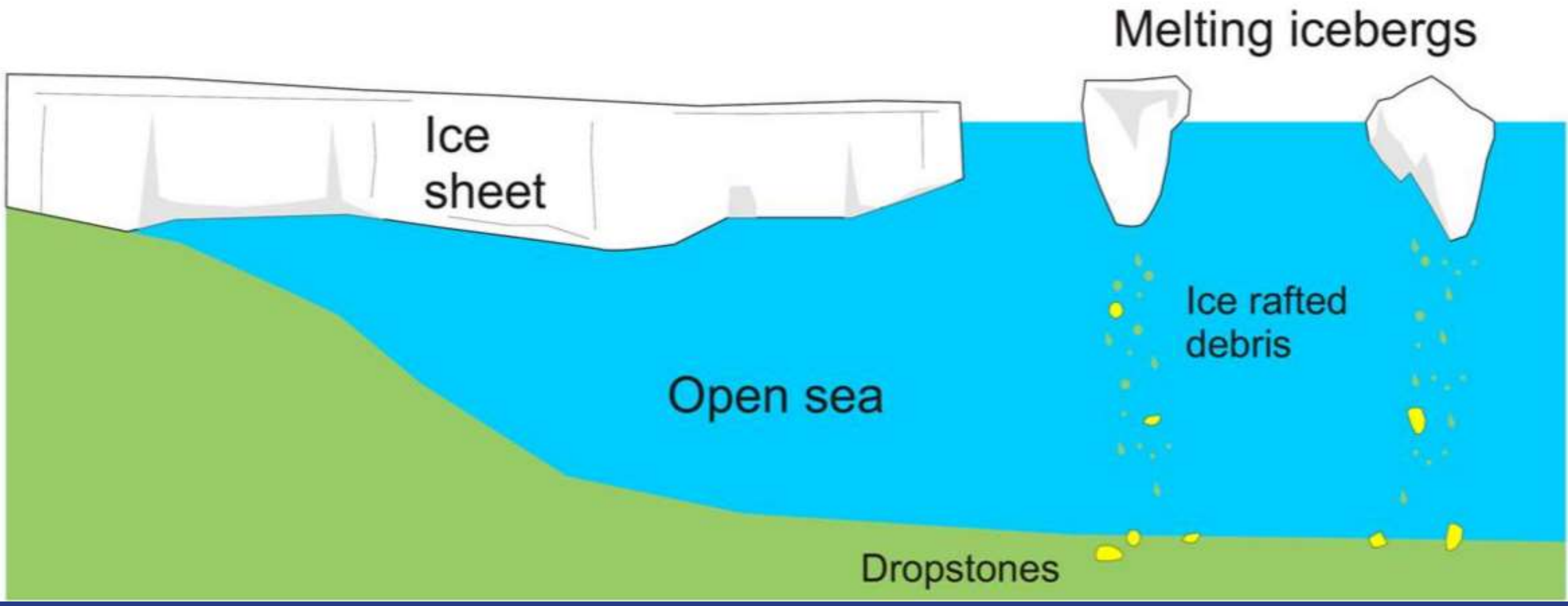

18:49


18:58

Glacier calving

An iceberg

Only 1/9th of an iceberg stnds above water. The rest is underwater


Melting icebergs
Ice
sheet
Ice rafted
debris
Open sea
Dropstones

Boulders carried by an iceberg. These boulders started their lives as parts of a glacial moraine and will end up at the bottom of the sea as dropstones when the iceberg melts.

A dropstone in the late Precambrian marine deposits in Namibia, Southwest Africa

Another dropstone in the late Precambrian marine deposits in Namibia, Southwest Africa

A dropstone in the Precambrian marine deposits, California, USA

The formation of sea-ice in ice shelves: the northern polar seas

The formation of sea-ice around Antarctica in the Southern Ocean

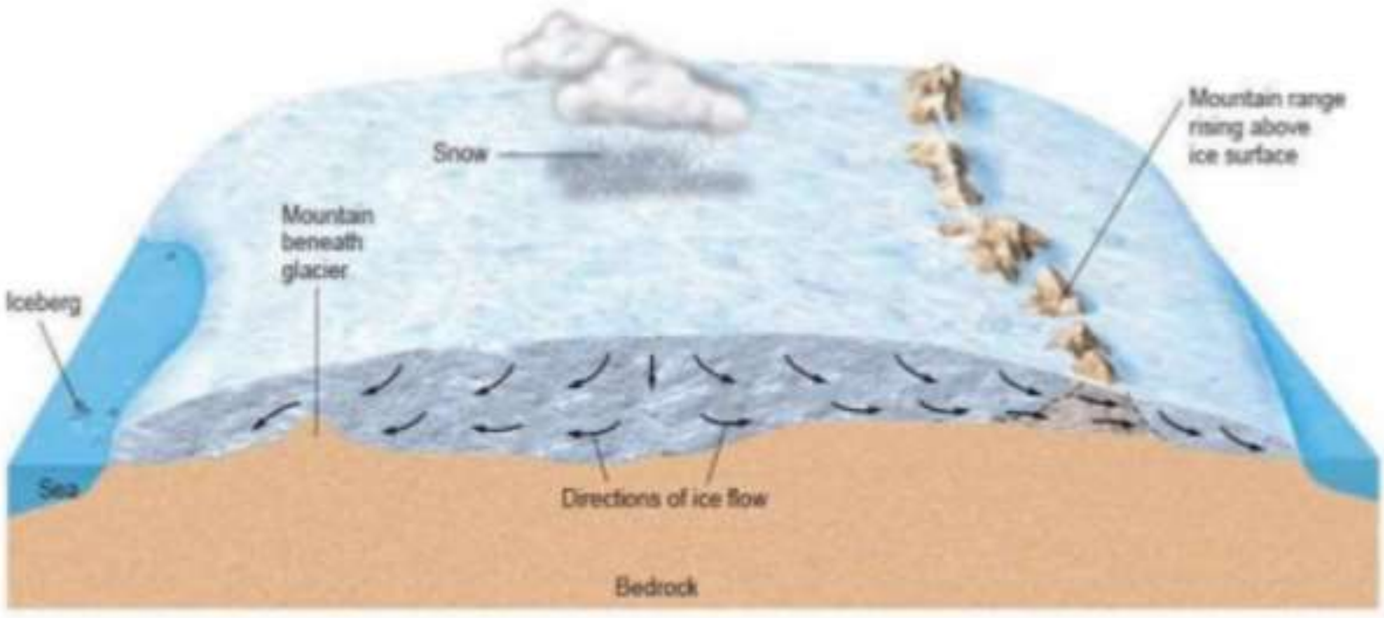
The edge of the Antarctic ice shelf
(*la banquise*)

Life below the *banquise*

Banquise breaking up during the summer melt. This breaking apart of the ice cover also produced icebergs, but flat ones.

How do ice sheets move?

Continental glaciers



Motion of continental ice sheets

Landforms and sediments that form under glaciers (sub-glacial bedforms)

Large-scale glacial lineations

Kames and kettles

Drumlins

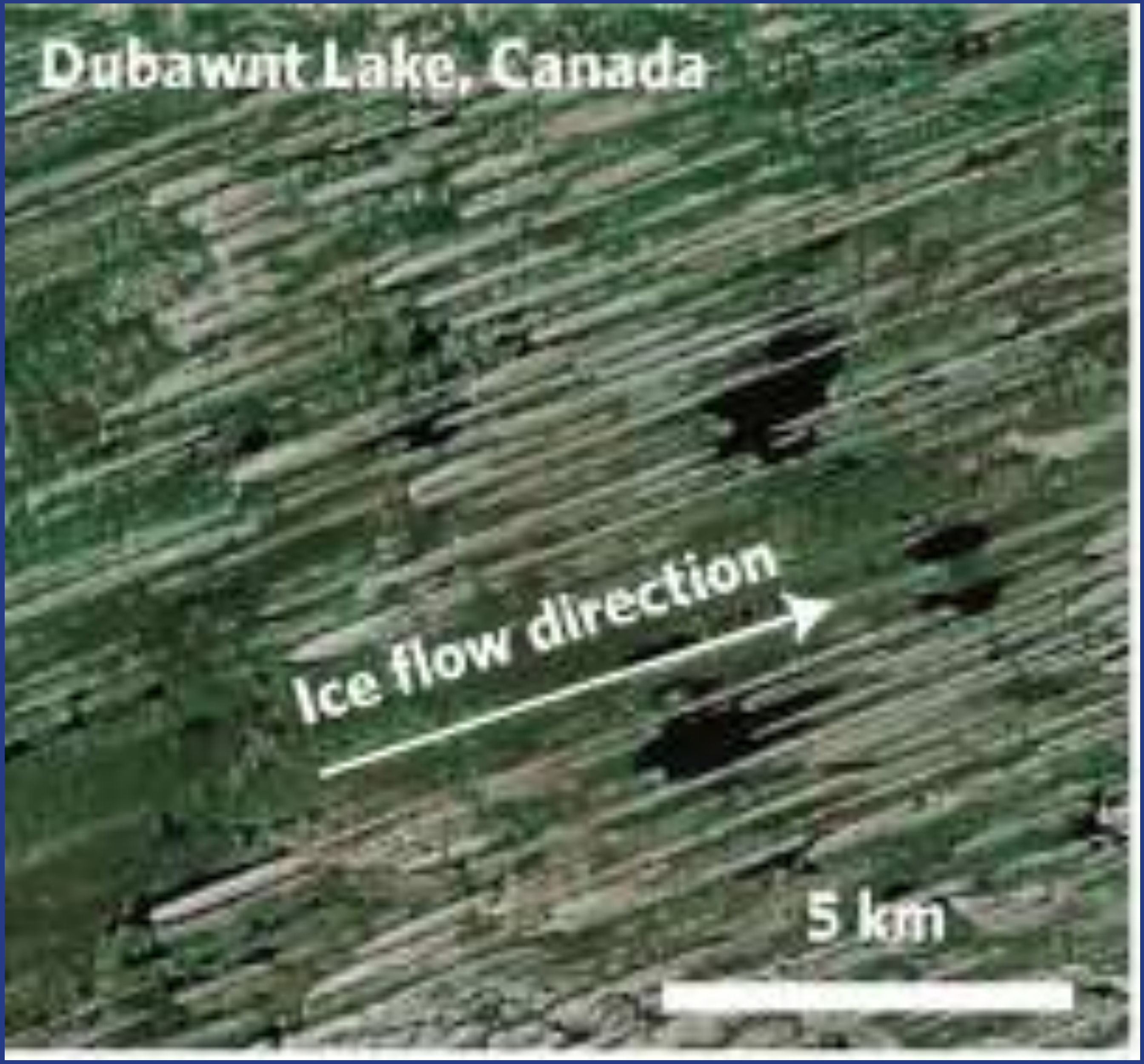
Eskers

Large-scale glacial lineations

Large-scale glacial lineations are long and narrow ridges and corrugations created under the ice by sub-ice scouring into soft sediment.

Large sub-glacial lineations (also called mega sub-glacial lineations) are long, elongated landforms made typically in soft sediments that reflect fast ice flow of an ice sheet. Indeed, MSGLs are often thought to be indicative of ice streaming, and are found all over the world on previously glaciated areas.

Large sub-glacial lineations are linear forms 10 to 100 km long. They have common length:width ratios of greater than 15:1 exhibiting a convergent flow pattern. Lega sub-glacial lineations typically have a large zone of convergence, feeding into a main trunk, which then diverges again near the ice margin. The elongation ratios of some of the mega-sub glacial lineations are up to 13 km long and have elongation ratios of up to 43:1.


Dubawnt Lake, Canada
Ice flow direction
5 km

Large sub-glacial lineations, northern Canada

Drumlins

A drumlin is an asymmetrically oval-shaped, elongated hill, largely composed of glacial till . They are usually up to a few kilometres long and some 50 m in height. The word drumlin is derived from an ancient Gaelic word, meaning a rounded hill.

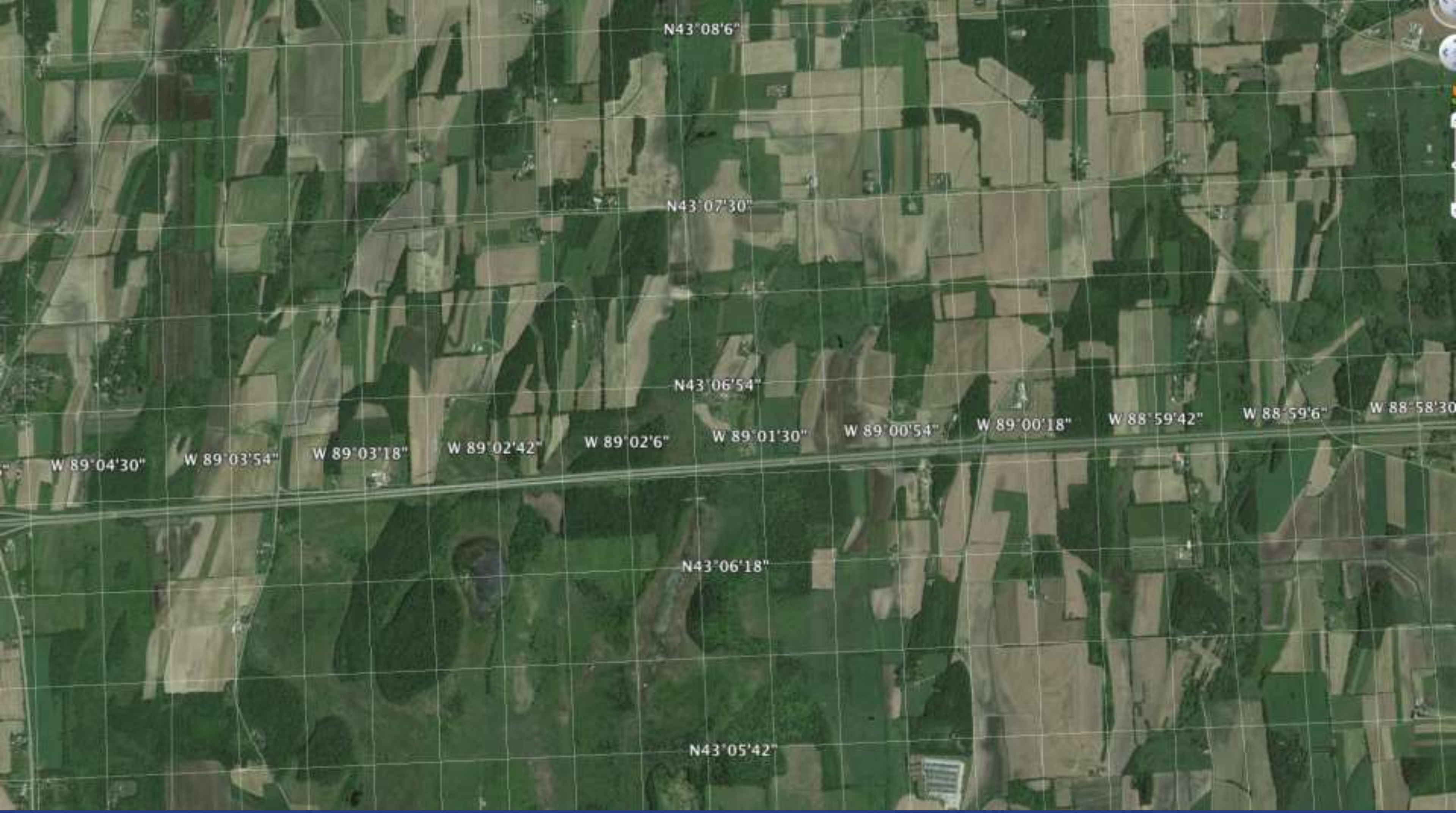
Drumlins may be of various shapes, but the typical drumlin resembles a half-buried egg along its long axis, but there are also drumlins that are perfectly circular. There are also varieties with two tails.

A drumlin showing the ice-flow direction

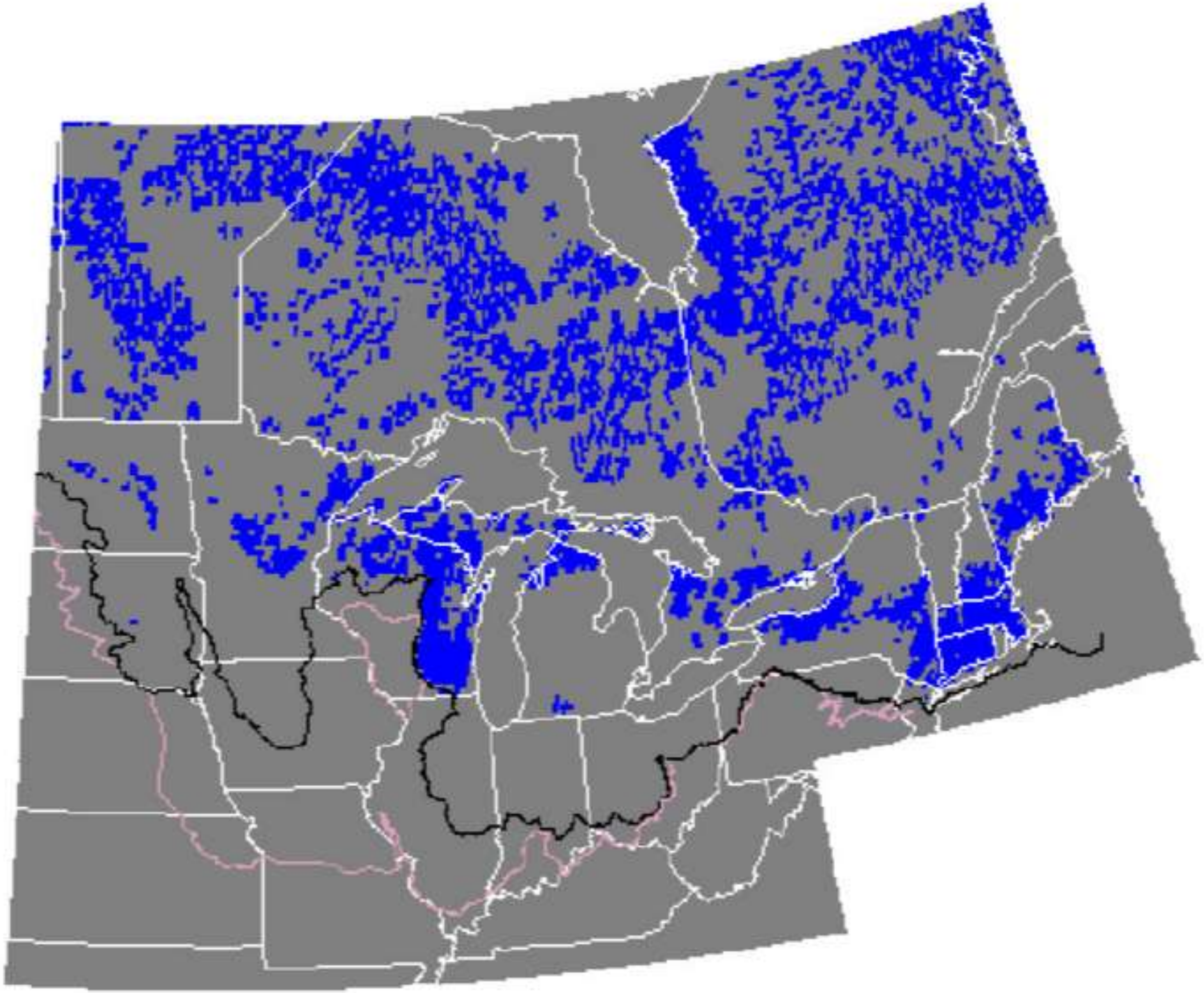
Another drumlin; locality unknown

Internal structure of a drumlin, Scotland, UK

Digital elevation model of a drumlin field in New York State, USA, by Richard Allmendinger



A drumlin field in a cultivated area, Wisconsin, USA

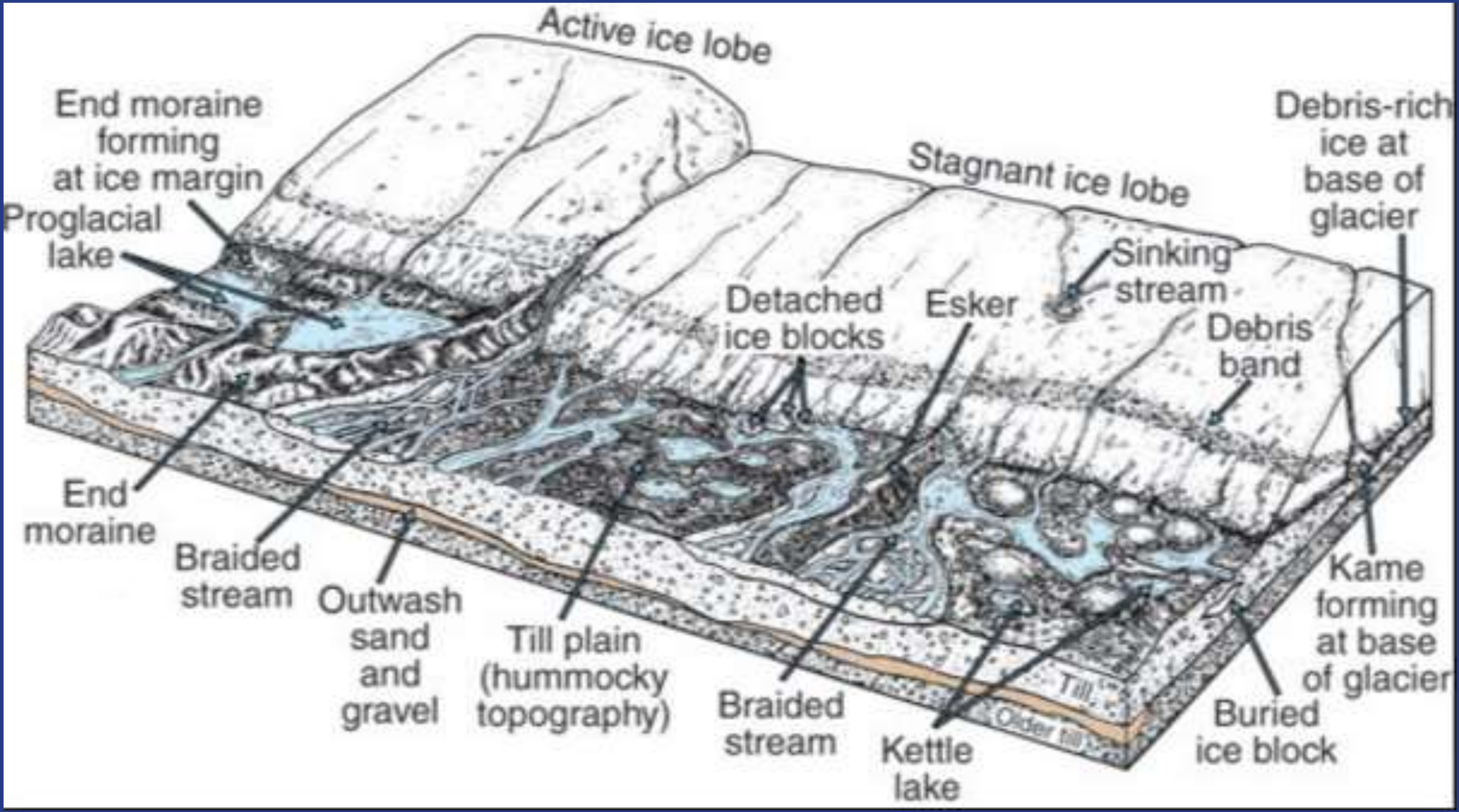


Southern Laurentide Ice Sheet Project
Drumlin Distribution Map
Draft Map - Feb. 2000

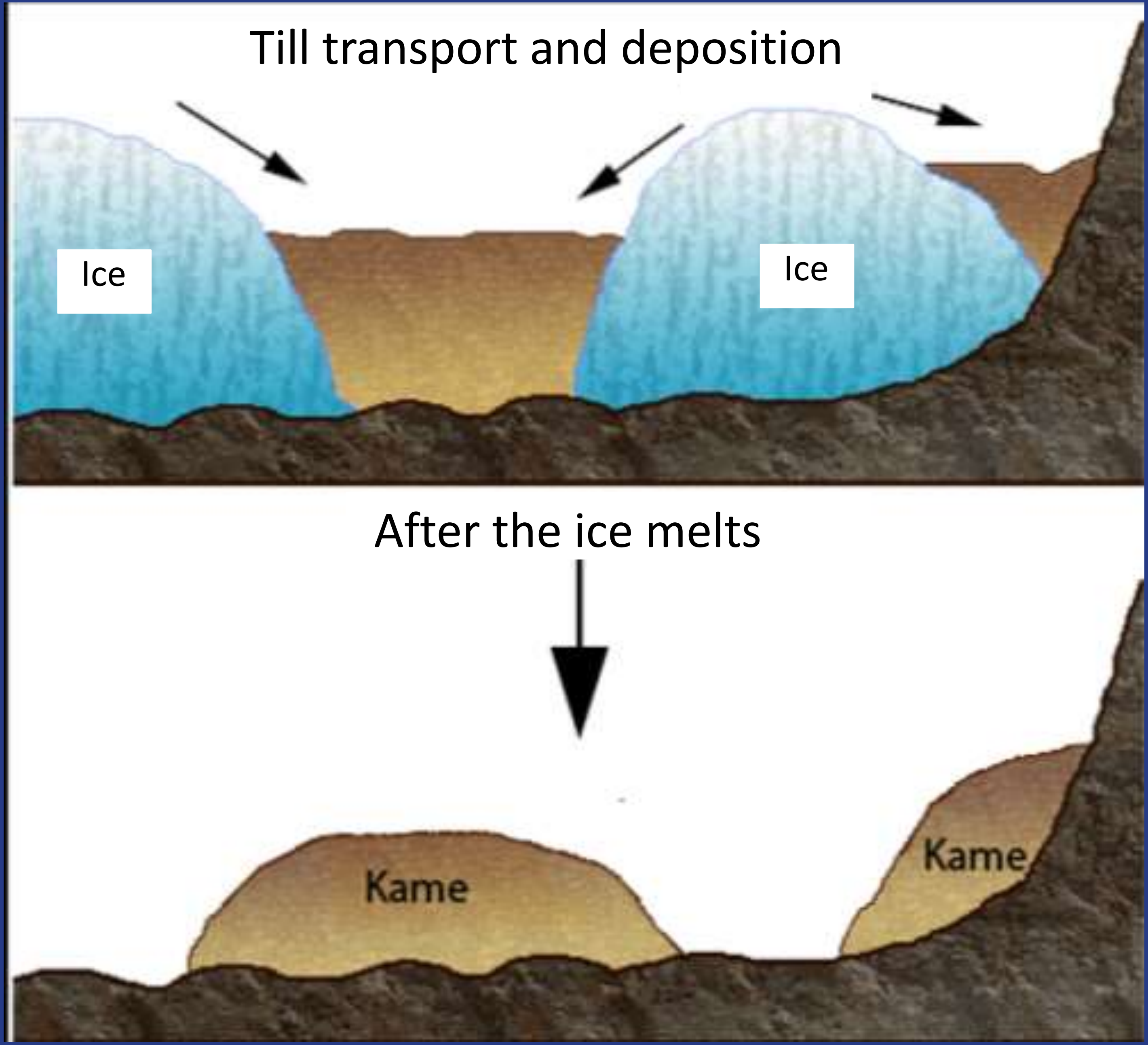
Kames and kettles

A kame is an irregularly-shaped hill composed of glacial till . Kames are formed by till accumulating in depressions atop melting glaciers and are finally dropped on the glacir bed when the glacier totally disappears.

Kames are commonly associated with kettles that are rounded to subrounded depressions formed by dead ice left by a retreating glacier around its tongue region.



The tongue region of a retreating glacier


Till transport and deposition
Ice
Ice
After the ice melts
Kame
Kame

Moulin kames, near Dundee, Scotland

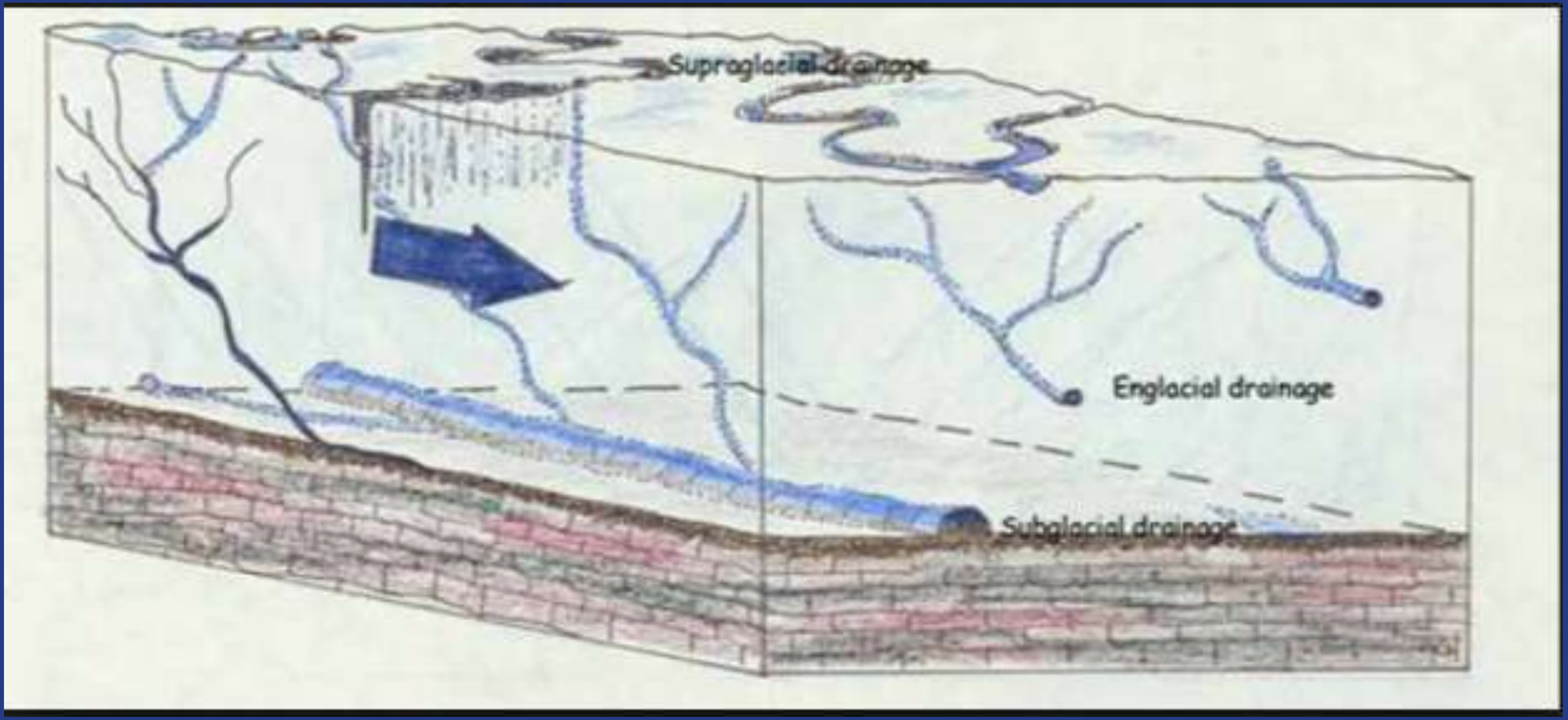
Kames and kettles

Kettle lakes in Siberia

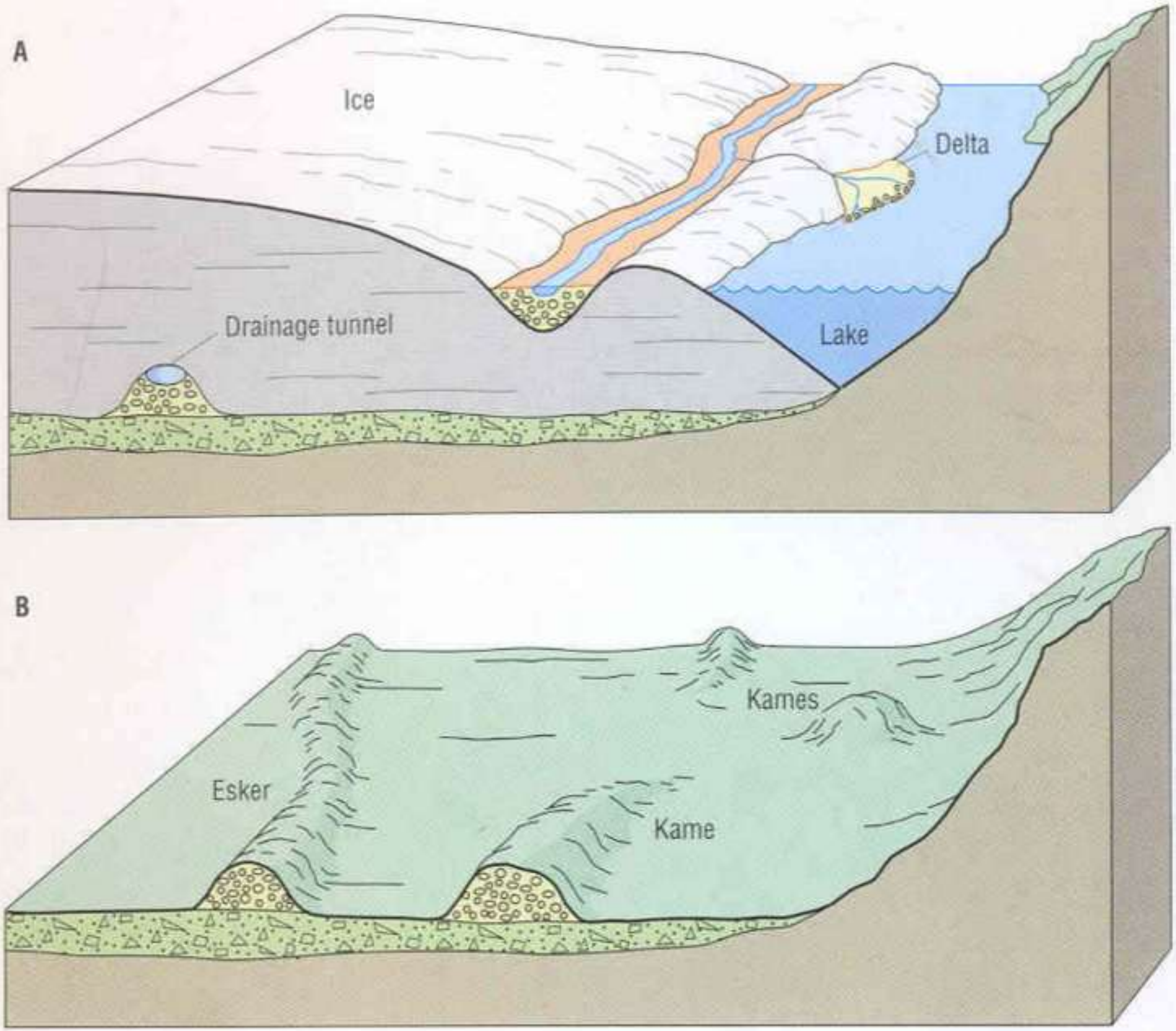
Eskers

An esker (also called eskar, eschar, os, osar, asar or a “serpent kame”) is a long, sinuous ridge formed of glacial till deposited under a glacier by a sub-glacial stream. Eskers can be of various sizes, but usually of kilometres long and can be hundreds of metres wide.

The word esker is derived from the Irish (i.e., Gaelic) word *eiscir* (Old Irish: *escir*), meaning ridge or elevation, especially one separating two plains or depressed surfaces



How surface drainage on a glacier goes underground and reaches its bottom. Compare this with karstic underground drainage

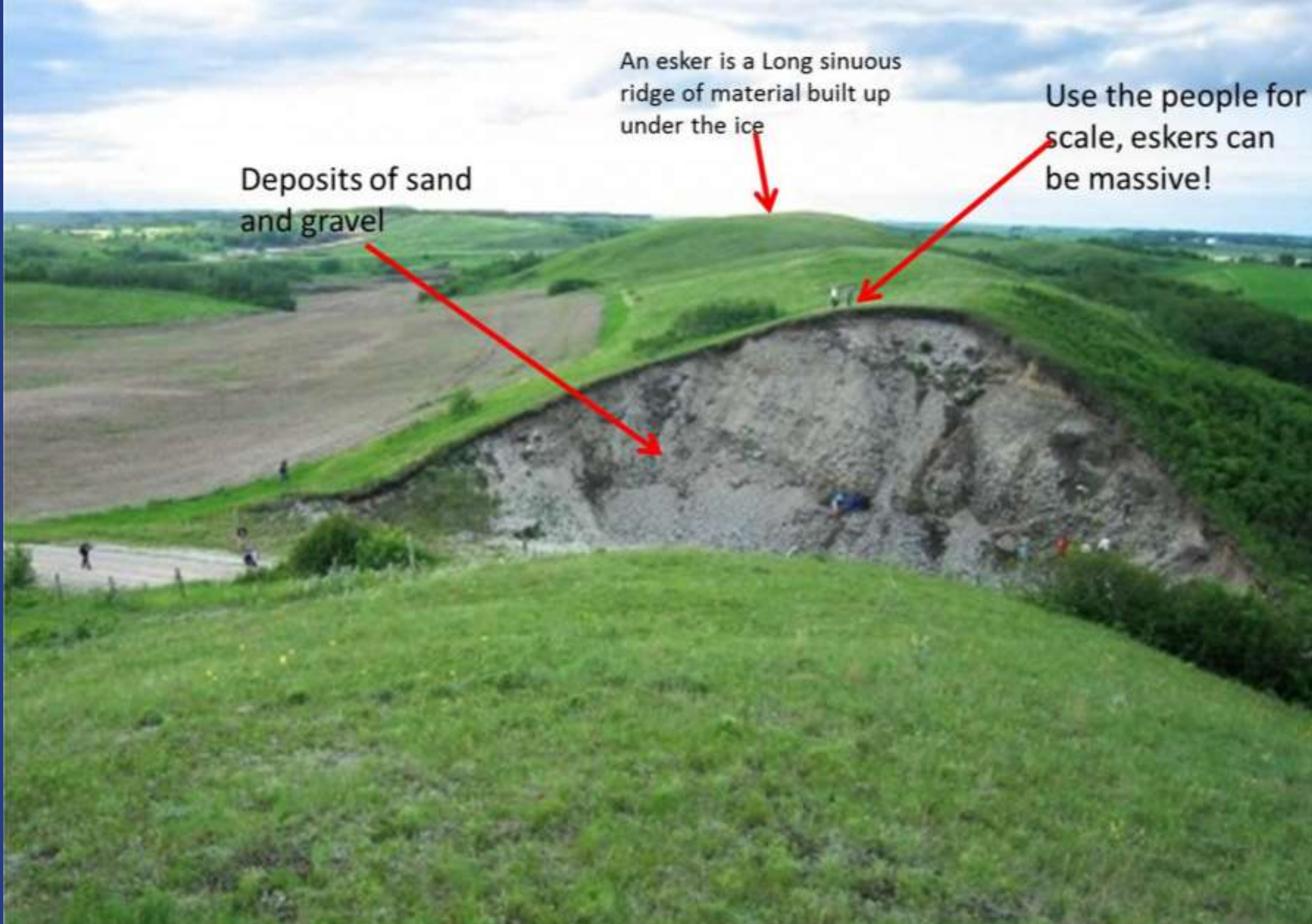

A
Ice
Delta
Drainage tunnel
Lake
B
Kames
Esker
Kame

A sub-glacial stream and the sediment it transports: Unteraar Glacier, Grimsel Pass, Swiss Alps

Another example of a sub-glacial stream

The Bedshiel esker, Scottish Borders area, Scotland, UK

The Keptie Hills esker, Scotland, UK



Esker at Arrow Hills, Manitoba, Canada

http://geology.about.com/od/glaciers_ice/ig/glacier-pictures/esker.htm

Cross-section of a smaller esker, Ireland

Peri-glacial landforms and sediments

Periglacial phenomena are those that occur on permafrost and result from seasonal freezing and thawing of the upper parts of the permafrost. The prefix peri- comes from the Greek περί (*peri*= all around, round about) and is used to denote “marginal to something”, in this case “marginal to glaciated areas”.

Bratschen

Bratschen are steep sided ridges formed from frost action and aeolian corrasion formed generally on steeply-foliated or jointed rocks.

Bratschen in the Tauern Fenster, Austrian Alps

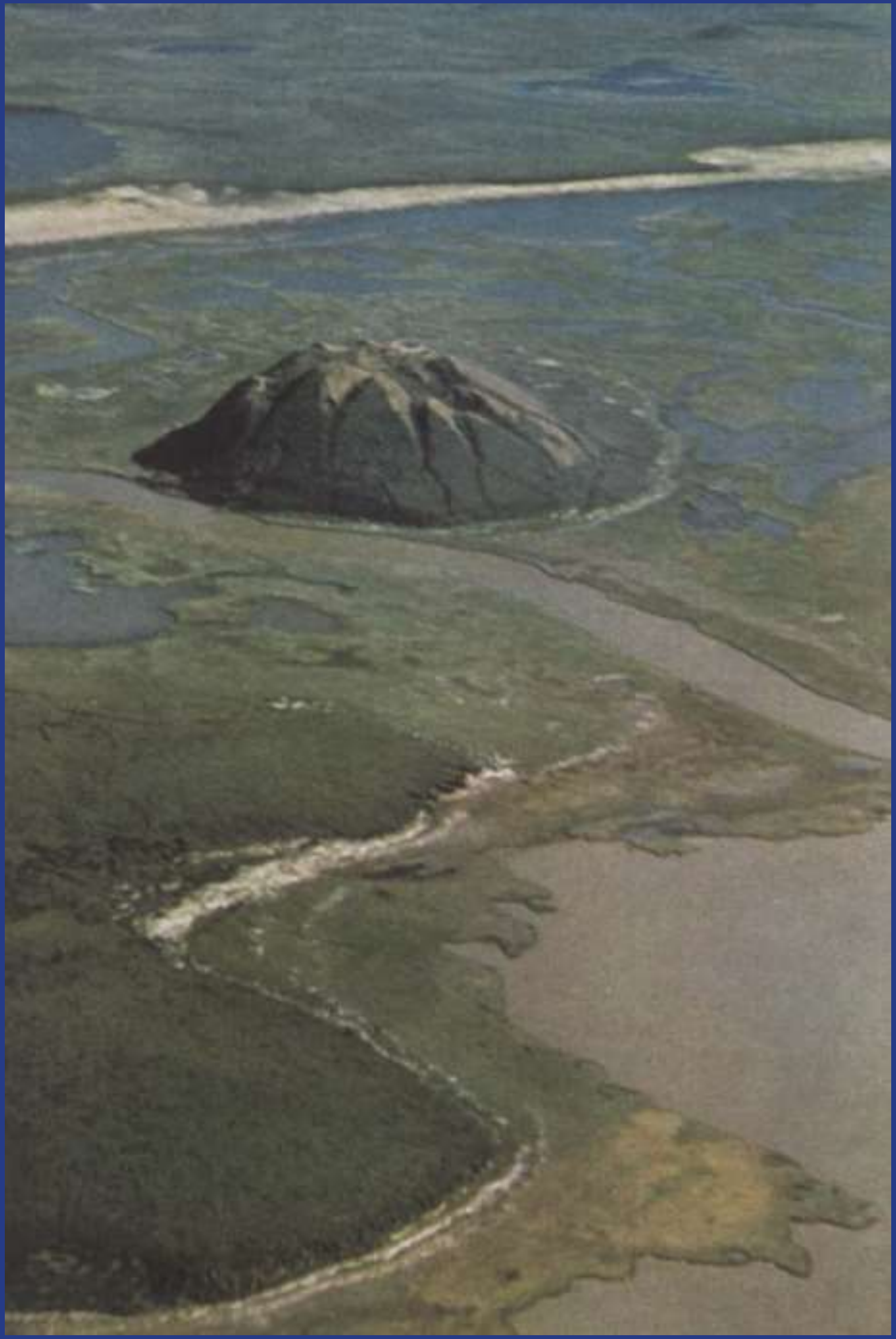
Palsas

A palsa is an oval frost heave containing permanently frozen ice lenses. They form where winter freezing penetrates deeper than surrounding areas and thus the ice lasts through the summer melting. Such conditions may be present in moors and bogs (palsa moors and palsa bogs) where the winter ice cover may be thin providing little insulation and permitting deeper freezing.

Well-developed palsas (locality unknown)

Pingos

Pingos are also termed “ice laccoliths” and can be described as very large palsas. The contain an ice core formed of water provided by the melted part of the permafrost during the summer. In the winter, when the upper layer of the permafrost refreezes the ice core is pushed up from all sides creating a laccolith-like ice core upheaving its top and often creating a radial fracture pattern.

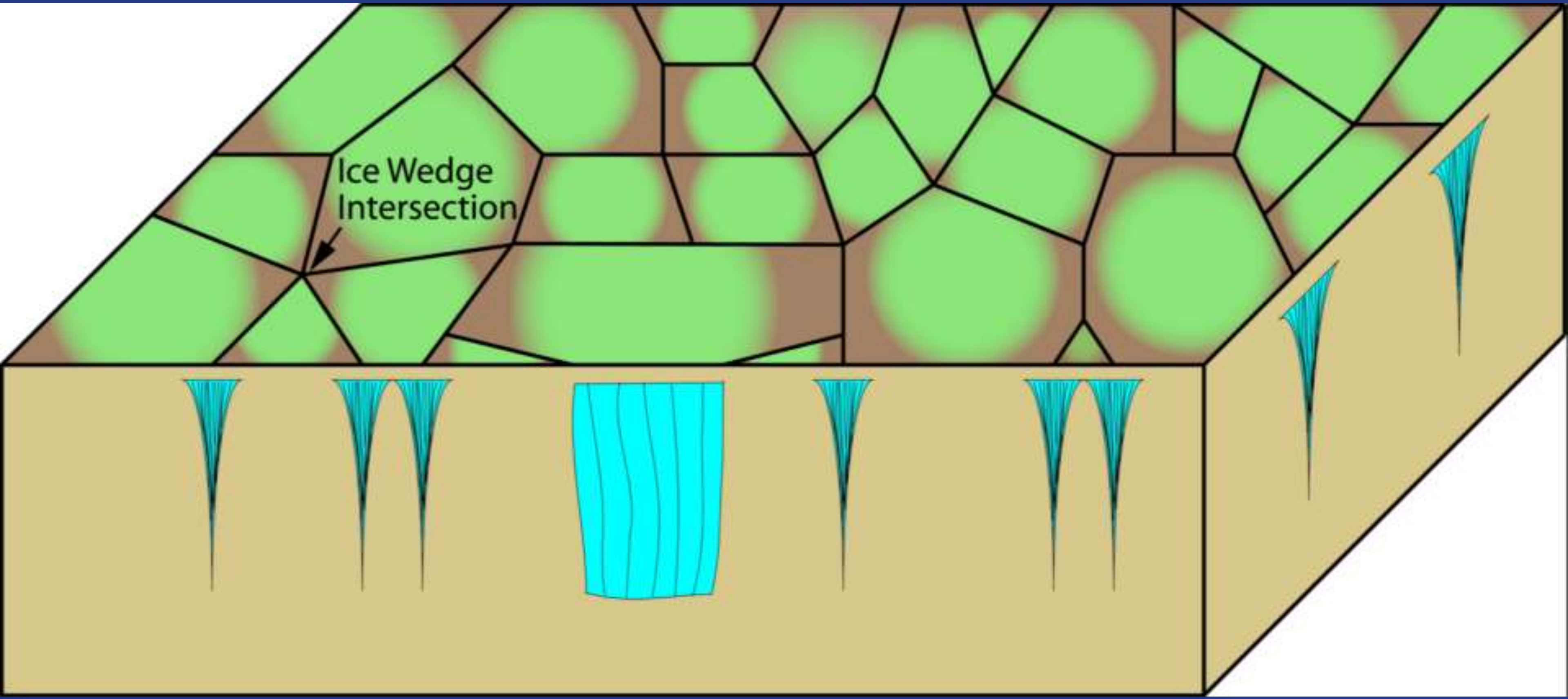


110 metre yüksekliğinde bir pingo. Alaska, USA

Patterned ground

Patterned ground refers to geometric shapes dividing the permafrost by septae filled with coarser-grained debris. They form as a result of frost heaving similar to the palsas. The coarser-grained debris in the septae are simply rocks that slide or roll from on top of the upheaved parts.

Patterned ground in Alaska, USA

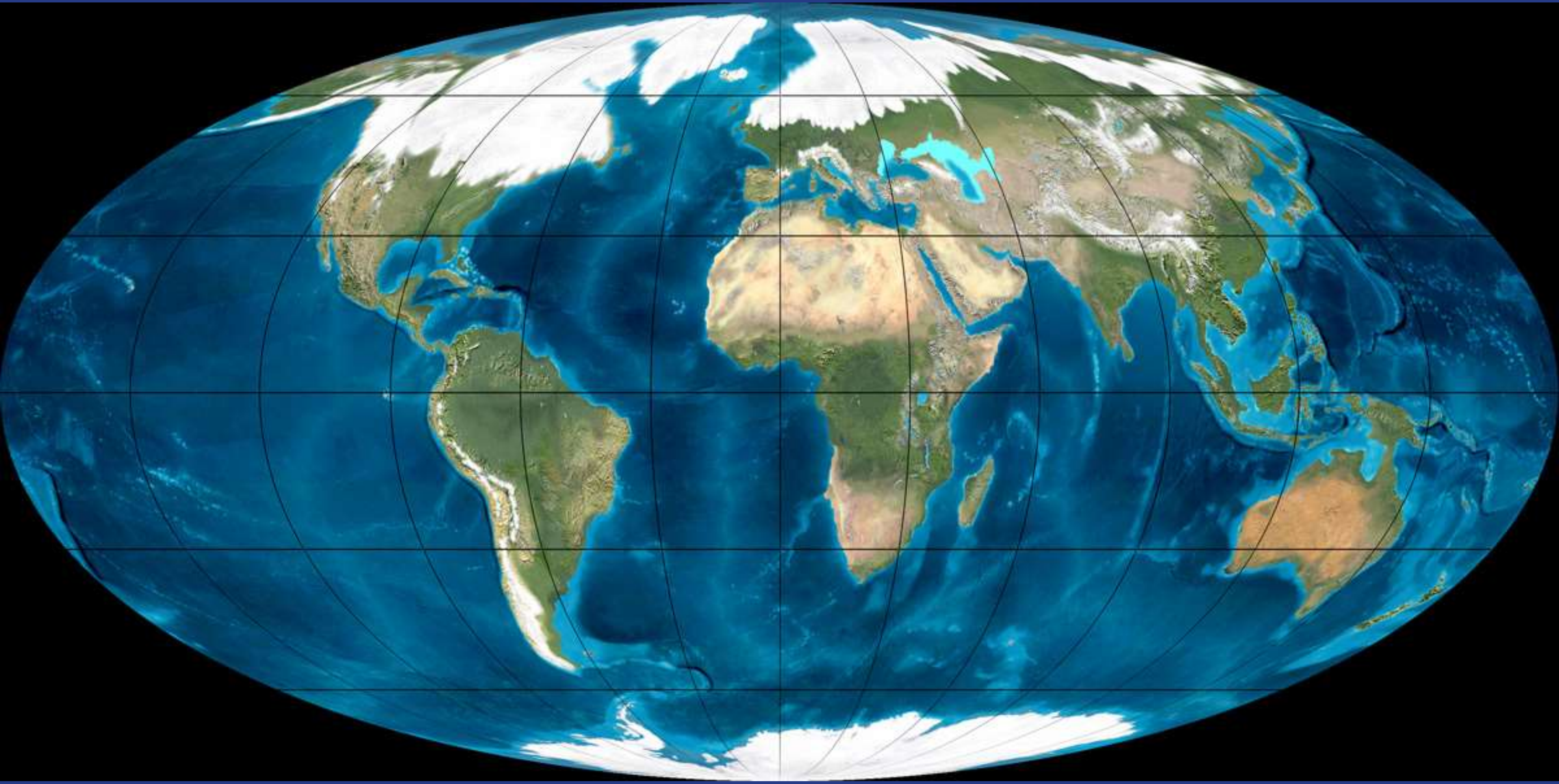


The formation of polygonal patterns in permafrost.

Cryoturbation

Cryoturbation, also known as “frost churning” refers to the deformation of the permafrost because of repeated melting and thawing events and is distinct from the deformation that takes place in moraines by glacier pushing (“glaciotectonics”).

Cryoturbation from the Canadian Arctic



The earth 50,000 years ago (by Ron Blakey)

Worry has enveloped mankind!

(Well, at least some of us)

Some believe that the climate change we see today is one with no past analogue

BUT IS IT TRUE?

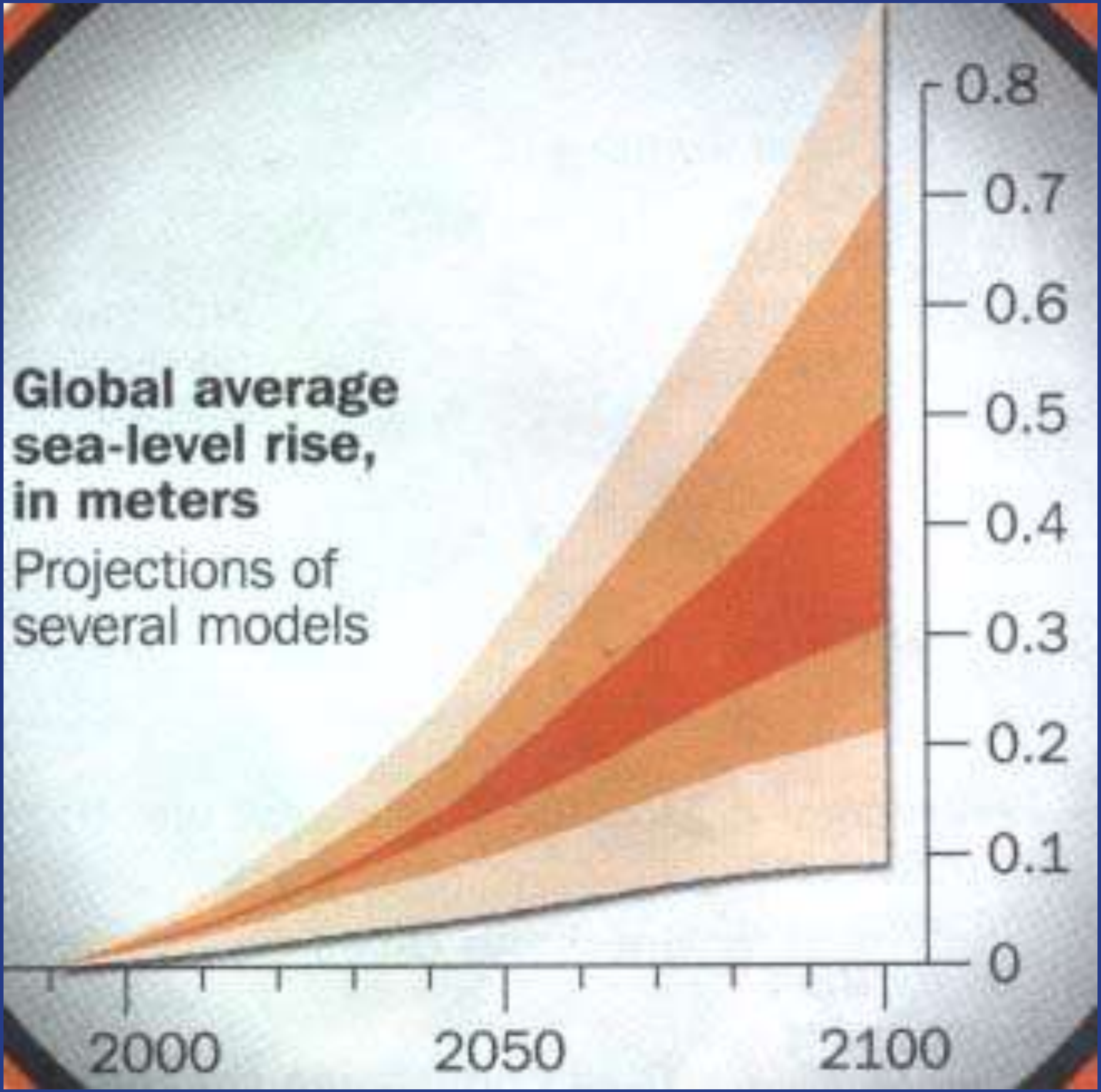
IS THE PUBLIC AWARE OF THE FACT THAT GLOBAL ENVIRONMENT HAS CONTINUOUSLY CHANGED SINCE THE ORIGIN OF OUR PLANET MORE THAN 4.5 BILLION YEARS AGO?

PEOPLE REALISE THAT DINOSAURS ARE NO LONGER AROUND, BUT WE STILL SEE IDIOTIC MOVIES SHOWING MEN AND DINOSAURS LIVING TOGETHER!

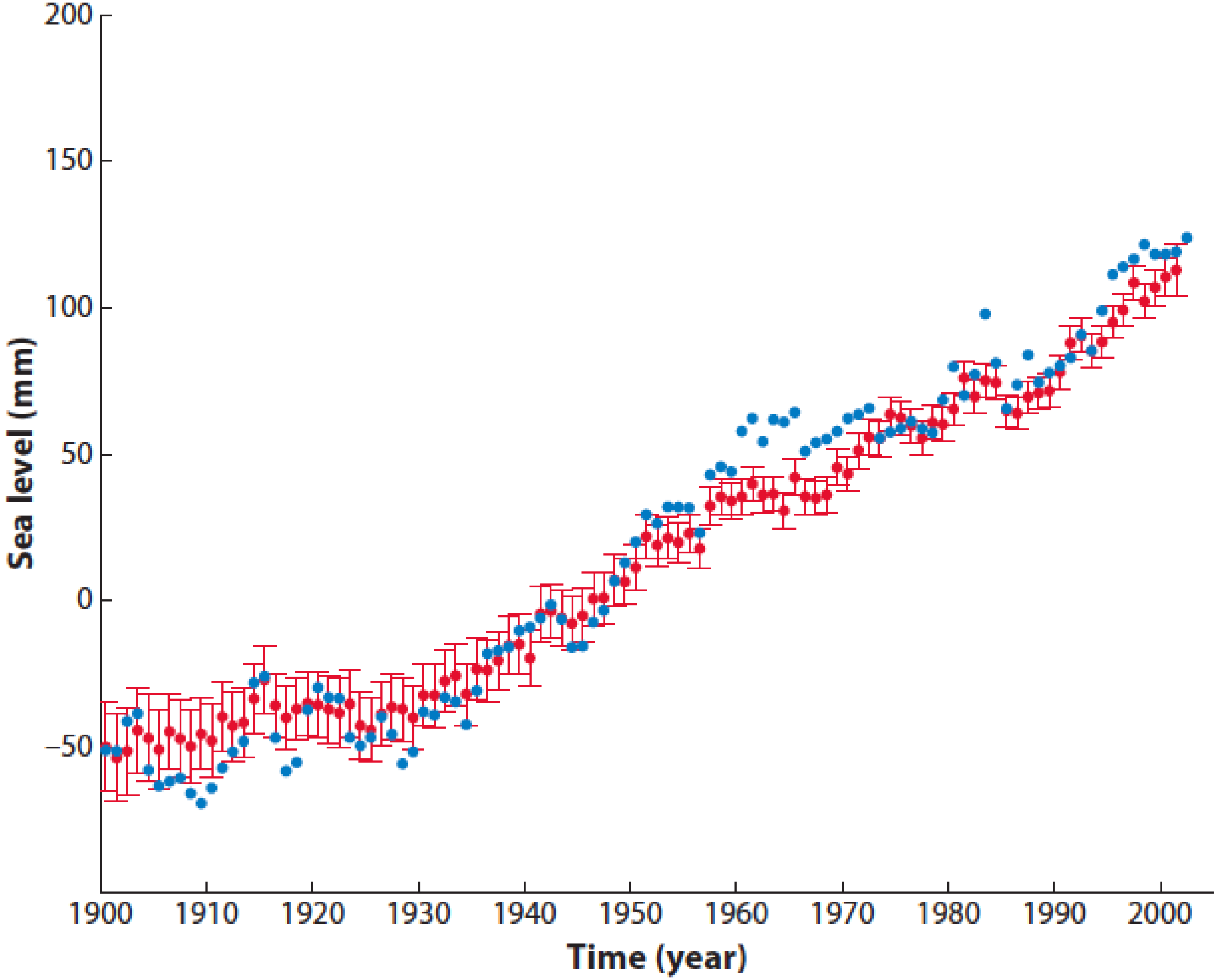
MOVIES ARE MADE SHOWING THAT THE EARTH CAN FREEZE IN A FEW HOURS OR THAT IT IS POSSIBLE TO TRAVEL TO THE CORE OF THE EARTH!

OTHER MOVIES SHOW THAT SUBDUCTION ZONE VOLCANOES CAN GO BERSERK IN A MATTER OF WEEKS AND ERUPT IN CONCERT AND THAT THIS CAN BE STOPPED BY A FEW EXPLOSIONS!

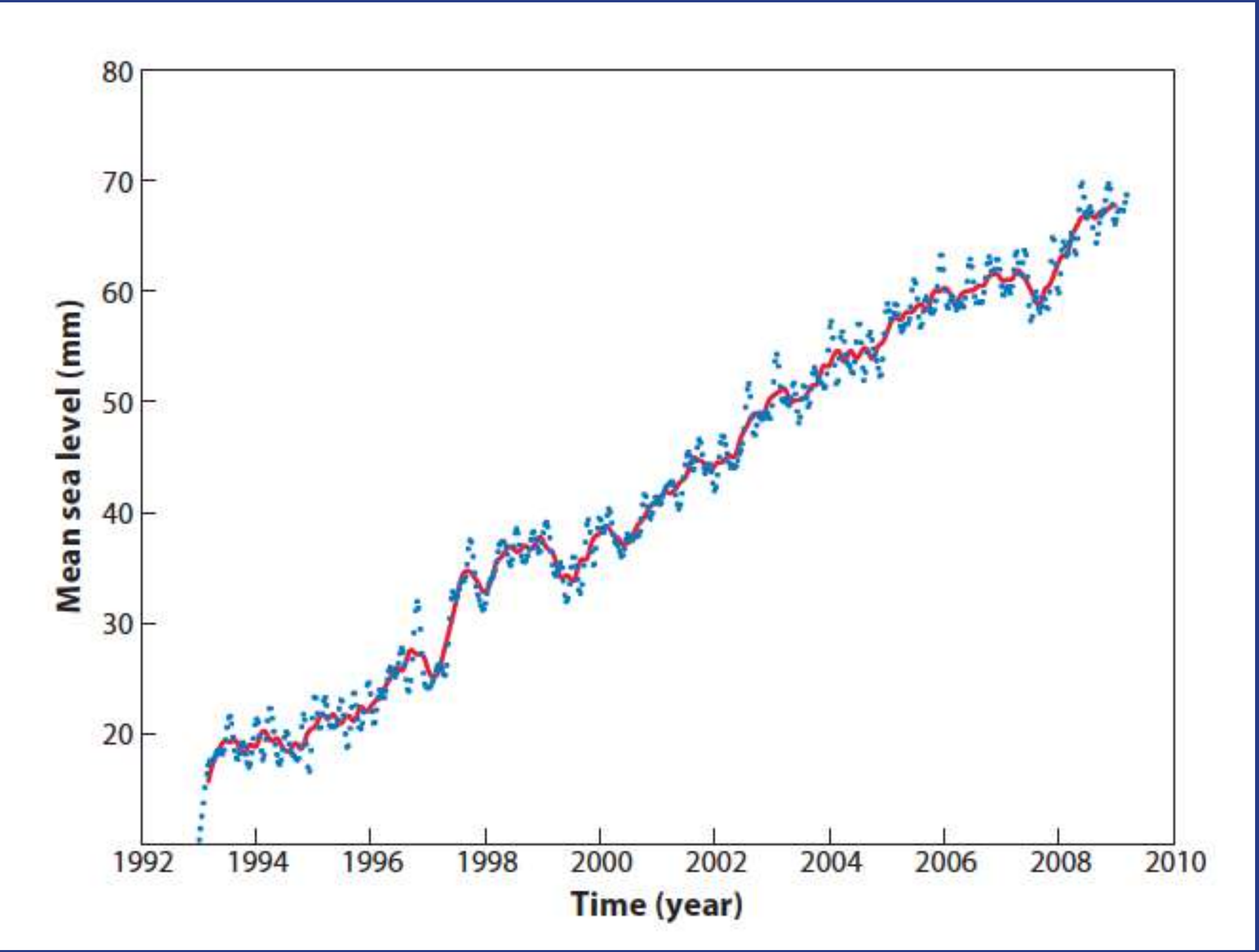
THE PUBLIC IS FRIGHTENINGLY IGNORANT ABOUT THE PLANET ON WHICH IT LIVES, YET VOTES ABOUT POLICIES THAT GOVERN OUR RELATIONSHIPS WITH THE PLANET. THIS CAN HAVE SUICIDAL CONSEQUENCES FOR THE ENTIRE HUMANKIND OR EVEN THE ENTIRE BIOSPHERE.



Time, 3rd April 2006 climate issue has summarised the existing models of expected sea-level change in the next century



Observed mean sea-level from tide gauges (from Cazenave and Llovel (2010)



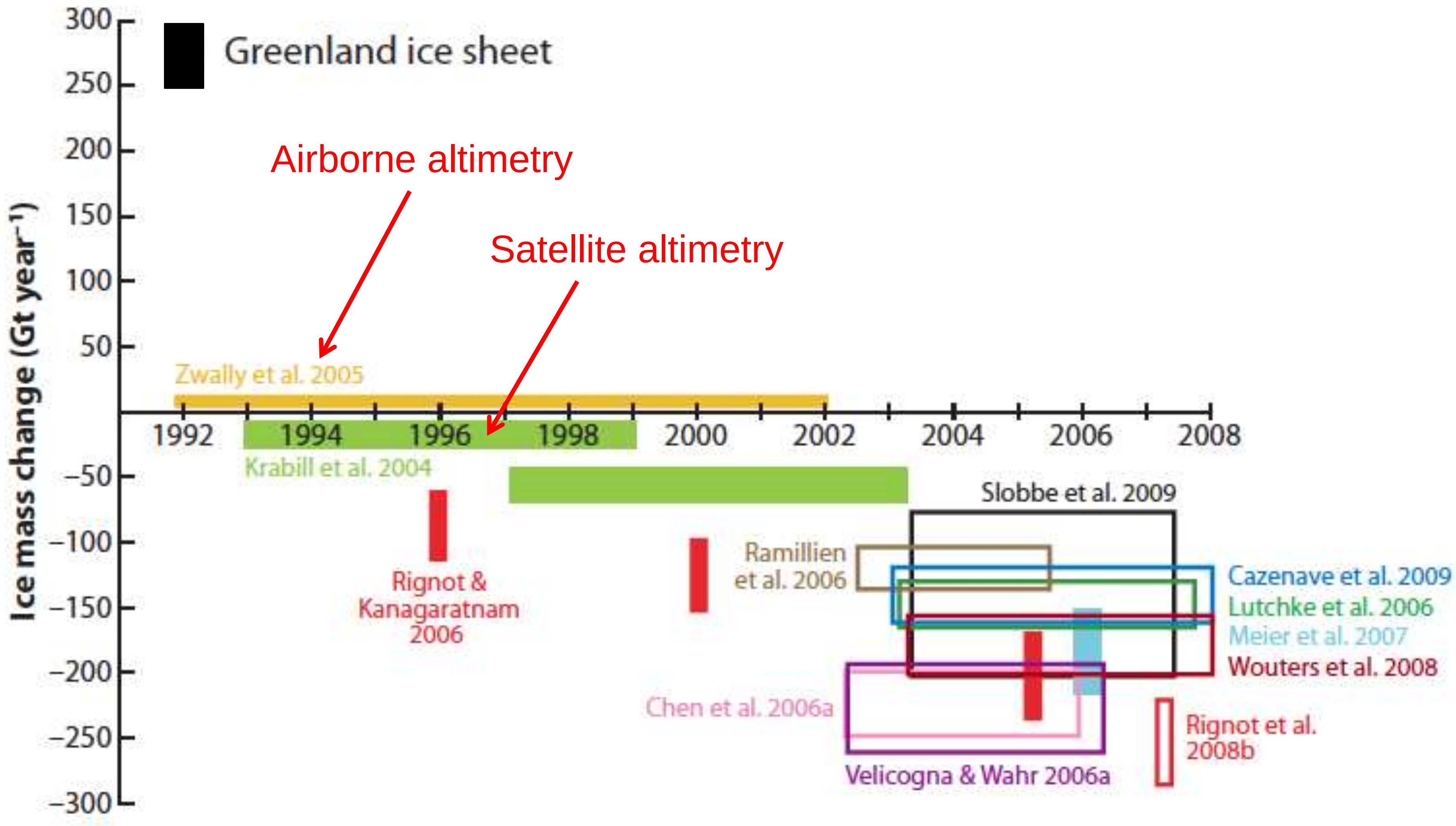
Global mean sea-level from satellite altimetry between January 1993 and december 2008 (from Cazenave and Llovel, 2010)

Between 1993-2007 sea level rise has averaged 2.85 ± 0.35 mm/a

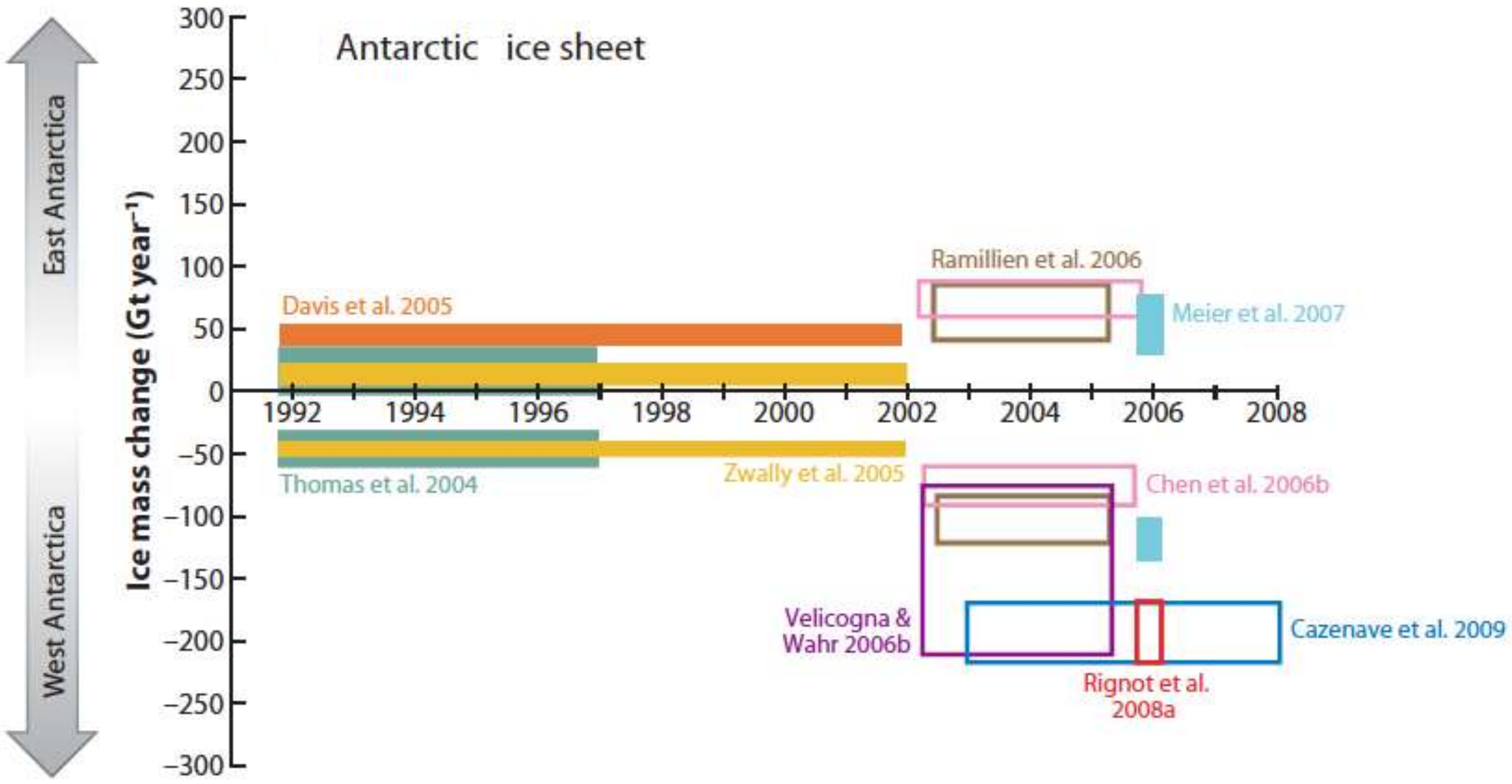
Of this sum,

30 % is a consequence of the thermal expansion of ocean water and the rest is due to glacier ice melt

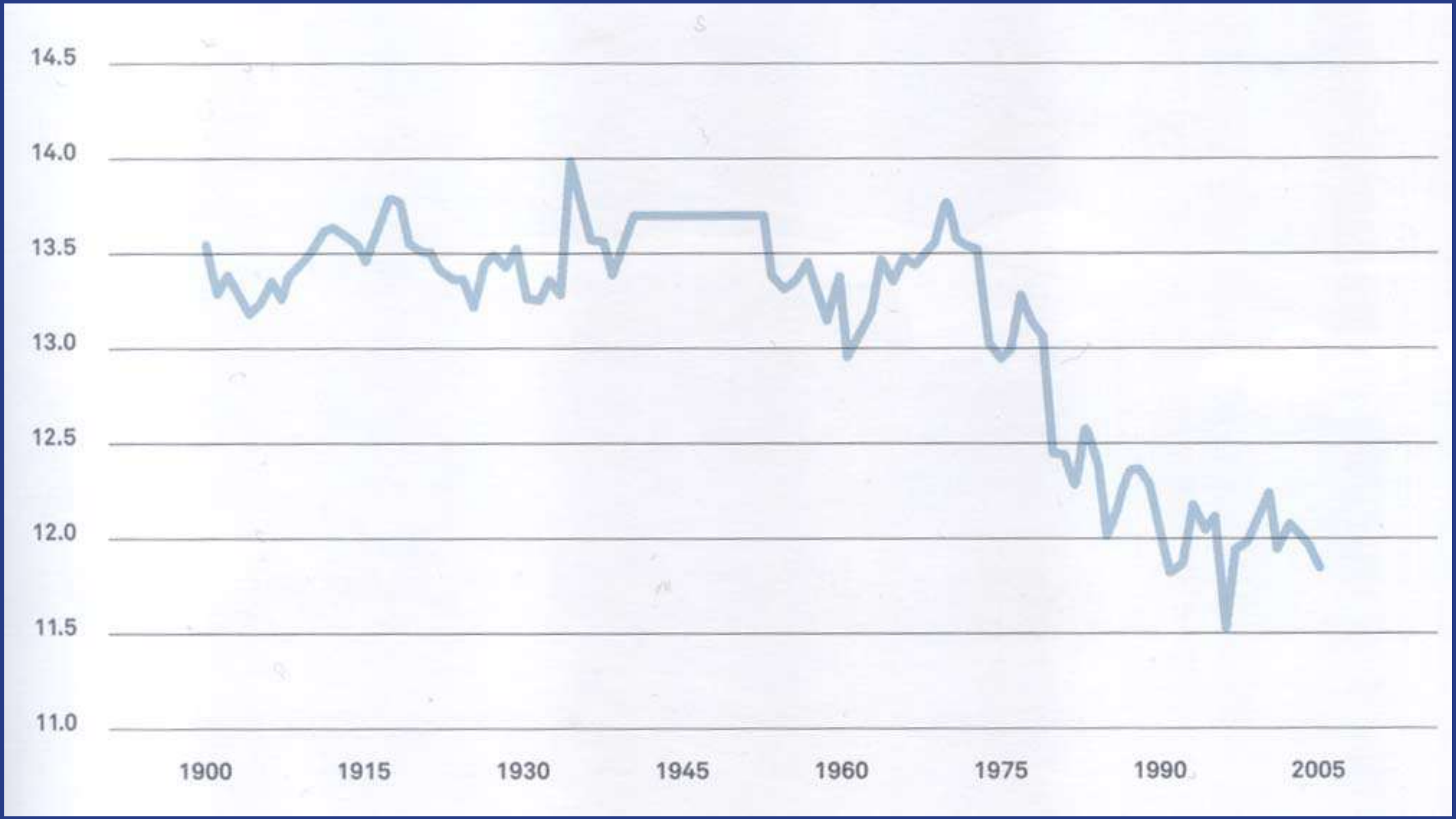
In recent years, however, the contribution of glacier melt to sea-level rise has increased to 80% !



The mass change of the Greenland ice sheet between 1992 and 2008. Notice the rapid acceleration of the ice loss both because of surface melting and basal lubrication of the ice tongues (from Czenave and Llovel, 2010)

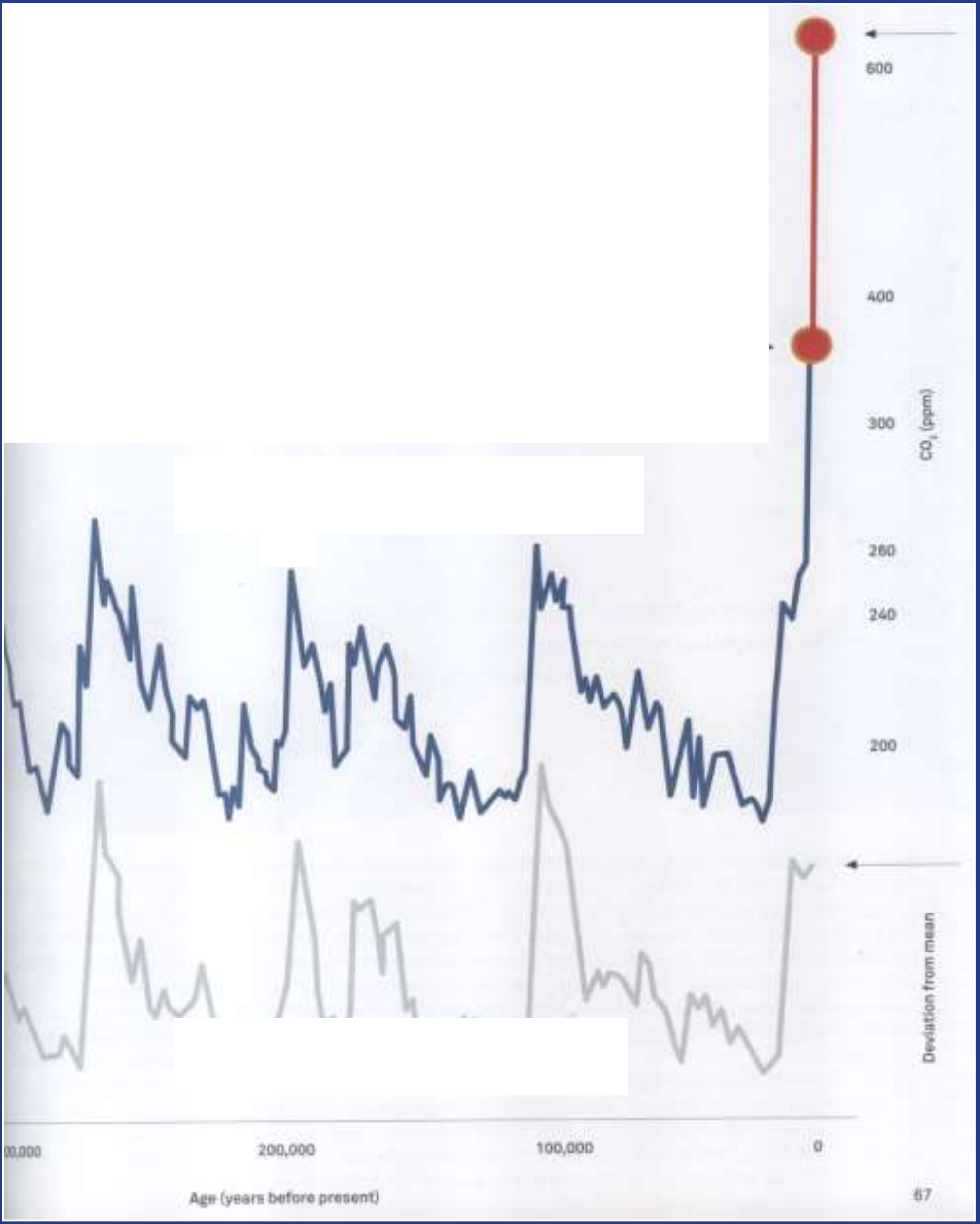


Ice mass loss in Antarctica (from Cazenave and Llovel, 2010)

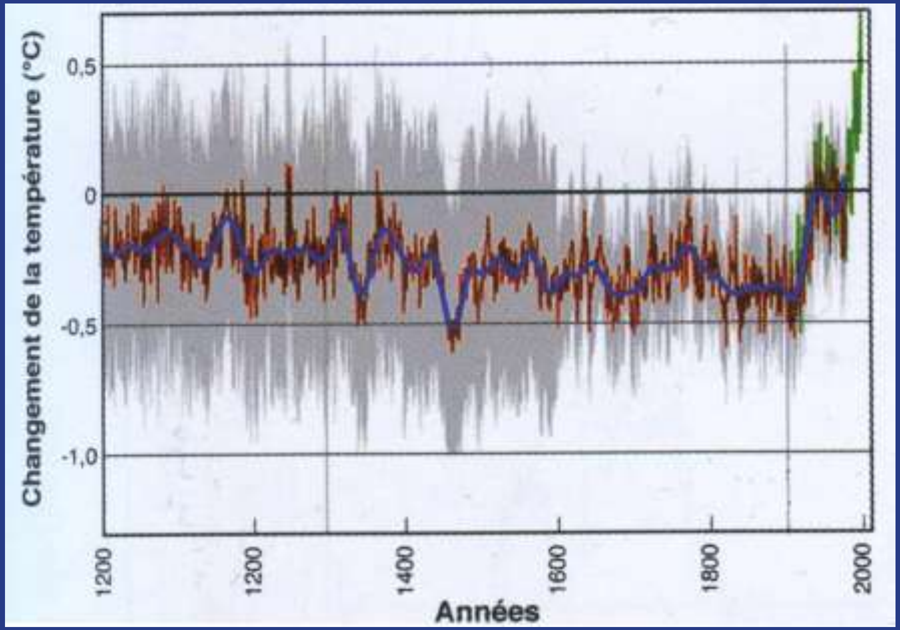


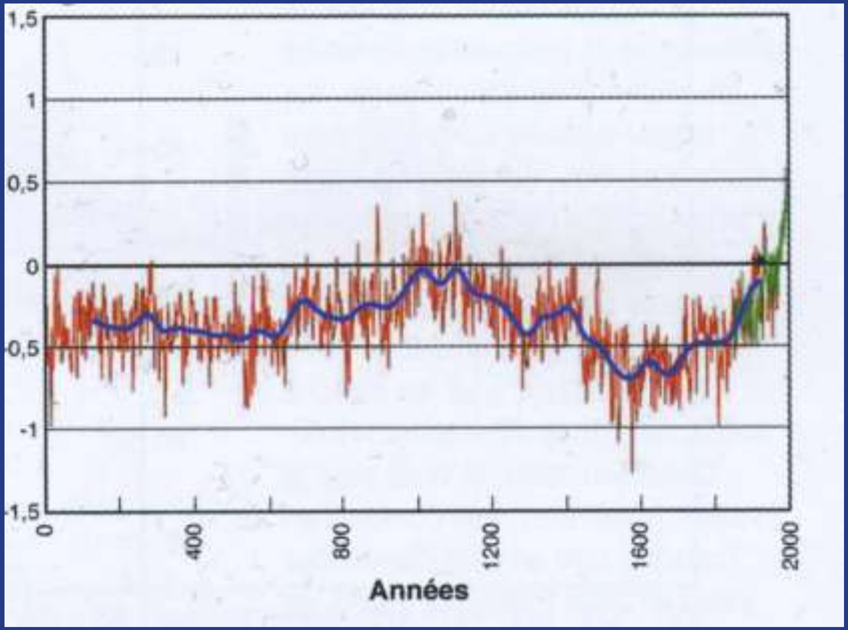
Change in area of sea-ice cover in the northern hemisphere (in millions of km^2)
(from Al Gore, who forced the US Navy to release its data)
(Gore, 2006)

WHAT CAUSES THE OBSERVED ICE MELTING AND THE SEA-LEVEL RISE?



This is the comparison between global temperature rise and CO_2 concentration that Gore published in his 2006 book



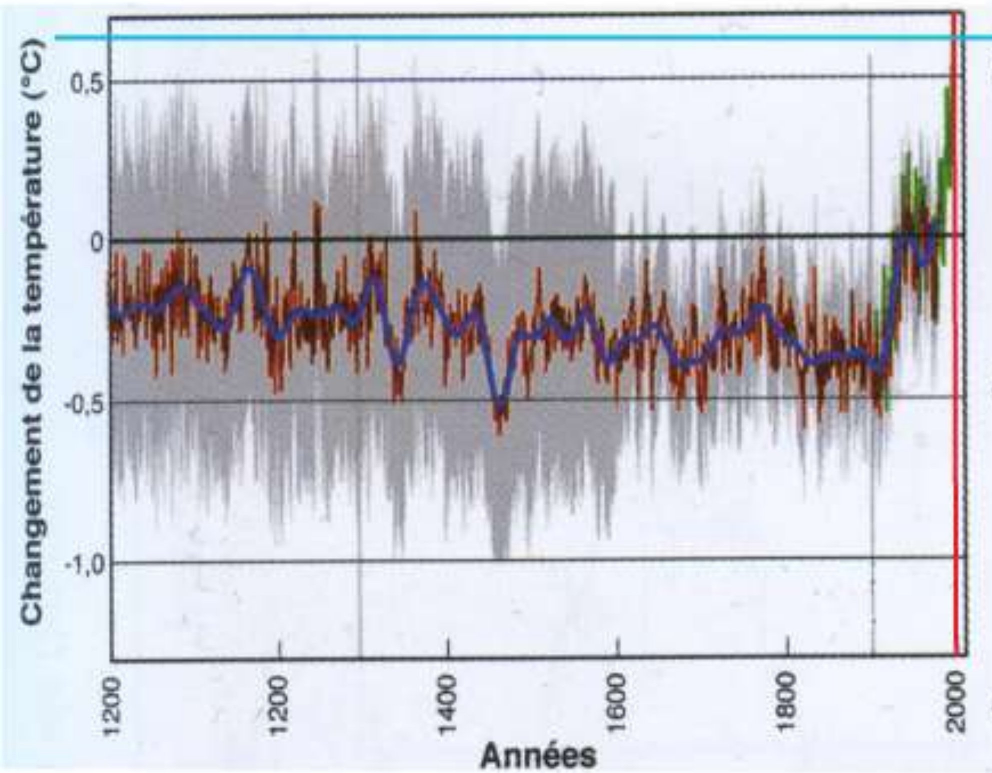


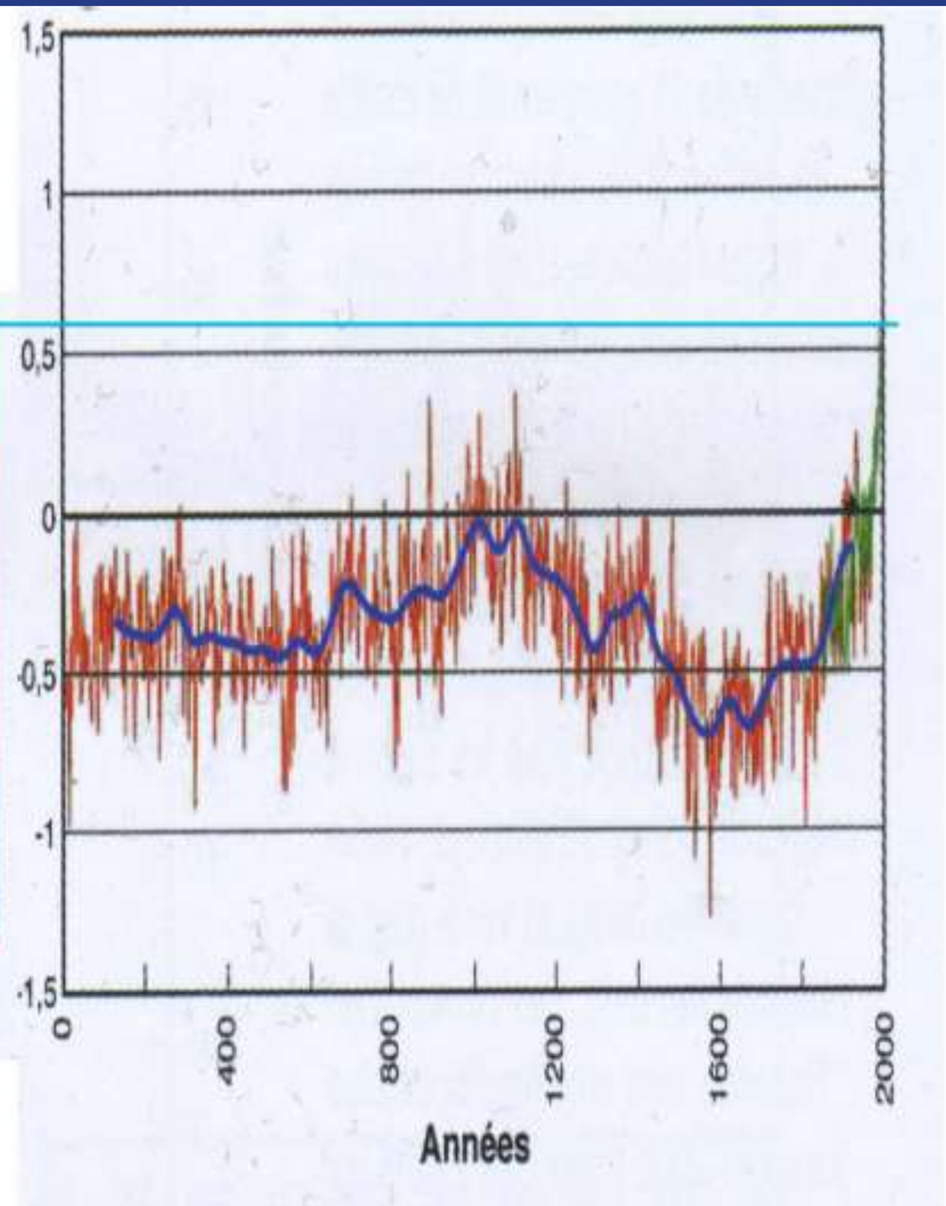
From Mann et al. (1999)
(This 'hockey-stick curve' was used by the 2001 UN Intergovernmental Panel on Climate Change)

From Moberg et al. (2005)

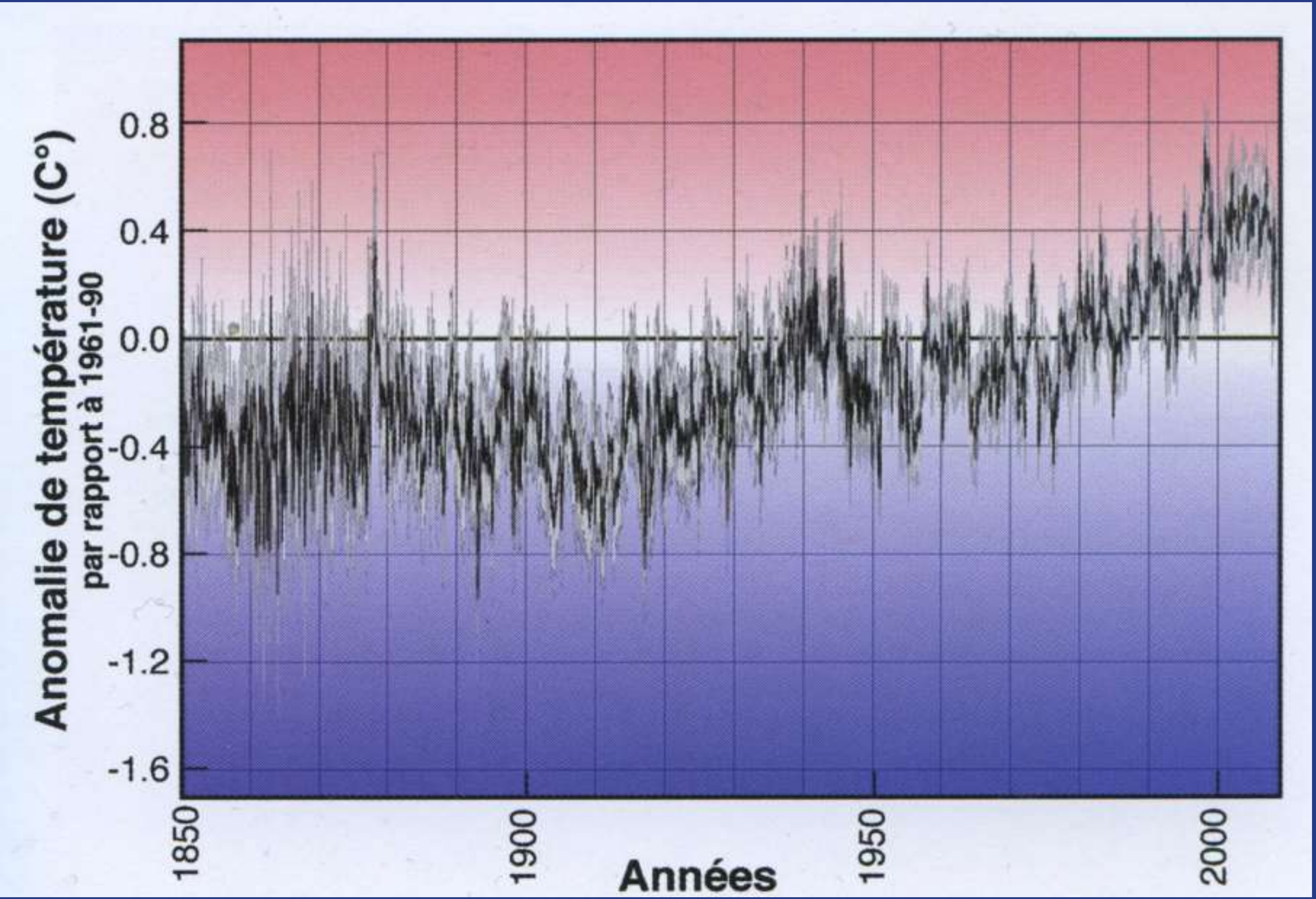
A comparison between two global temperature change curves (from Courtillot, 2009)

A comparison of the two curves after the scales have been adjusted



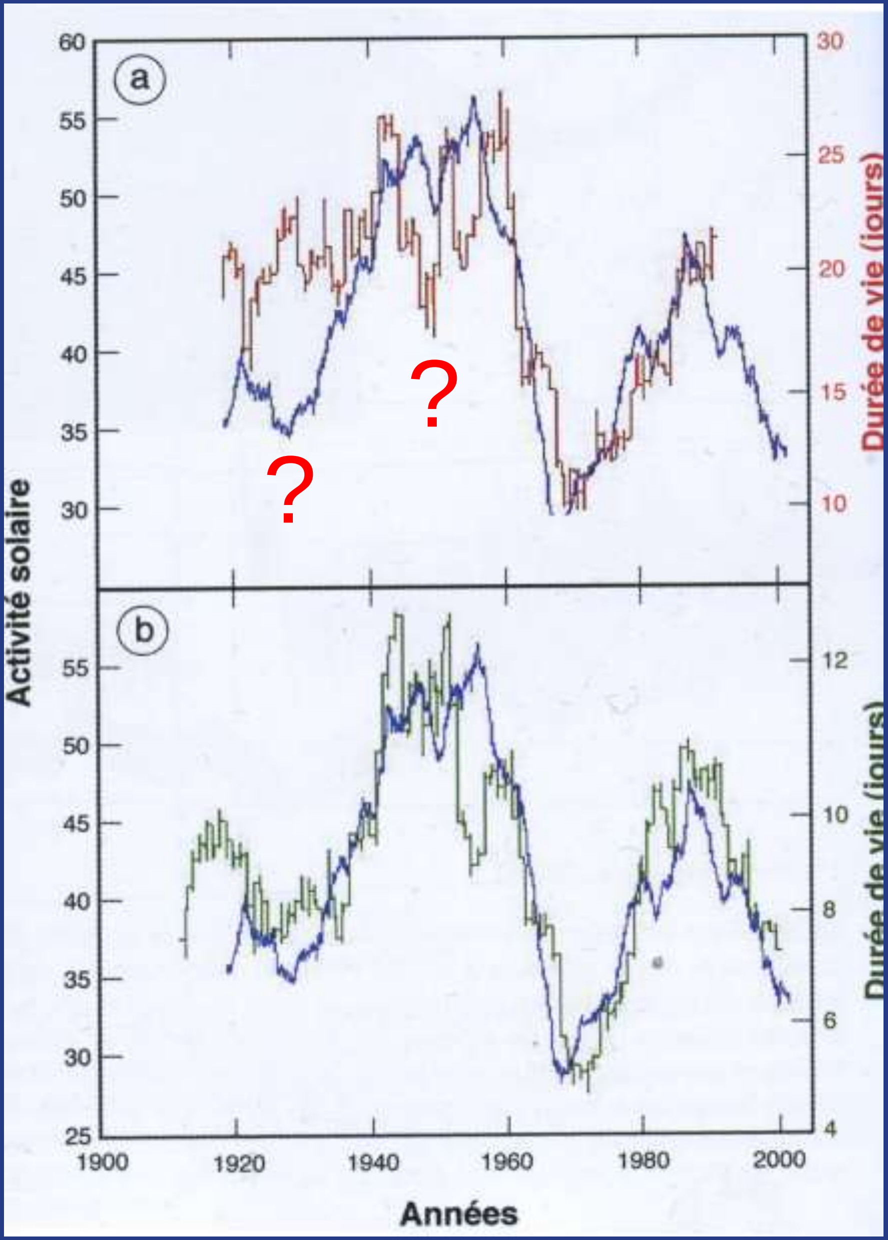


The two curves say the same thing: It is getting hotter !

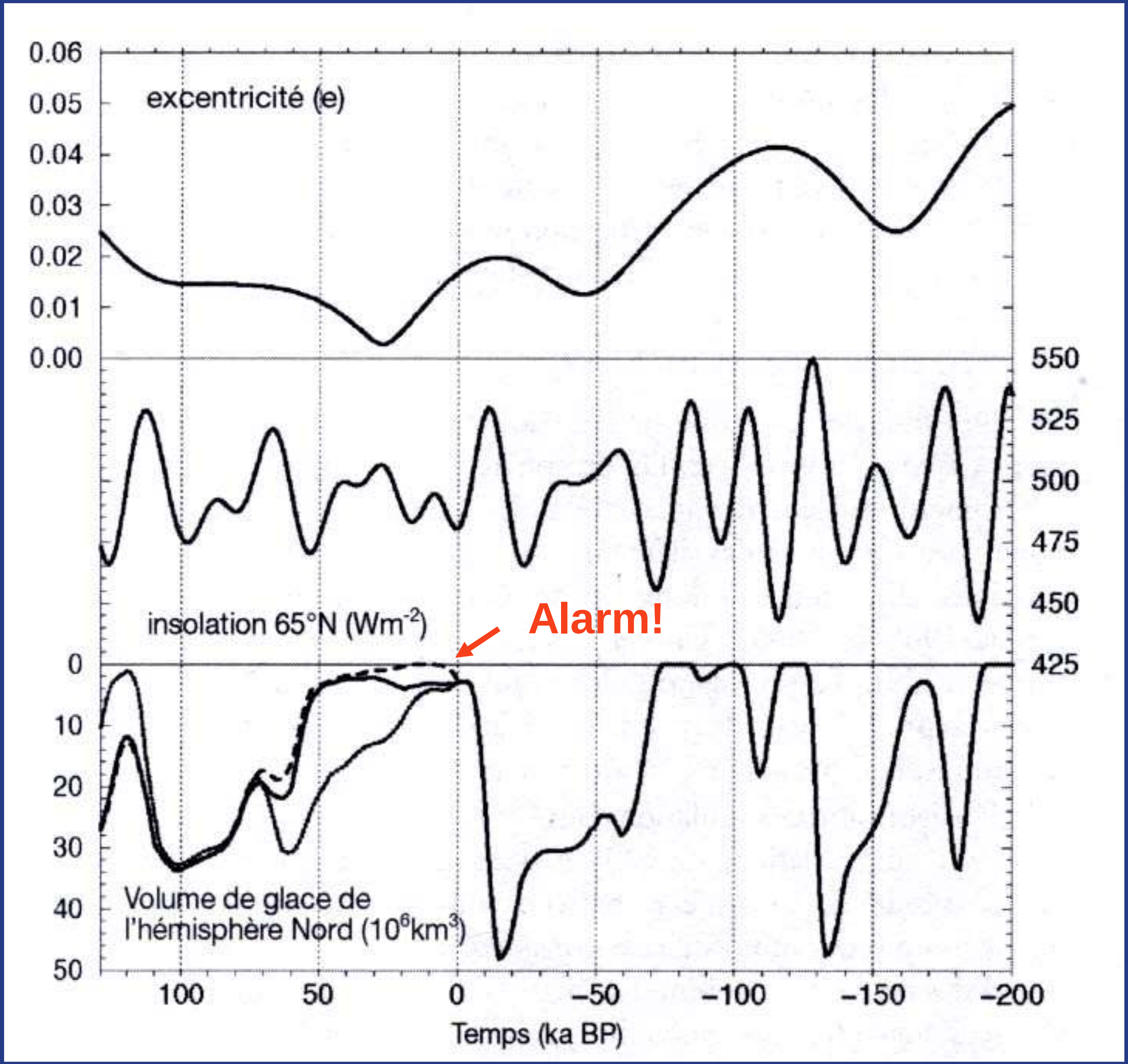


Courtillot’s preferred temperature change curve updated to 2009 (Courtillot, 2009)

NOW THAT WE AGREE THAT IT IS GETTING HOTTER, THE QUESTION BECOMES 'WHY?'



Comparison of solar activity with the duration of daily temperature trends on earth (from Courtillot, 2009) Match imperfect, but general trends agree



Change in excentricity of the earth's orbit

Solar energy arriving at the top of the atmosphere

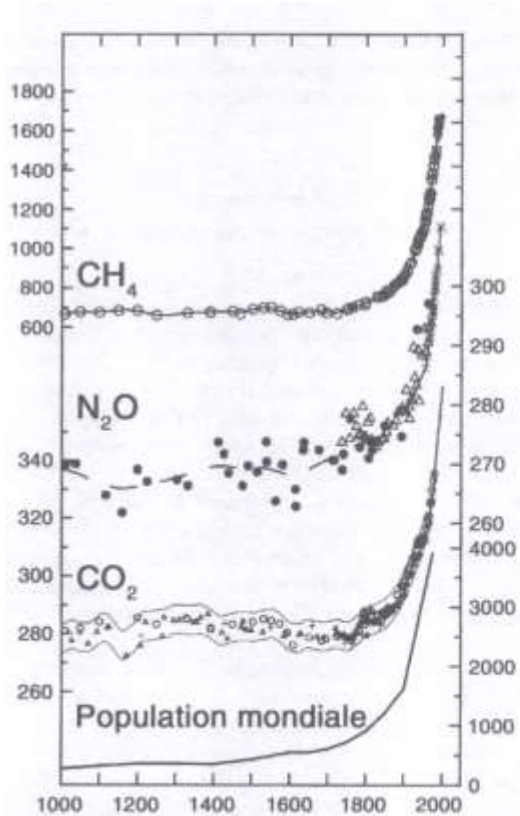
Ice volume

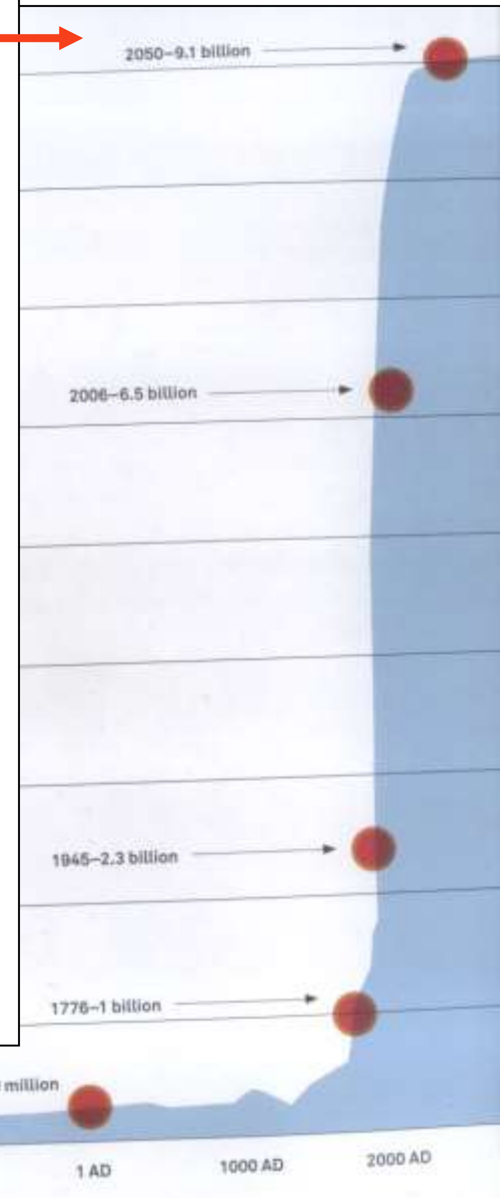
Change in ice volume from 200.000 years ago to 130.000 years ago and its comparison with excentricity and solar energy arrival at the earth's atmosphere (Berger and Loutre, 2006)

ALARM!

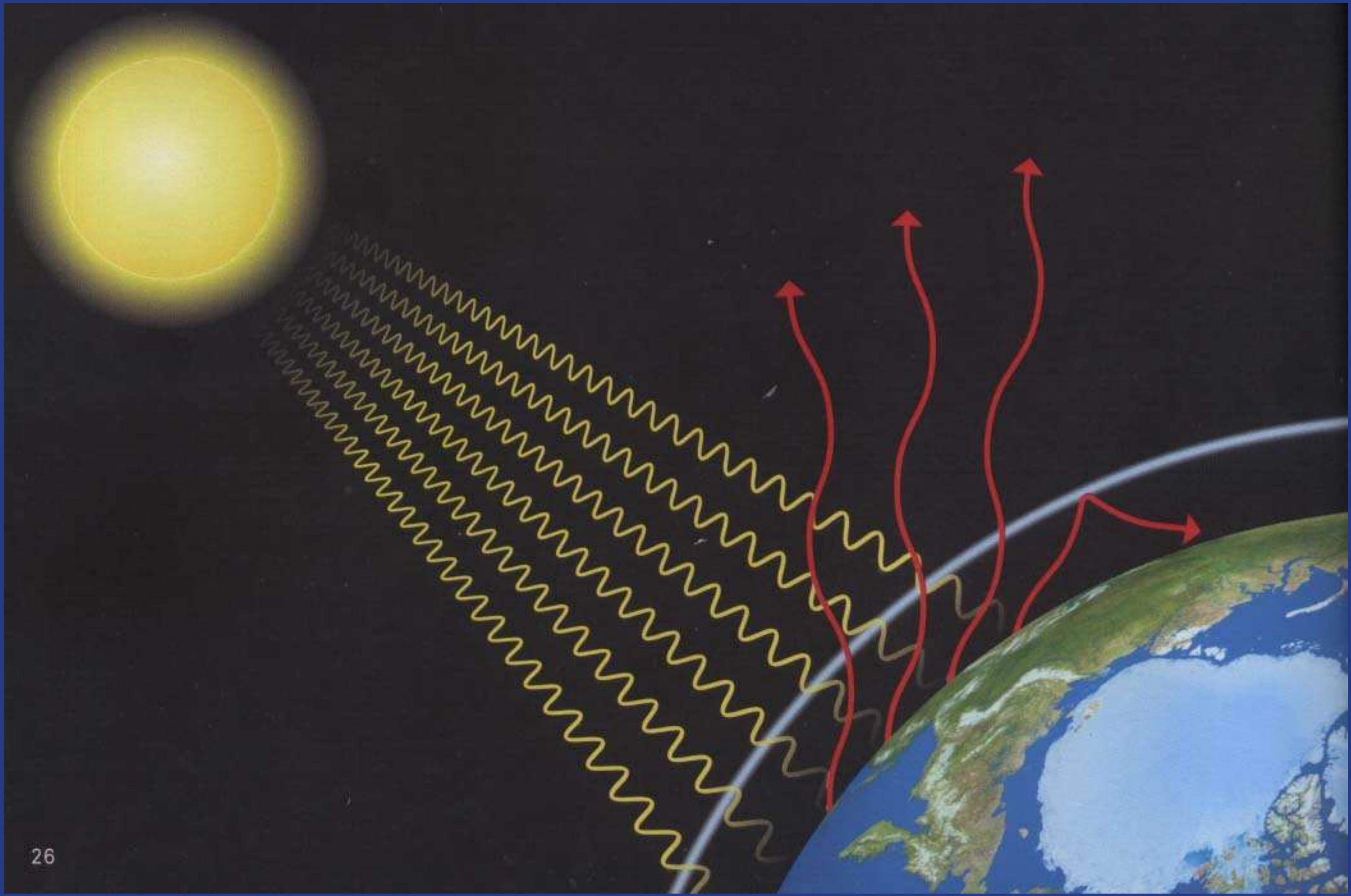
9,1 billion in 2050!

First humans

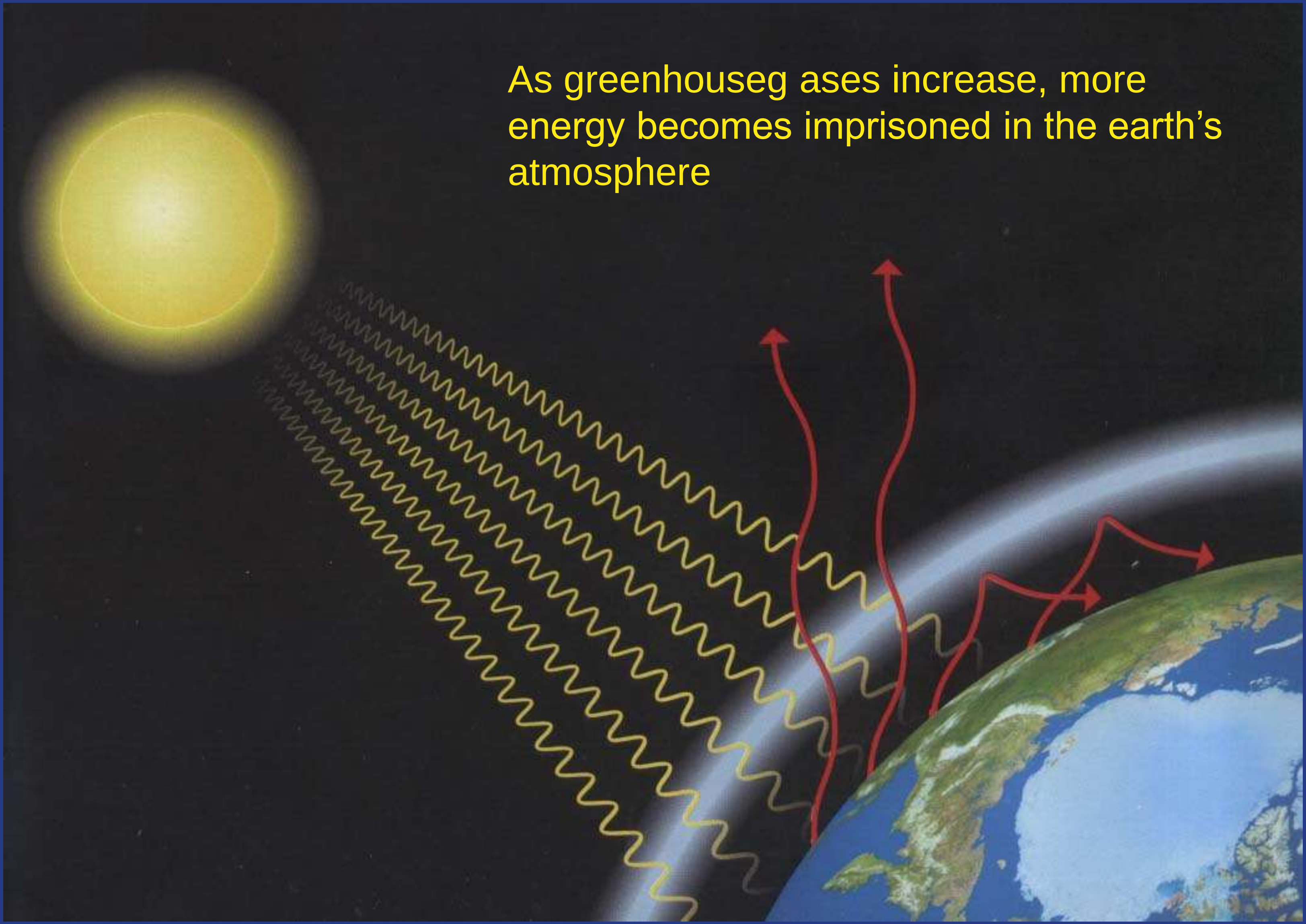




Population increase and its correlatior with the increase in green house gases

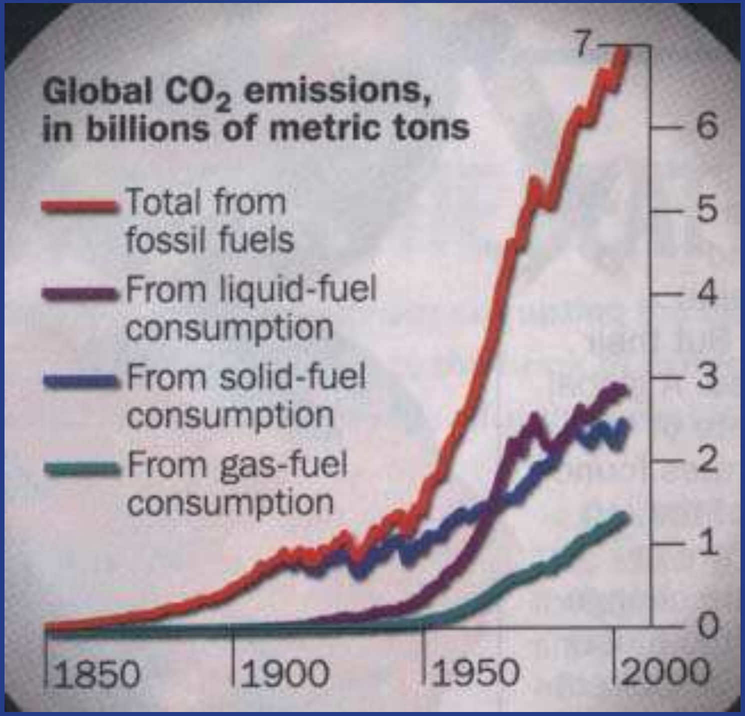


(Gore, 2006)

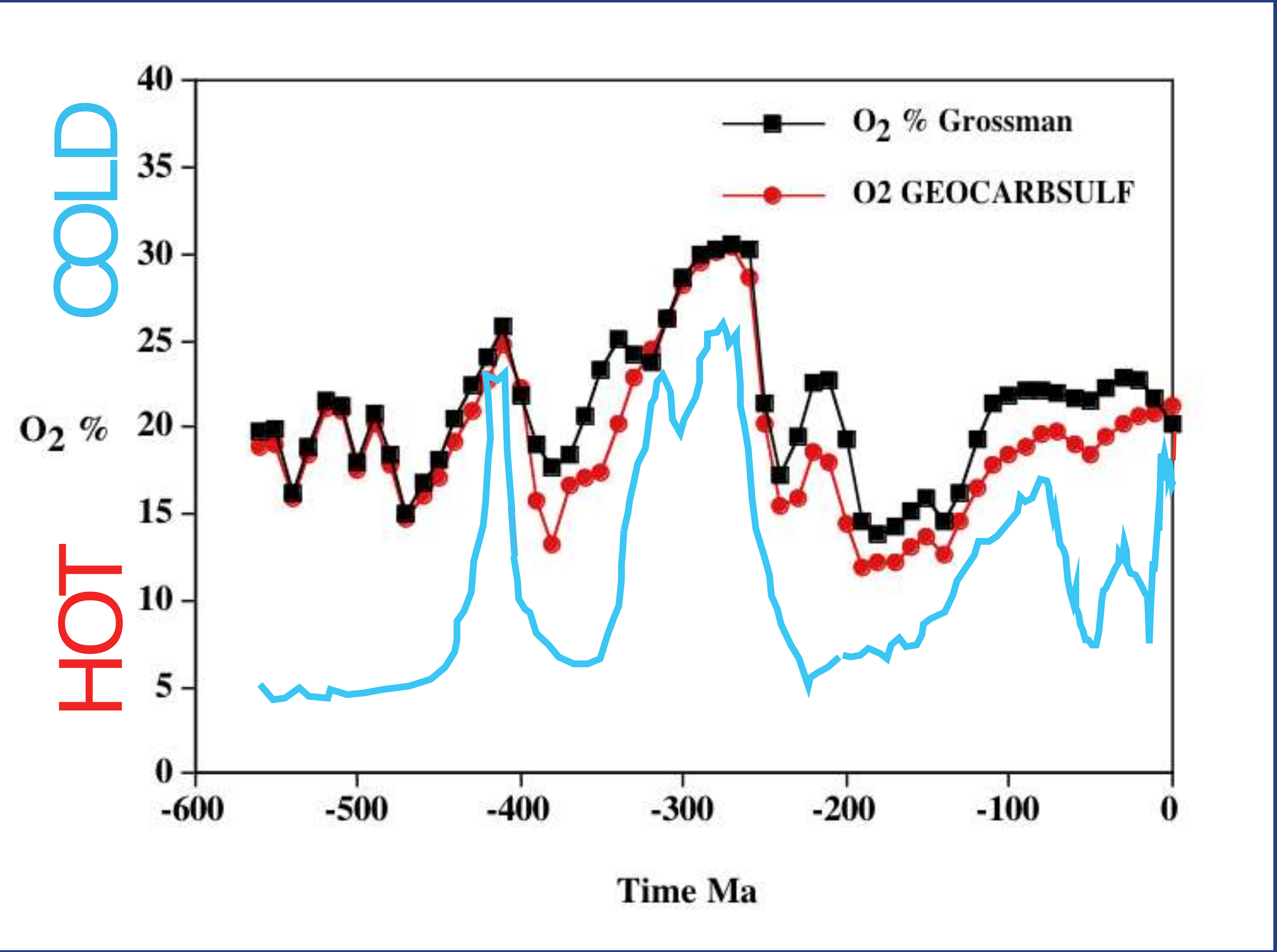

As greenhouseg ases increase, more energy becomes imprisoned in the earth's atmosphere

(Gore, 2006)

IT SEEMS CLEAR THAT AS OUR POPULATION INCREASES WE GENERATE MORE AND MORE GREENHOUSE GASES, MOST NOTABLY CO_2, BECAUSE WE NEED MORE AND MORE ENERGY. ALL LIFE USES SUN’S ENERGY. WE USE IT MUCH FASTER BY EXPLOITING THE SOLAR ENERGY IMPRISONED IN FOSSIL FUELS THROUGHOUT HUNDREDS OF MILLIONS OF YEARS.



CO_2 generation in billions of tons from fossil fuels (from *Time*, 2006)



Percentage of O_2 in the atmosphere compared with averge global temperature (O_2 from Berner, temp. from Courtillot)

FOSSIL FUEL CONSUMPTION CONDEMNS OUR CIVILISATION TO A HOTTER EARTH WITH HIGH SEA-LEVELS.

NUCLEAR IS AN ALTERNATIVE, BUT THE RECENT EVENTS IN THE FUKUSHIMA-DAICHI NUCLEAR PLANTS HAVE MADE EVERYONE VERY WEARY OF NUCLEAR POWER PLANTS. STATISTICS ABOUT THEM ARE FLAWED, BECAUSE WE DO NOT HAVE ENOUGH DATAPOINTS.

A SAFER ALTERNATIVE ARE THE SO-CALLED RENEWABLE ENERGY RESOURCES. BUT THE PROBLEM HERE IS, HOW RENEWABLE ARE SUCH RESOURCES? UNLESS WE UNDERSTAND THE NATURE AND DIRECTION OF GLOBAL CLIMATE CHANGE WE CANNOT FORECAST THE RENEWABILITY OF THE SO-CALLED RENEWABLE ENERGY RESOURCES.

AS AN EXAMPLE, LET US LOOK AT THE FUTURE OF THE MEDITERRANEAN REGION WITHIN THE PRESENT CENTURY

The "Great Game" Enters the Mediterranean: Gas, Oil, War, and Geo-Politics
by Mahdi Darius Nazemroay

A four-year-old title that justifies the choice of the Mediterranean as an example

The Mediterranean Region as commonly understood.

It accounts for 9% of the World's total energy demand. This will stay unchanged till 2030 (Observatoire Méditerrannéen de l'Énergie, 2009)

Kinds of energy:

Non-renewable (fossil fuels):
Geology

Renewable (solar radiation and atmospheric, hydrospheric and biospheric motions):

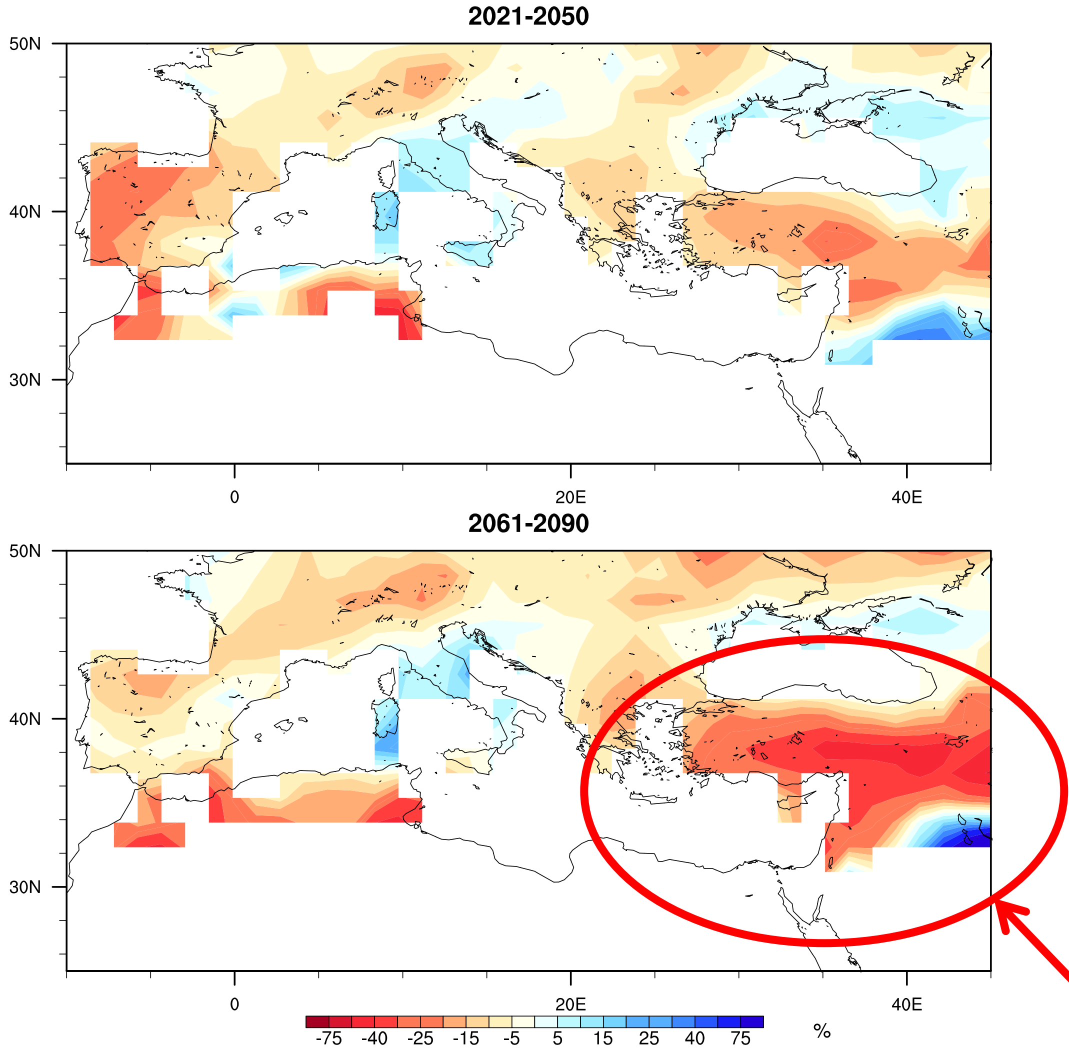
Climatology and Agriculture

According to the BP 2007 statistics published in 2008:

- The oil reserves are mostly located in the Middle East and to a lesser degree in Russia, Venezuela, Kazakhstan, Libya and Nigeria, which collectively account for 84% of the world reserves; ***42** years of reserves plus **21** years of resources*

- The gas reserves are mostly located in the Middle East and Russia, which collectively account for 66% of the world reserves; ***61** years of reserves plus **69** years of resources*

- The coal reserves are mostly located in the USA, Russia, China, India, Australia and South Africa which collectively account for 82% of the world reserves; *Will last us for another **5 to 6 millenia**!*

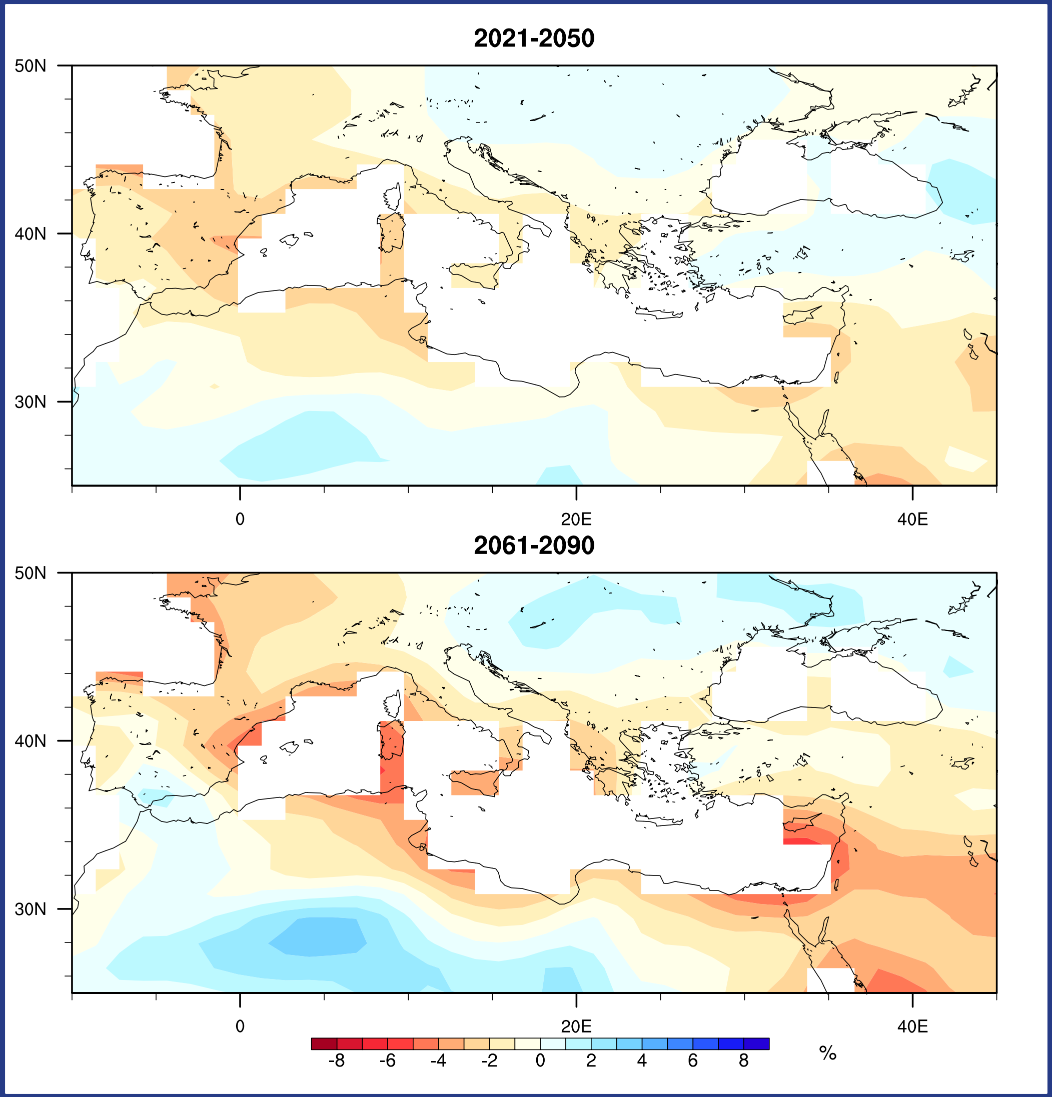


Relative change in hydro power potential with reference to [1961-1990] period, using downwelling solar flux density field from the CCSM A2 simulations as a proxy for two episodes in the future:

2021-2050

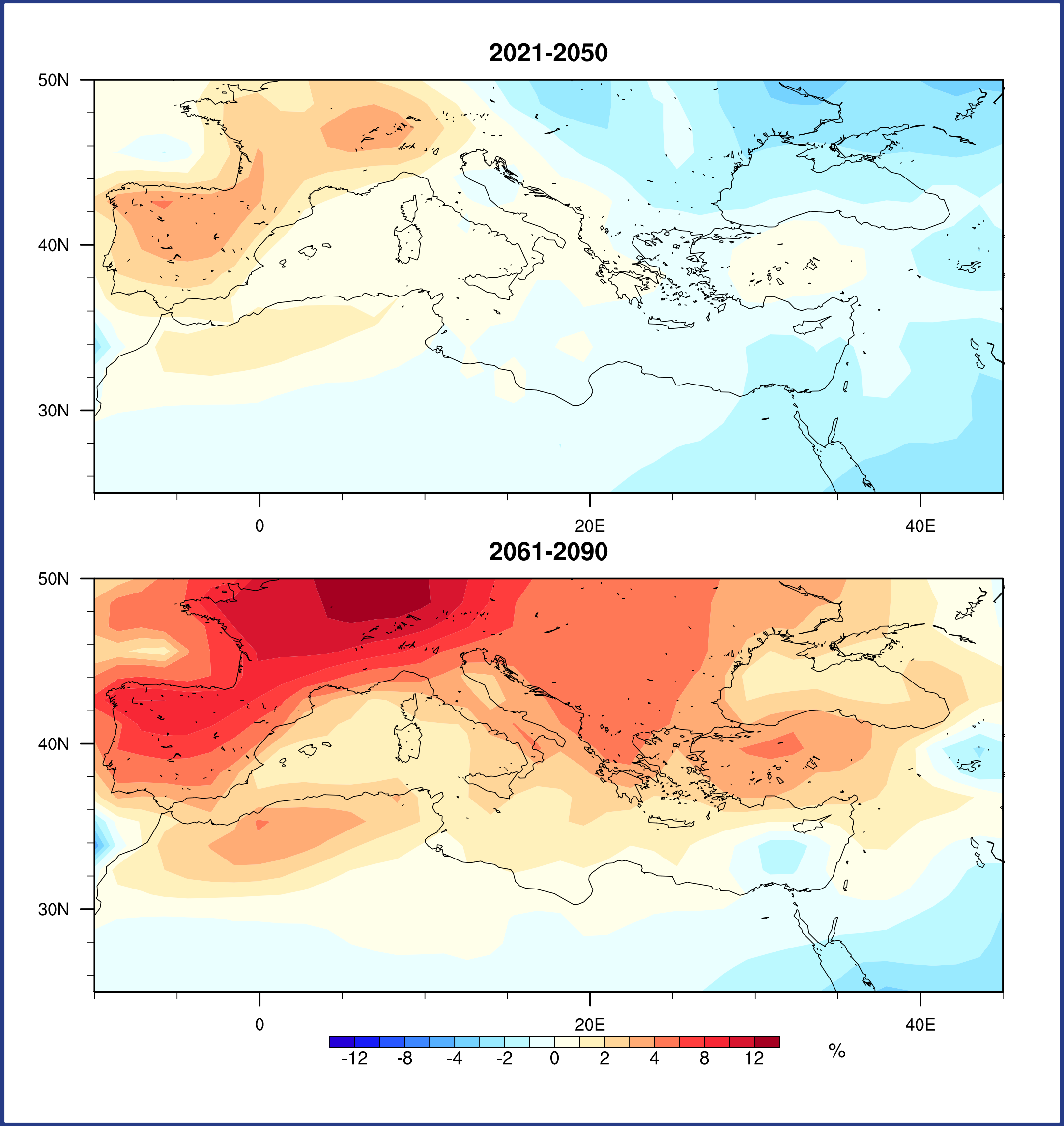
2061-2090

Region of main trouble!
Turkey!



Relative change in wind power potential with reference to [1961-1990] period, using 2m field from the CCSM A2 simulations as a proxy.

The Mediterranean will get less windy. So a ***net loss of wind power***.



Relative change in solar power potential with reference to [1961-1990] period, using downwelling solar flux density field form the CCSM A2 simulations as a proxy. Notice that in the Mediterranean the potential for solar energy increases everywhere.

From the viewpoint of solar energy, it is good that the earth is getting hotter.

Conclusions for the energy potential of the Mediterranean countries:

Non-renewable:

Oil: 70 BBBO+?45 BBBO

Natural gas: 99 BBBOE + ?30 BBBOE

Coal: 74.5 BBBOE

Nuclear: 7.720 BBBOE (for the next 20 a with the existing reactors)

So-called renewable:

Water: 261 MBBO/a (with decreasing potential)

Wind: 250 MBBO/a (with decreasing potential)

Sun: 198 x 10^{12} BBBOE/a (with increasing potential)

IT NOW SEMS THAT SOLAR ENERGY IS A SOLUTION TO OUR ENERGY PROBLEM IN THE FUTURE. *ALL LIFE USES SOLAR ENERGY*.

WE HAVE OVERSHOT OUR QUOTA OF IT BY USING FOSSIL FUELS, *I.E.*, STORED SOLAR ENERGY, BECAUSE WE ARE EXHAUSTING ITS SAVINGS IN FOSSIL FUELS. THE SAVINGS WILL EVENTUALLY RUN OUT AND THEIR SWIFT EXHAUSTION WILL OVERHEAT US.

BECAUSE WE REQUIRE MORE SOLAR ENERGY TO SURVIVE THAN AN ORDINARY PRIMATE ANIMAL (*E.G.*, CHIMPANZEES) , WE HAVE TO FIND EXTRAORDINARY MEANS OF HARNESSING A LOT OF IT.

WE ARE LUCKY THAT A LOT OF IT IS AVAILABLE AND WE KNOW HOW TO HARNESS IT. ALL WE HAVE TO DO IS TO INVEST IN IT MORE TO EXPEDITE ITS EFFICIENT AND WIDESPREAD EMPLOYMENT

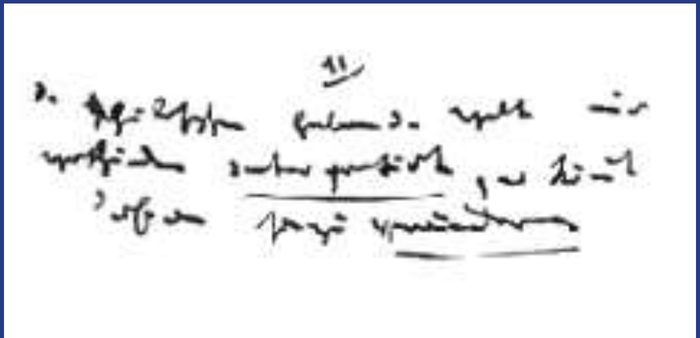
IMPORTANT MESSAGE:

THERE SHOULD BE NO RIGHT TO REMAIN IGNORANT ABOUT THE PLANET ON WHICH WE LIVE

RELIGION, ENABLING PEOPLE TO HAVE IRRATIONAL HOPES AND IMAGINARY FRIENDS, CONSTITUTES THE BIGGEST STUMBLING BLOCK IN FRONT OF A SAFE CONDUCT OF OUR RELATIONSHIPS WITH NATURE.

AN EXAMPLE OF AN IDIOTIC STATEMENT RAISED TO THE STATUS OF RELIGIOUS DOGMA:

‘Philosophers have long interpreted Nature in various ways; what is in fact needed is to change it’



Karl MARX, *Theses on Feuerbach*