Changing Landscapes:

Glaciated Landscapes

What are periglacial landscapes like?

What you need to know

a. Ground ice formation and associated features, including ice lenses, ice wedge polygons, patterned ground, pingos and thermokarst landscape
b. Frost weathering and mass movement can lead to features including nivation hollows, blockfields and scree slopes, pro-talus ramparts, solifluction terraces and head deposits
c. Periglacial action of water and wind and associated landforms of dry valleys (water) and loess plateaux (wind)

Cold Environments: type

GLACIAL

- areas that have been or are being altered by ice on the ground
- exhibit characteristic erosional and depositional landforms
- currently found only at high latitudes and altitudes

PERIGLACIAL

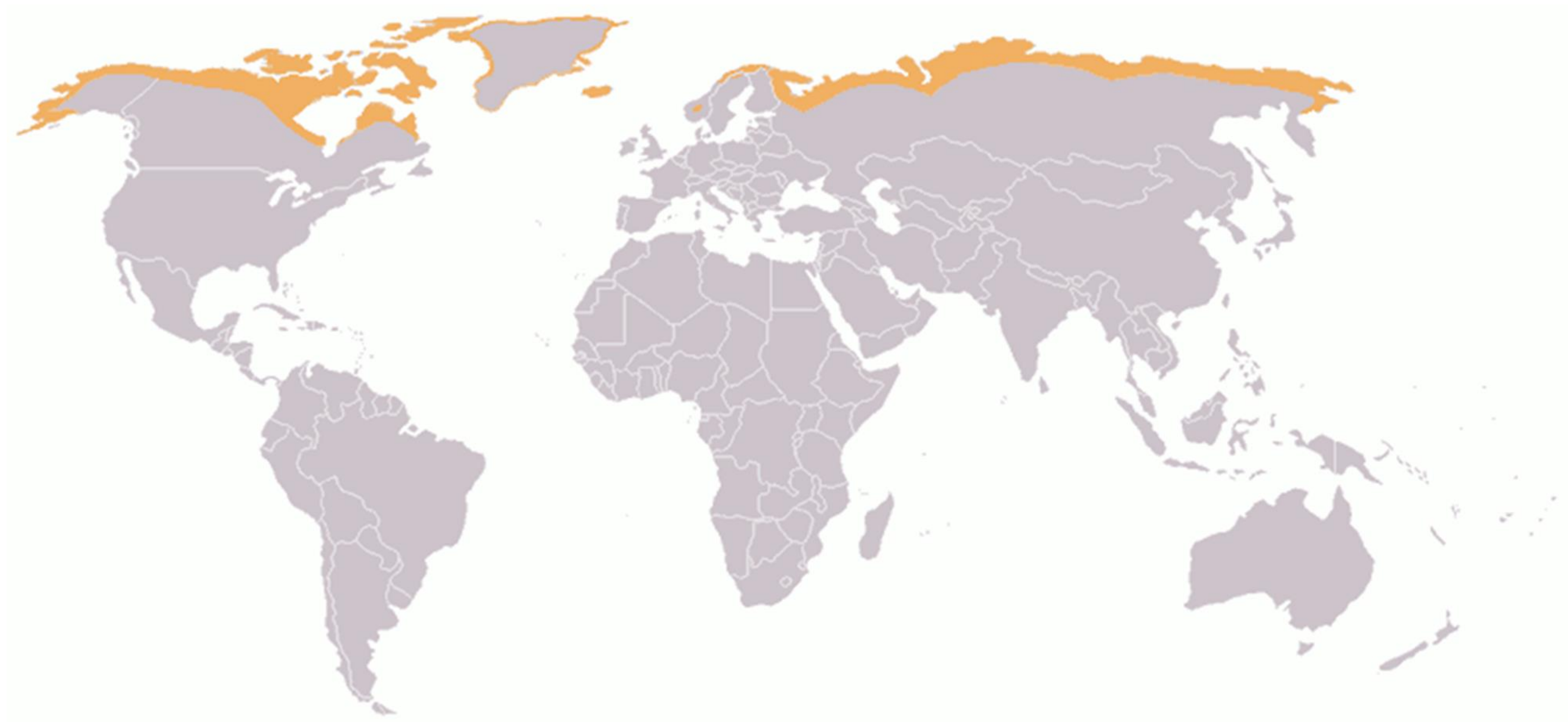
- areas that have been or are being altered by ice in the ground
- freeze/thaw (frost-action) processes are the key agents of change
- are found at the outer margins of the cold environments…not necessarily at the edge of ice bodies

Periglacial landscapes

Often, but not exclusively, associated with tundra – extensive, open, treeless areas

High-latitude tundra zone begins where average temp of warmest month < 10°C – same as the poleward limit of coniferous (boreal) forest

Alpine tundra occurs at lower latitudes, but above tree-line



Distribution of Arctic tundra (shown in orange) - Wikipedia

Tundra - Alaska

Tundra - Siberia

Low-Arctic tundra in the Indigirka lowlands in northeast Siberia, Russia (70.82N, 147.47E)

Alpine Tundra - Colorado

Rocky Mountain National Park

Periglacial landscapes

Periglacial climates = long cold winters with temps rarely > 0°C

Generally: mean temp of coldest month < -3°C, mean annual precipitation <1000mm

But can vary…

[find out about Polar lowlands, Subpolar lowlands, Mid-latitude lowlands and Highlands – Classification of periglacial climates by Washburn]

However, freezing and thawing must be possible – frost action is an essential aspect

Long, cold winters and short summers → development of **permafrost**

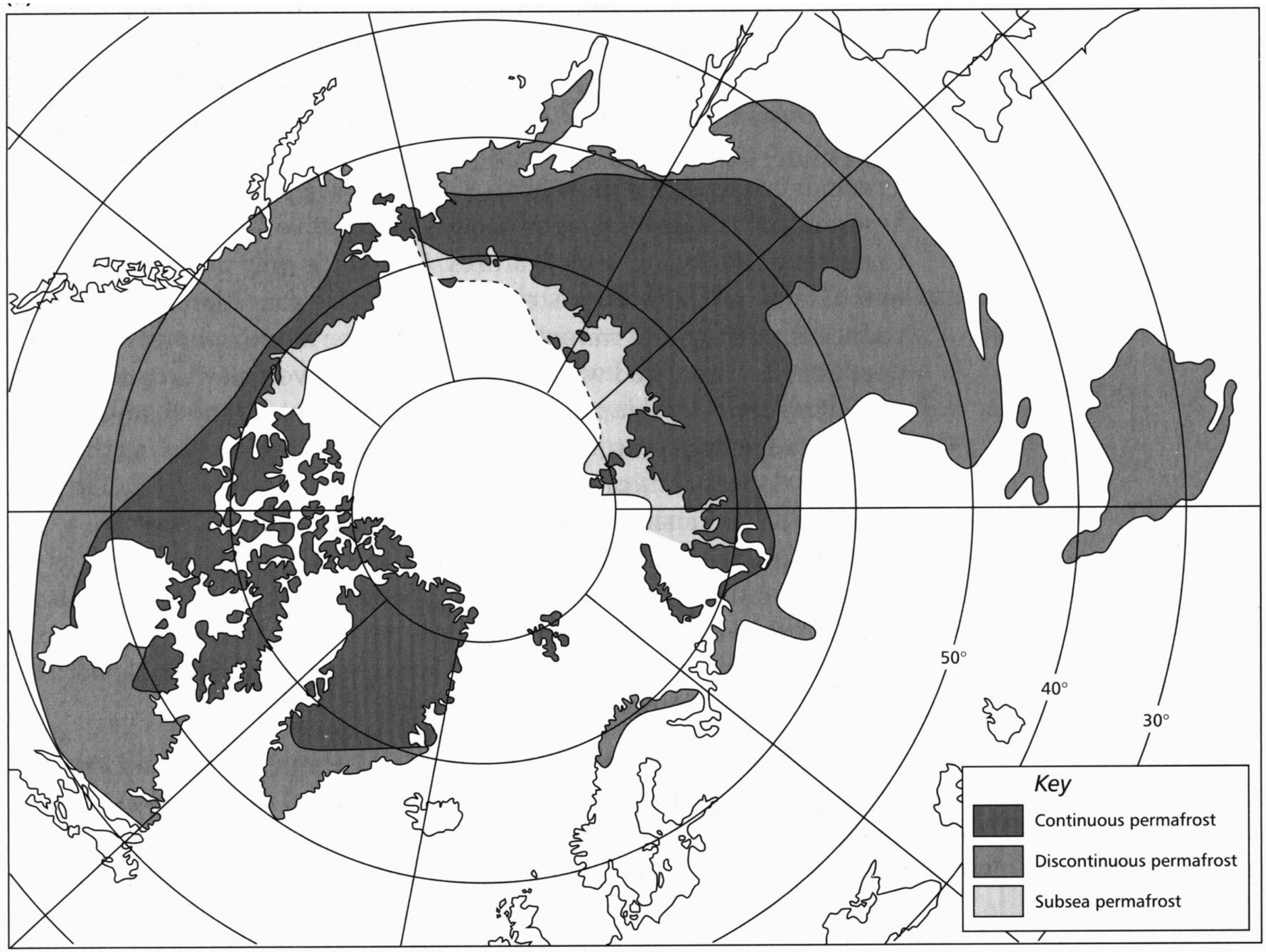
Permafrost

Not just permanently frozen ground…more precisely defined as:

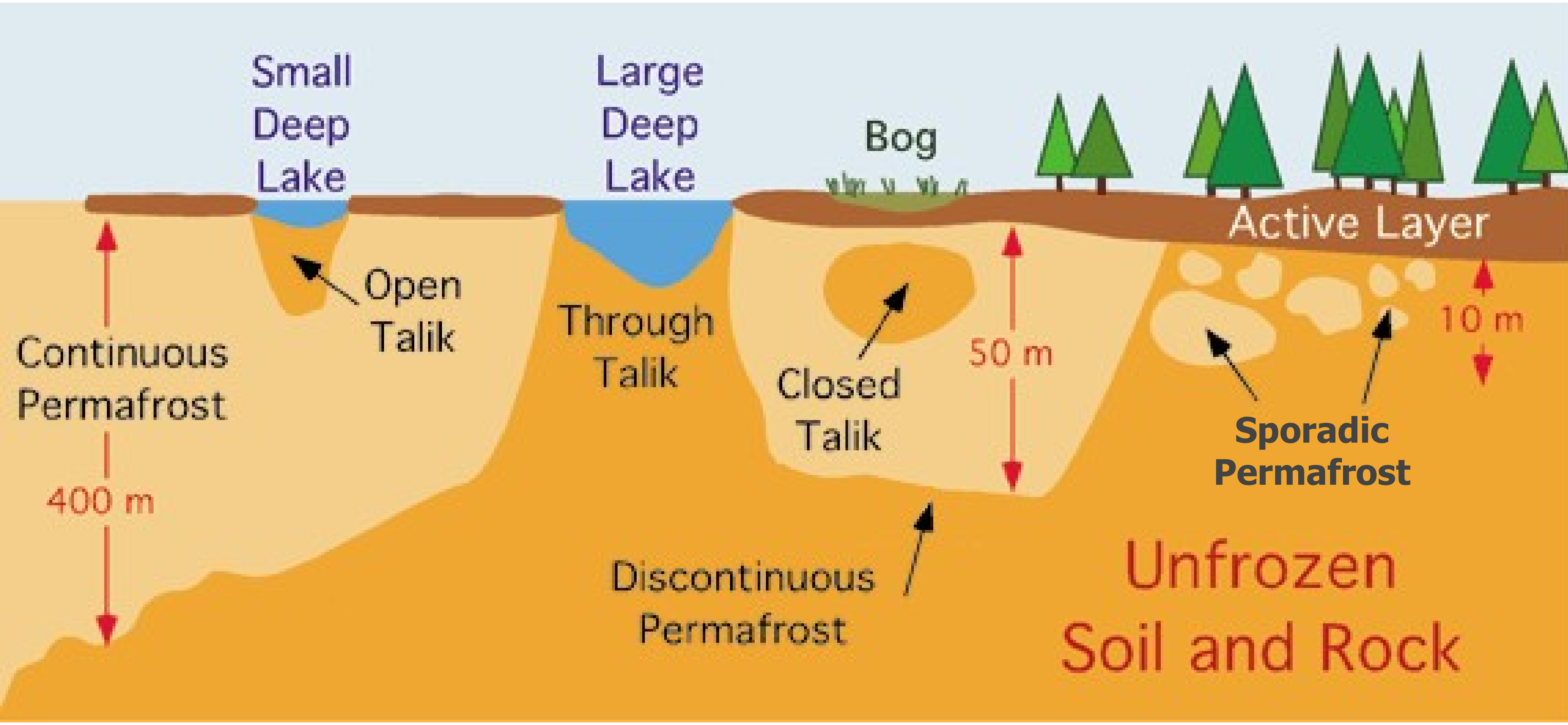
‘the thermal condition in soil and rock where the summer temperature has not risen above 0°C for at least 2 consecutive years.’

Most water in permafrost zone remains frozen throughout the year as **ground ice**

Permafrost in the Northern Hemisphere



Types of permafrost



Mean annual temperatures between -1°C and -5°C.

Little, if any, summer melting.

Top layer of the permafrost which thaws during the summer. Can range in depth from a few cm to 5m.

As far south as 50°N in Russia (Lizard Pt. in Cornwall is just south of 50°N.

Unfrozen ground in the permafrost.

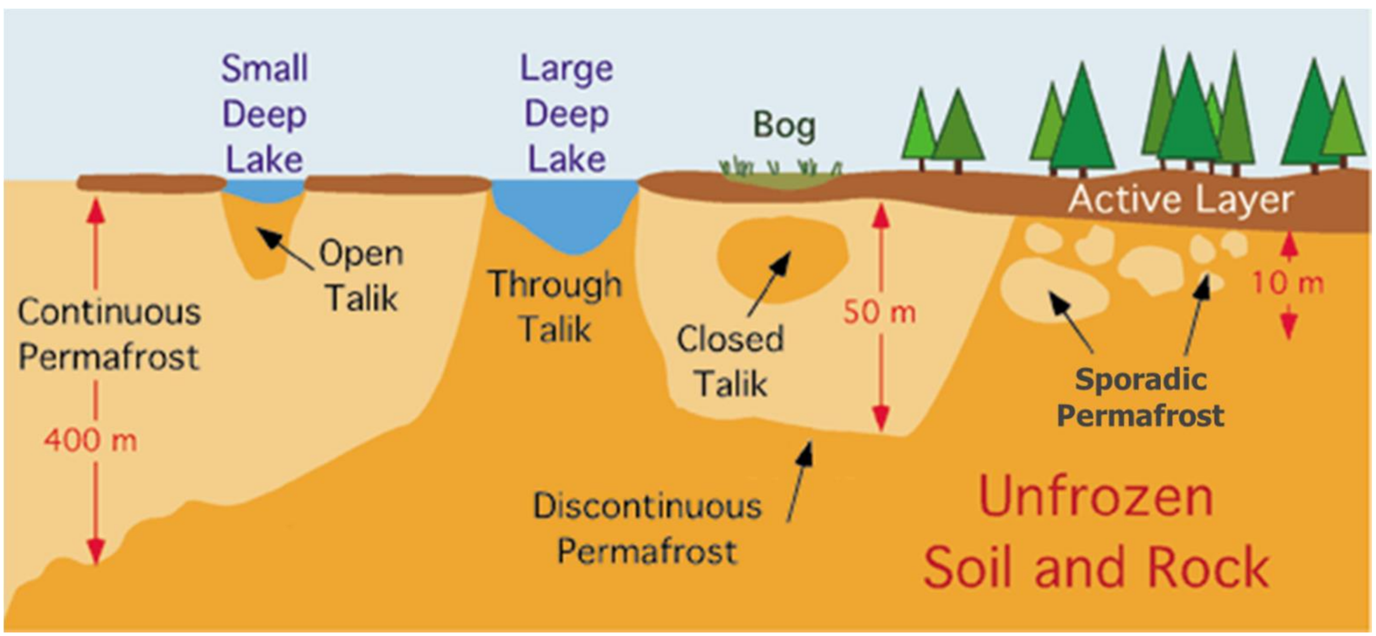
Mean annual temperatures < -5°C.

Up to 700m deep in N Canada; as much as 1500m in Siberia, indicating conditions were much colder in the past and this has been so for thousands of years.

Found near lakes and the coast where the heat from water melts the permafrost in some areas. Vegetation can also help insulate the ground, preventing re-freezing.

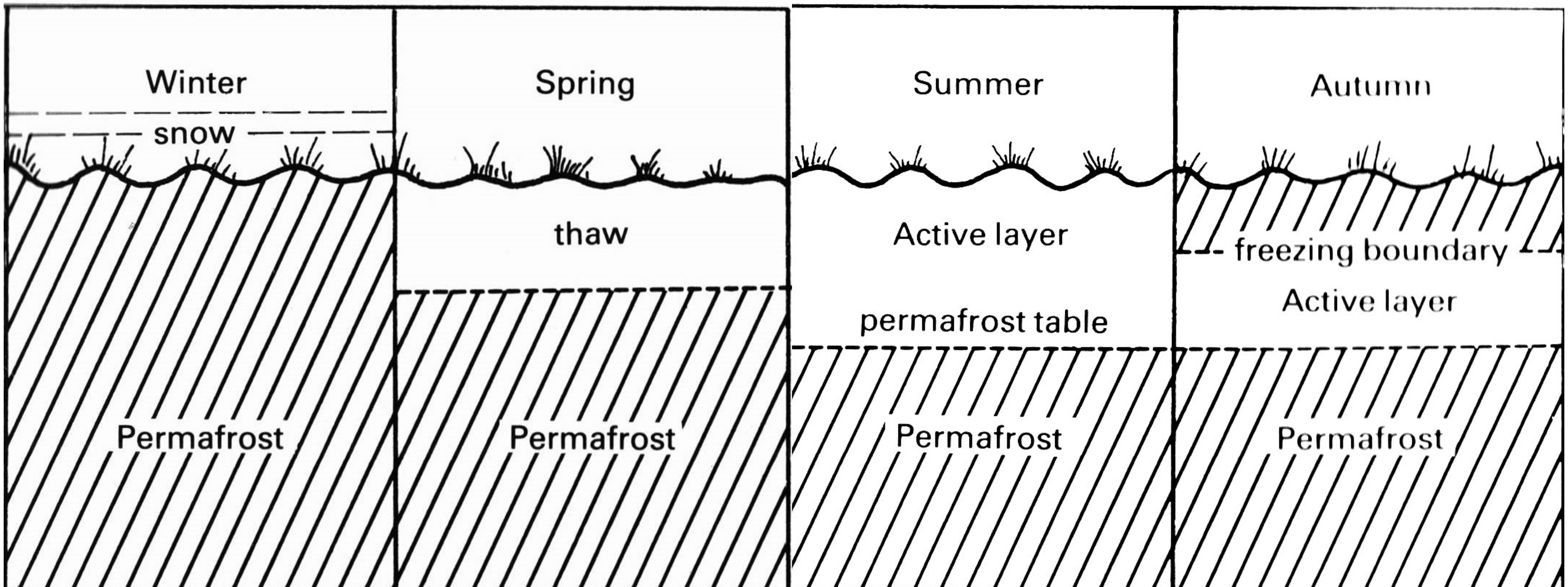
Mainly polar environments today.

Mean annual temperatures just < 0°C; summer temperatures > 0°C.



Now add your own definitions of closed, open and through talik

Seasonal variations in permafrost processes



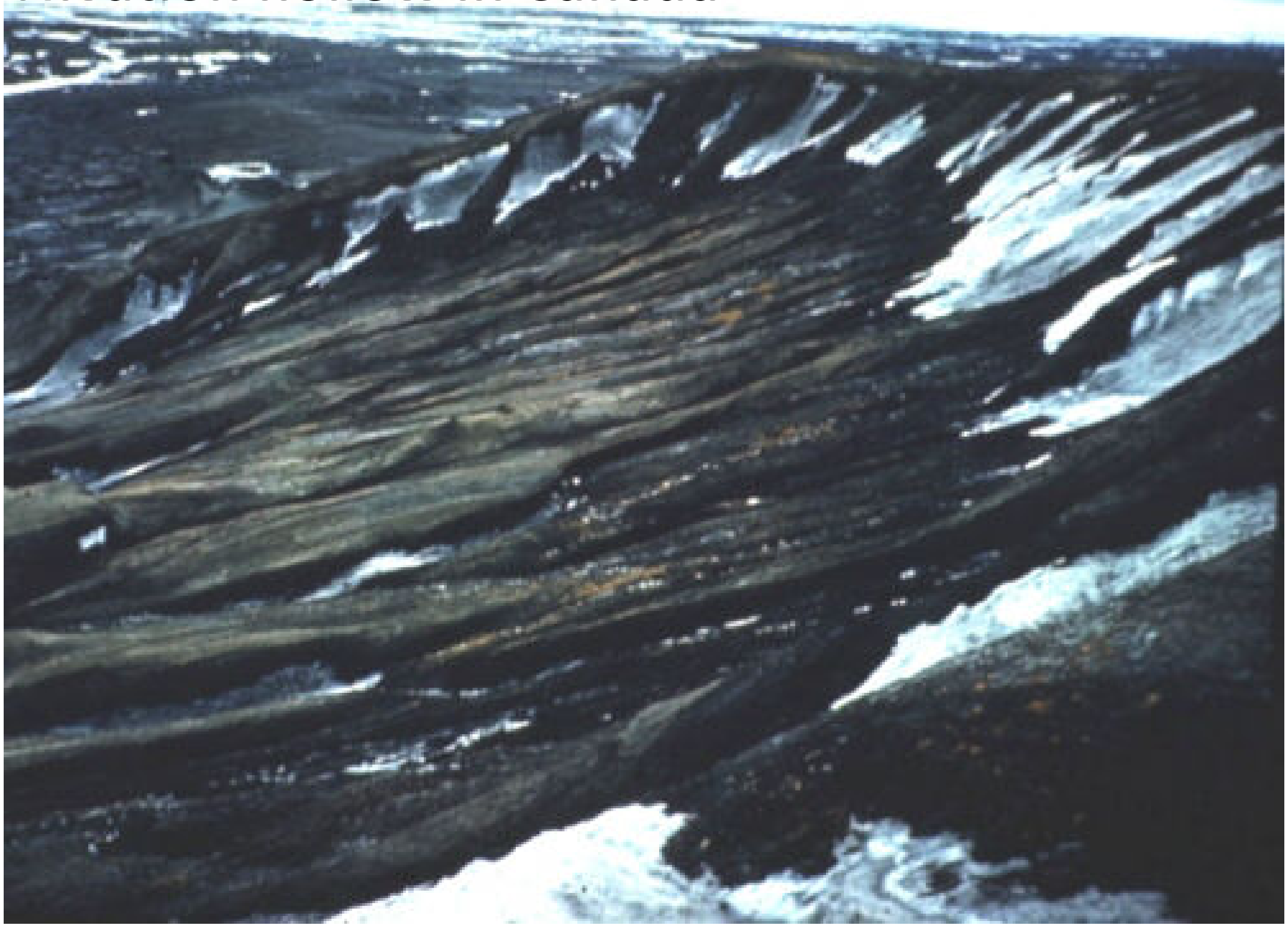
frost activity	zero	minor	unimportant	max
surface/soil water activity	zero	max	minor	unimportant
wind activity on ground	zero	unimportant	max	minor

Periglacial Slope Processes

Nivation

Remember?

Nivation hollow in Canada



Frost creep & solifluction

Frost creep

Soil particles pushed outwards at 90° to slope during freezing (**frost heave**)

On thawing, particles lowered vertically downward

Can move larger stones & boulders downslope

Slow process – a few cm/yr

Frost creep & solifluction

Solifluction

A downslope flow of water-saturated soil or regolith (general term for all loose material covering ground)

Saturation → high pore-water pressure ∴↓ friction allowing material to move like a very viscous fluid

Faster than soil creep but still between 0.5 – 5 cm/yr – rarely >10cm/yr

Max slope of 10-20 ° steeper slopes → faster drainage ∴ saturation less likely

Not just restricted to periglacial areas, but v. common in these environments:

- Permafrost creates impermeable layer at shallow depth
- Spring/summer melting of snow/ice cover releases much water → saturation
- Can then operate on slopes of 1°

[**Gelifluction** often used to refer to solifluction in periglacial environments]

Periglacial slope features

Blockfields and scree slopes

Blockfields (aka felsenmeer):

Usually on flatter ground, e.g. mountain summits (e.g. Glyder Fawr, Snowdonia)

Result of frost shattering/freeze thaw

Angular fragments

Blockfields and scree slopes

Scree slope (aka talus slope):

Accumulation of frost shattered, angular fragments at foot of slope

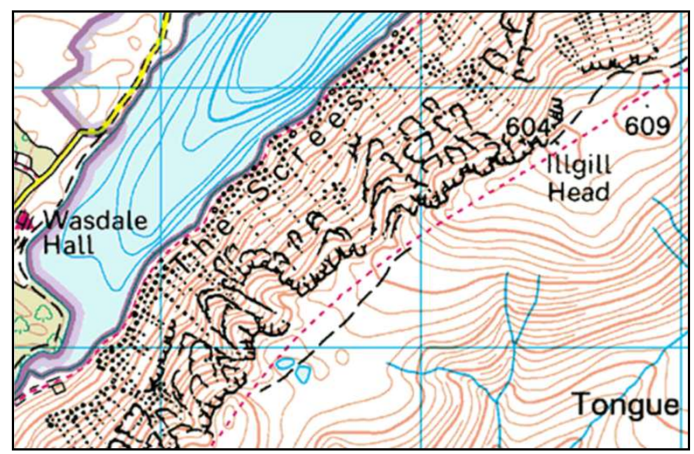
Smaller stones at top, bigger at bottom

Upper slope tends to have rest angle 30°-38°

Lower part 25°-30°

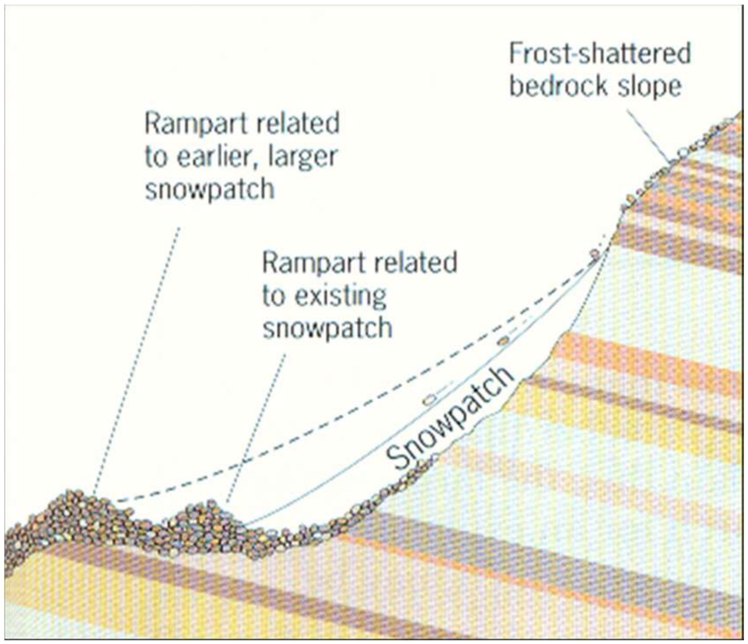
(even though smaller stones tend to have shallower rest angle)

Wastwater, Cumbria



Protalus rampart

Develop where a snow patch covers bottom of slope – falling fragments slide over snow and accumulate at foot of snow patch



Solifluction landforms

Solifluction produces a range of related slope features:

- **Lobes** – rounded, tongue-like features resulting from different flow rates
- **Terraces** – wider features that can be turf- or stone-banked that form on gentler slopes
- **Aprons/sheets** – more extensive areas usually at the foot of slopes where it can also be called **head** (or coombe rock in chalk downland areas)

Solifluction landscapes/landforms

Solifluction apron, Northwest Territory, Canada

Solifluction

Solifluction in the Brecon Beacons, S Wales

Solifluction lobes

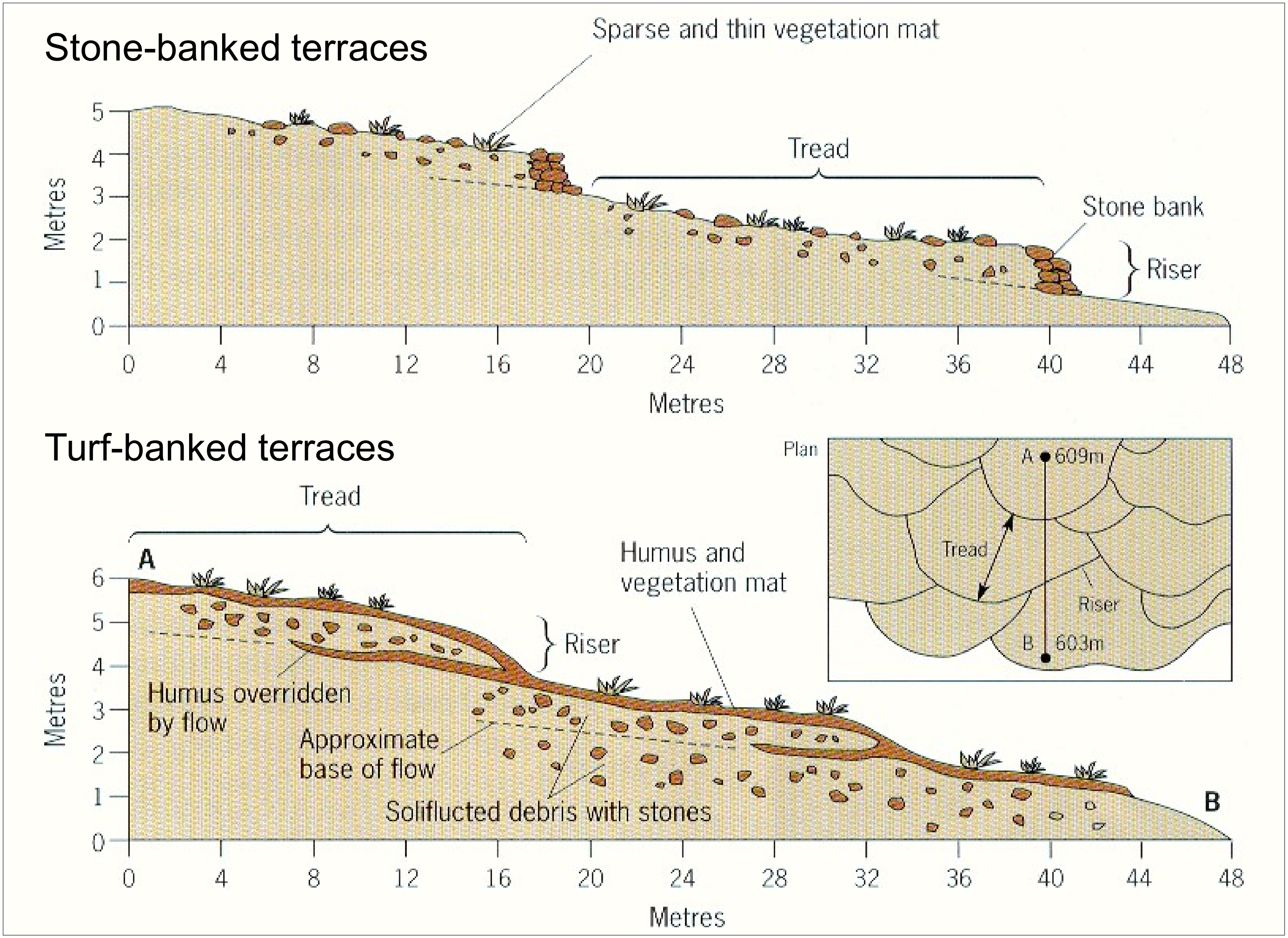
Norway

Solifluction lobes

Alaska

Solifluction terraces

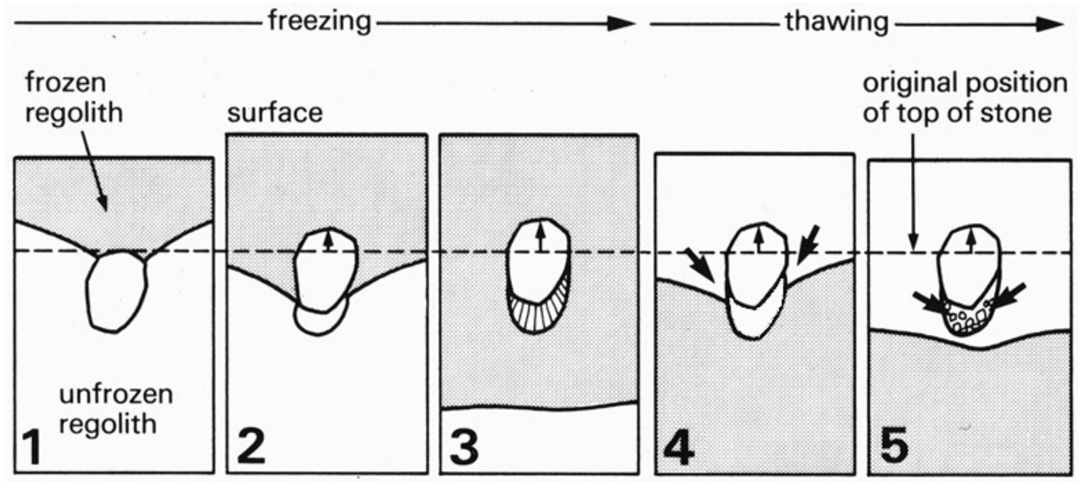
Solifluction terraces



Active layer processes and features

Frost Heave

Frost heave



1. Freezing progresses down from surface – stone freezes to upper surface + is pulled up as it expands (**frost pull**)
2. Freezing front reaches void left by lifted stone
3. Ice crystals grown in void and push up stone (**frost push**)
4. Thawing progresses downwards from surface, which contracts – ice thaws beneath stone wet sediment holds it in place
5. Debris washes into void left by thawed ice crystals – stone moves closer to surface. Cycle repeats until stone breaks through surface when, on freezing, ice crystals push stone entirely out of ground

Frost heave

Number 11 garden 2011

Needle ice/piprake

Iceland

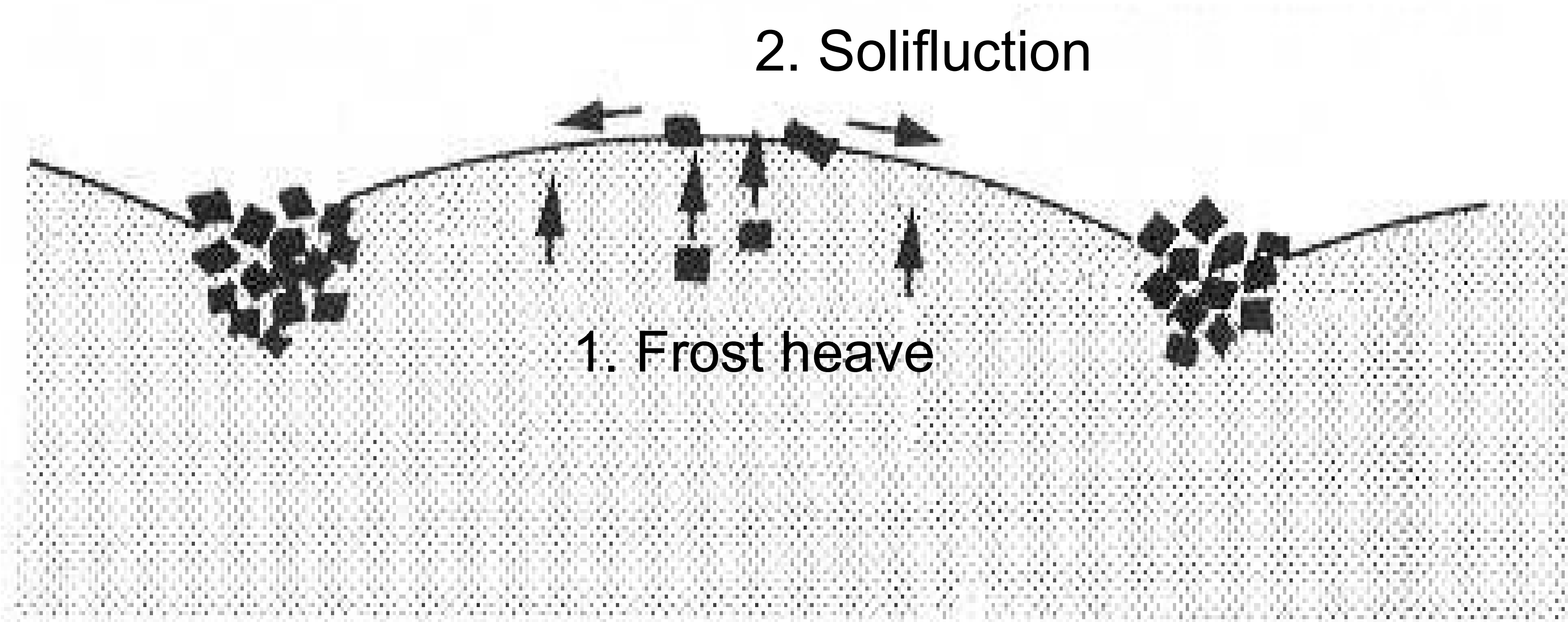
Patterned ground

Stone polygons in Iceland

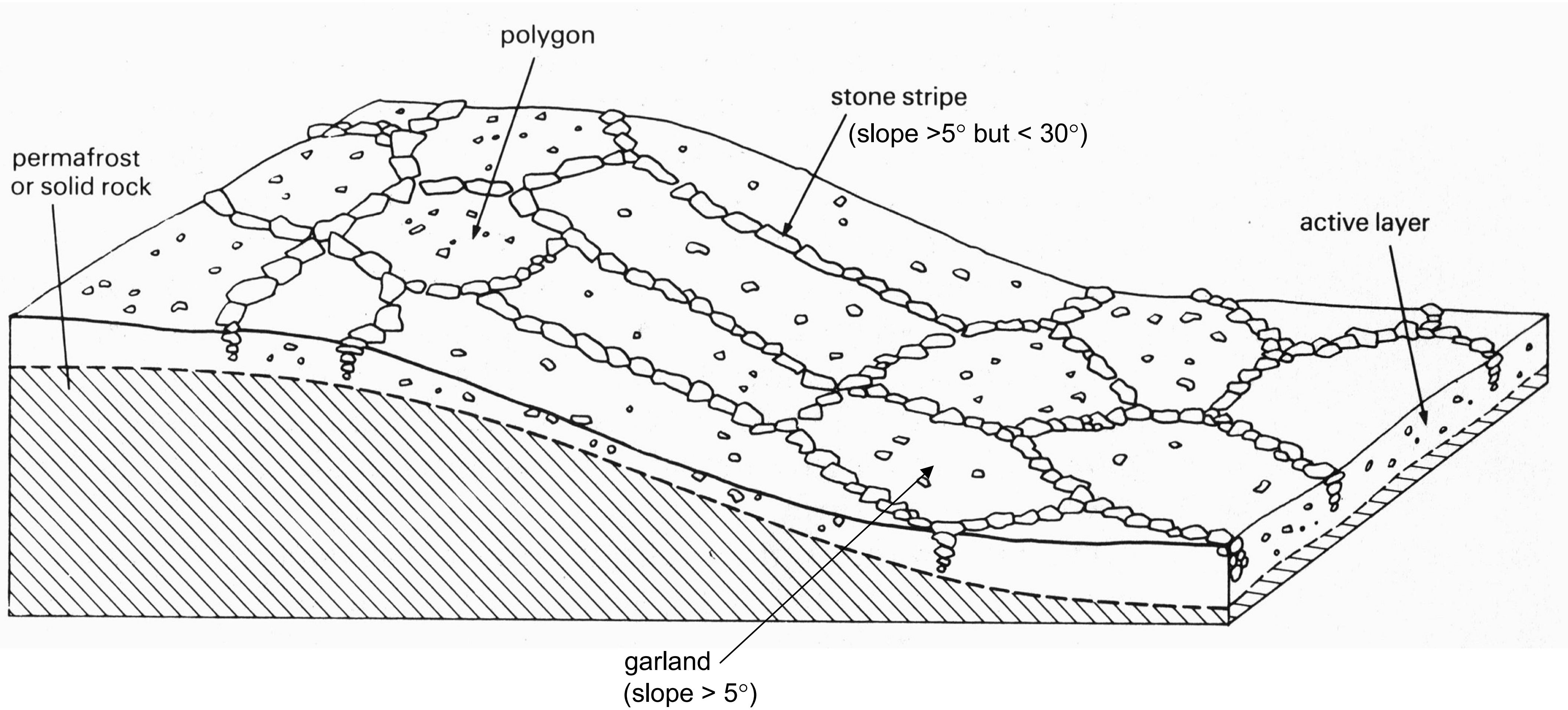
Stone rings

Stone rings, permafrost, Svalbard, 2007
(Hannes Grobe)

Stone sorting



Stone polygons



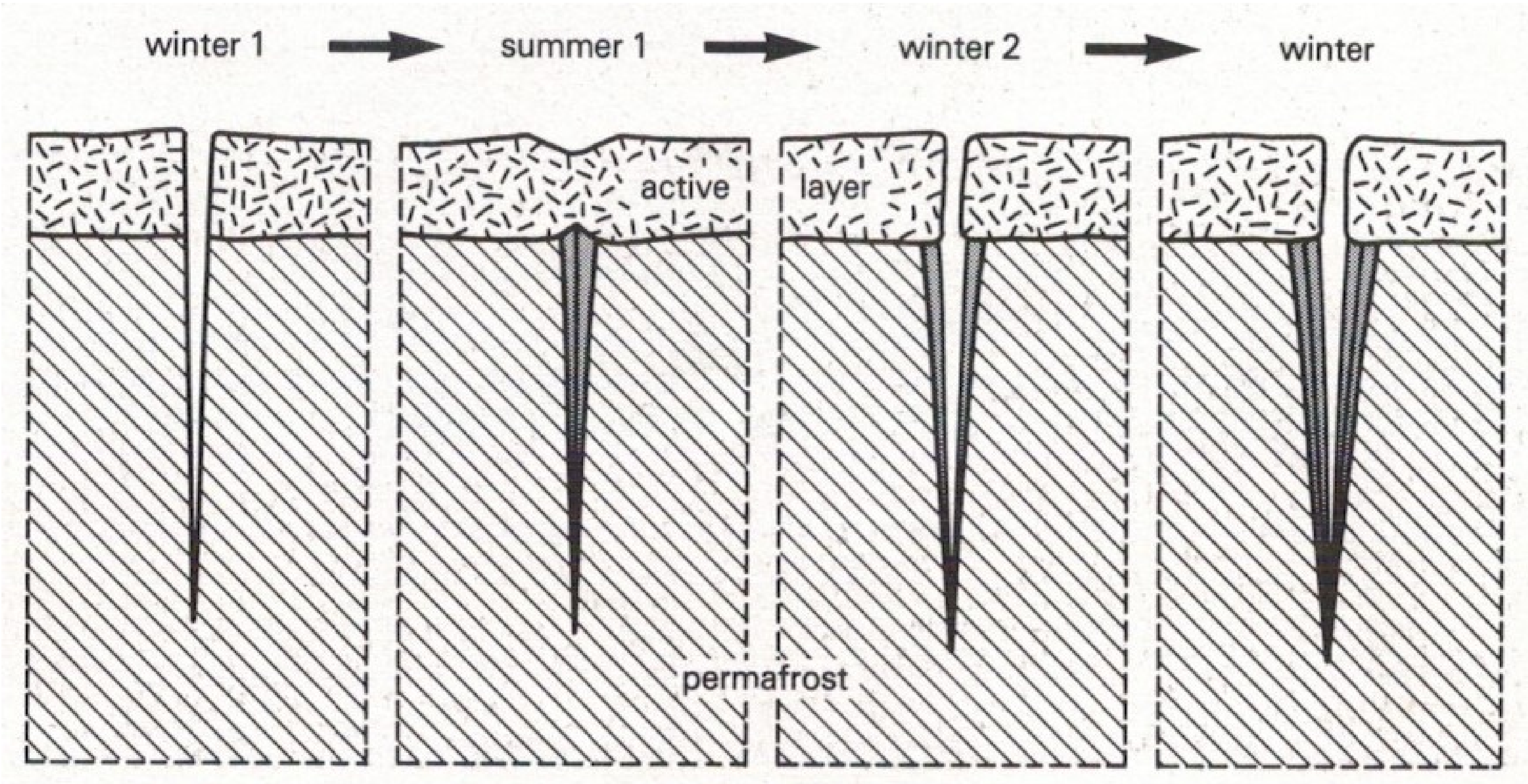
Stone polygons in Iceland

Ice wedges and polygons

Ice wedge polygons

Ice wedges in Sprengisandur, Iceland, 1989
(Till Niermann)

Ice wedge formation



Frost cracking occurs as ground temp ↓ -20°C (rate of temp ↓ > actual temp)

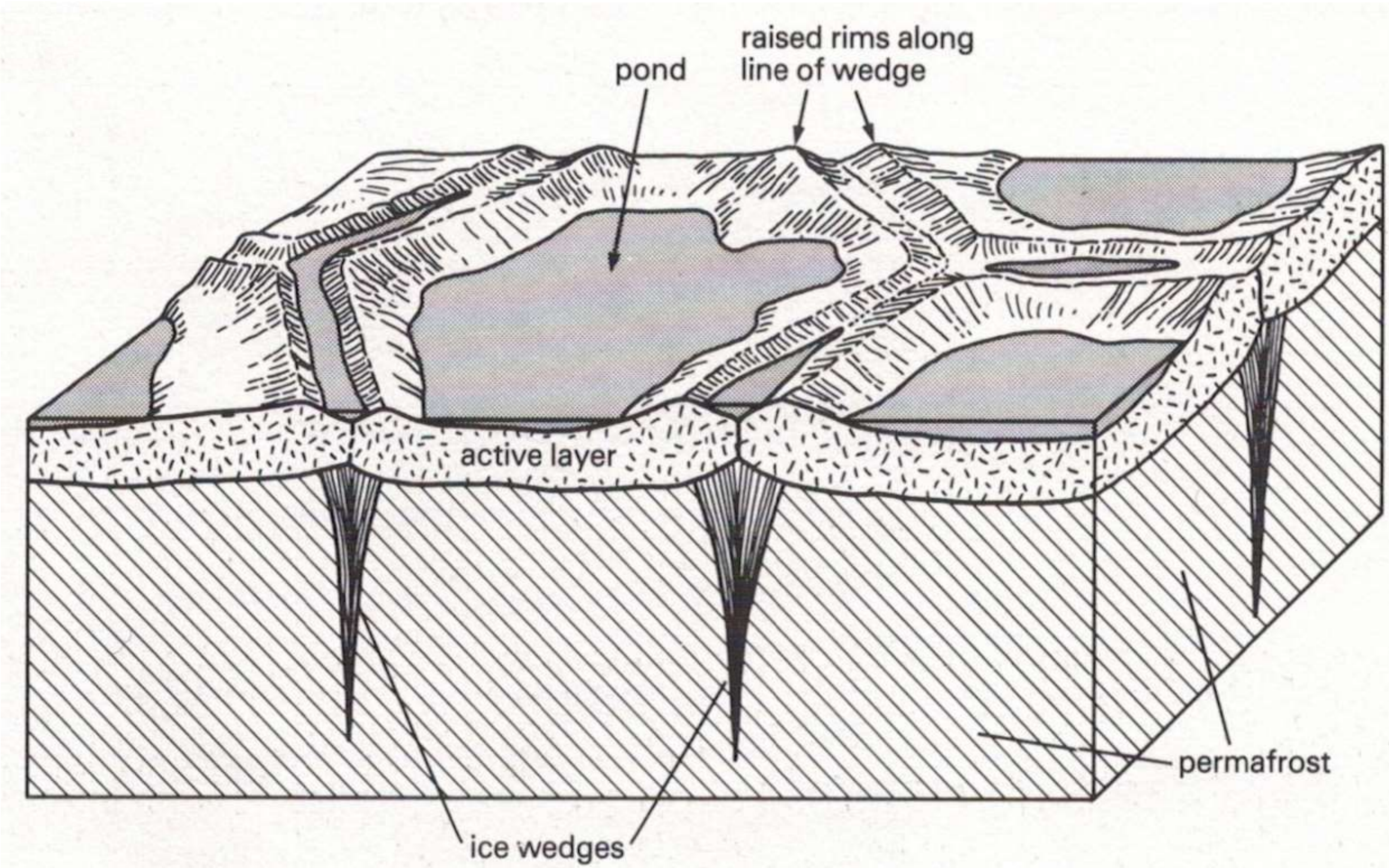
Water from spring snow melt flows into crack and freezes – stops crack closing

Large ice wedges (1-2m wide at top and 8-10m deep) can take c. 100yrs to form

Exposed ice wedge, Canada

Ice wedge cast, New England

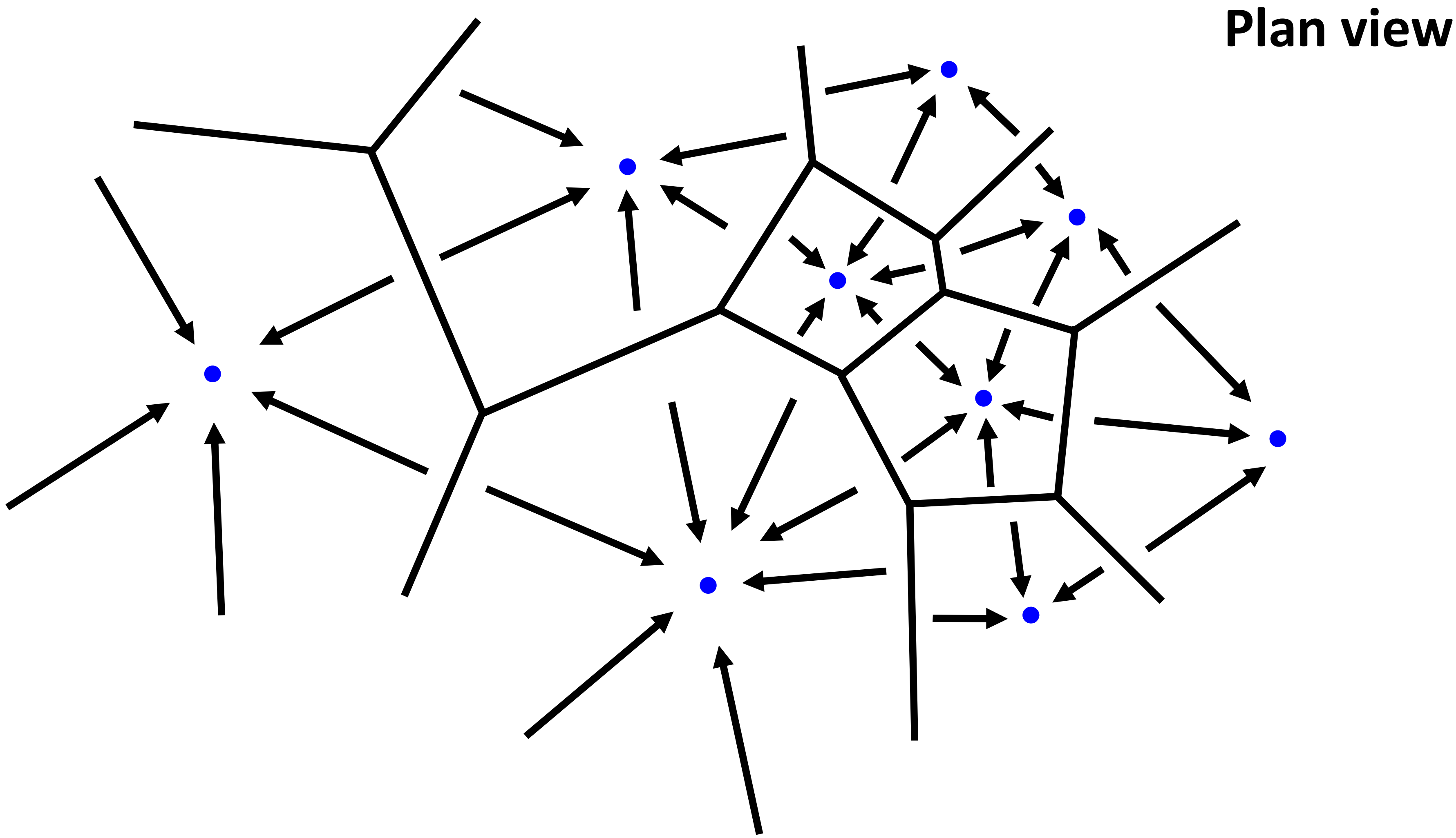
Ice wedge polygons



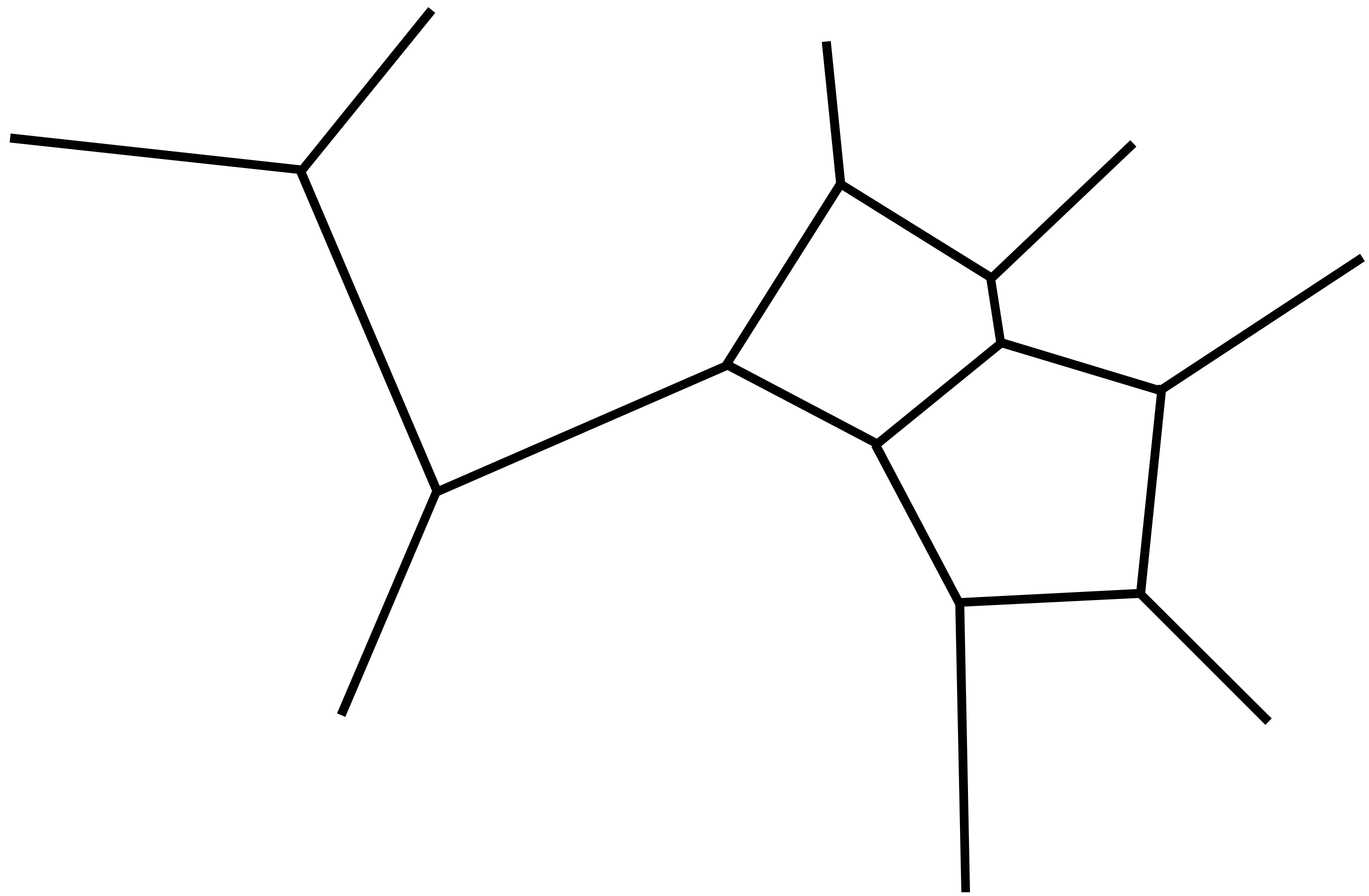
Ice wedge polygons

Hudson Bay Lowlands, Manitoba

Ice wedge polygons - formation

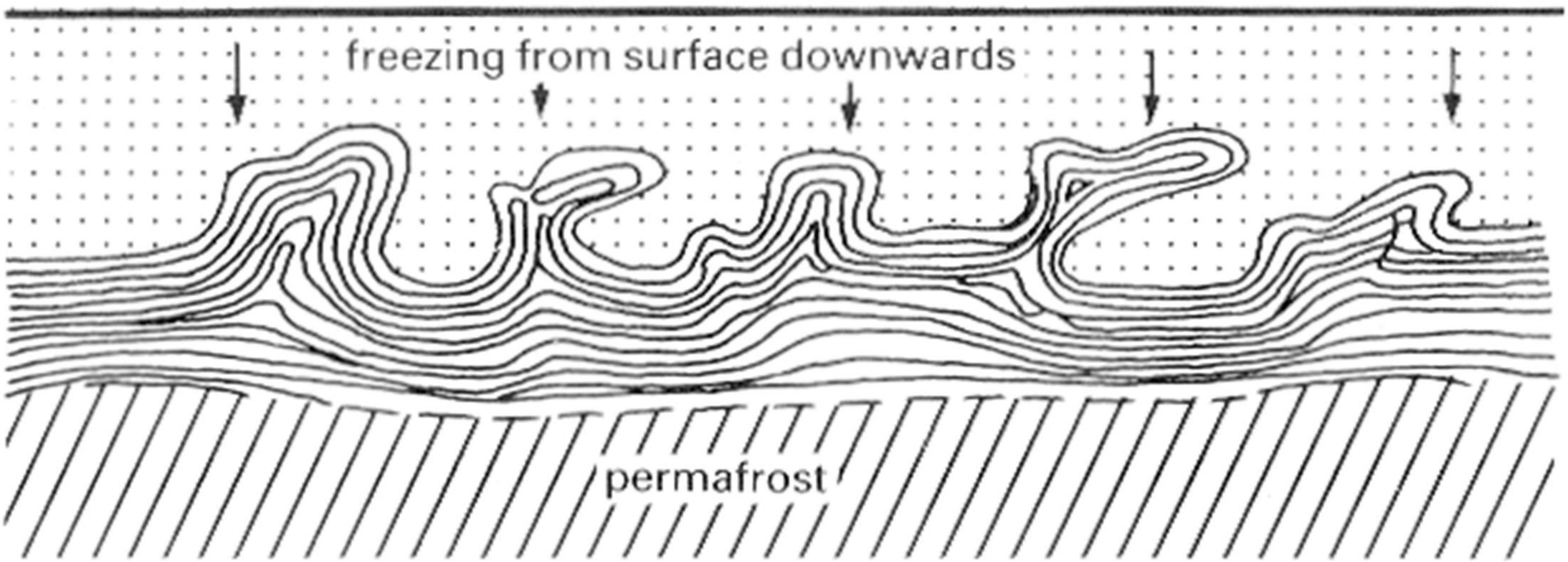


Ice wedge polygons - formation



Cryoturbation and ice lenses

Cryoturbation



Involutions

Cryoturbation

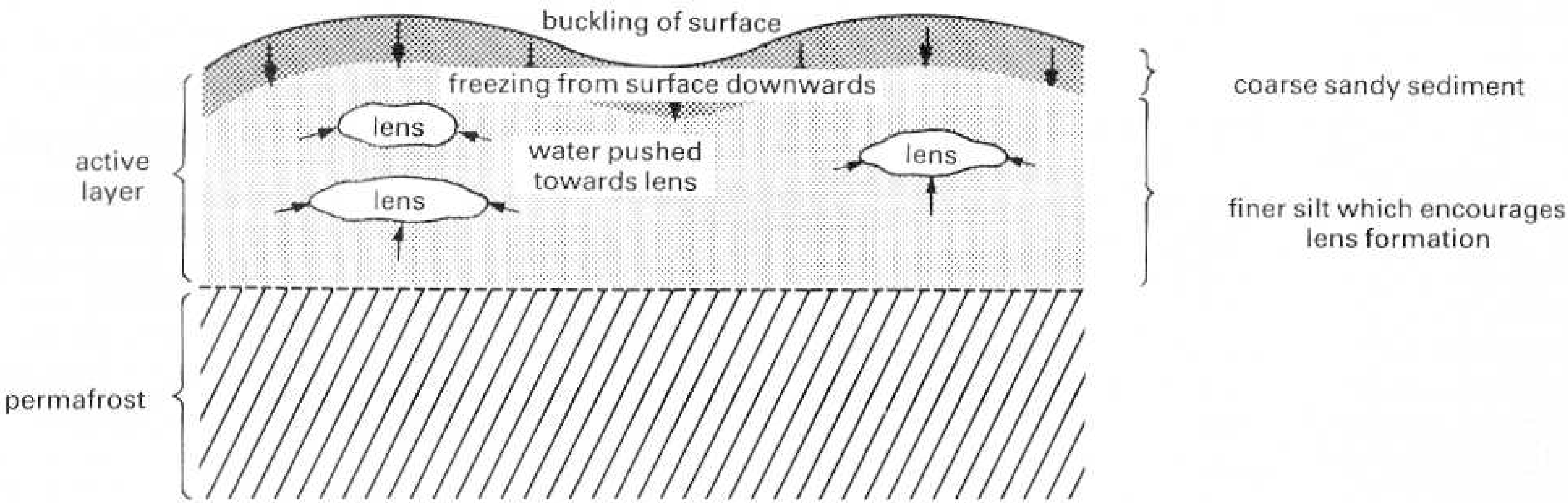
Involutions at Hengistbury Head

Cryoturbation

Ice lenses

Unequal rates of freezing in active layer (variations in sediment size/water content) → pockets of ice form

Once started they draw water towards them and grow – usually in lens shapes from mm-m thick:



Ice lenses

Exposed ice lens, Canada

Pingu

Pingos

Pinga

Pingo

Draw an annotated sketch to show the main characteristics of pingos

Pingos

Pingos - 100m across, Northwest Territories, Canada

Pingos

Pingos - 40m high, Northwest Territories, Canada

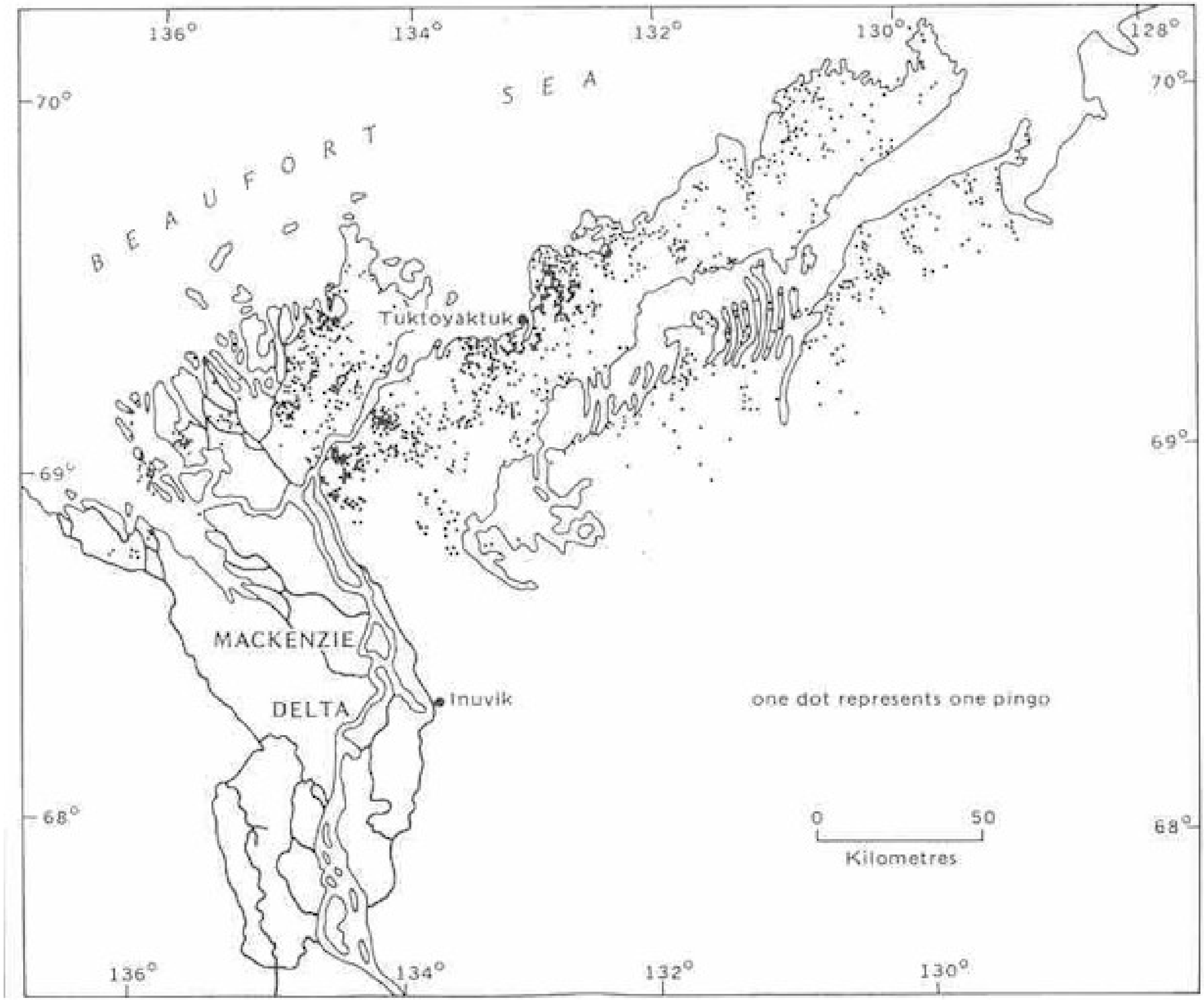
Pingos

A cutting through a small pingo, Canada

Collapsed pingo – pingo ramparts

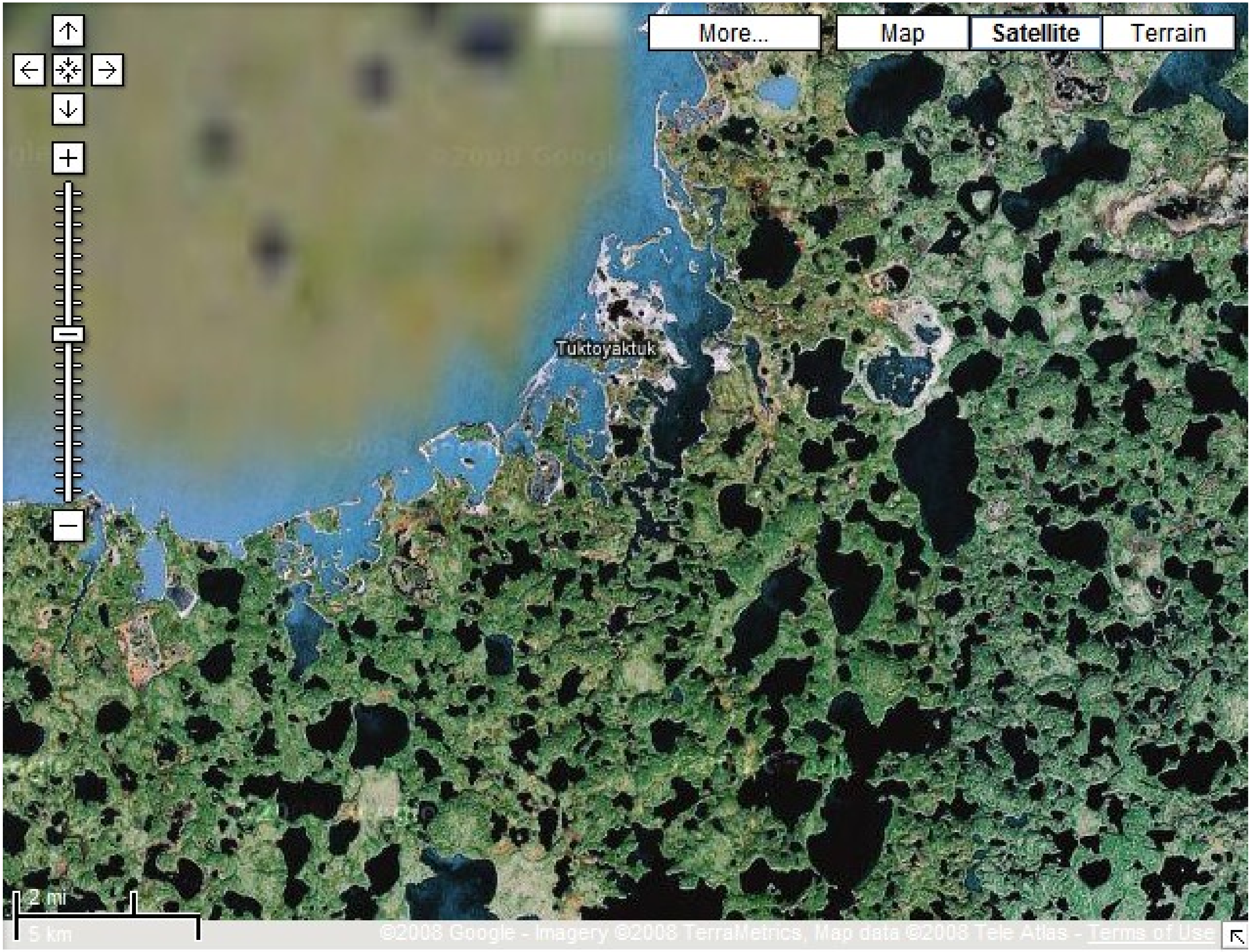
East Greenland

Pingos



Pingo Distribution Tuktoyaktuk peninsula, NWT, Canada

Pingos


More...
Map
Satellite
Terrain
Tuktoyaktuk
2 mi
5 km
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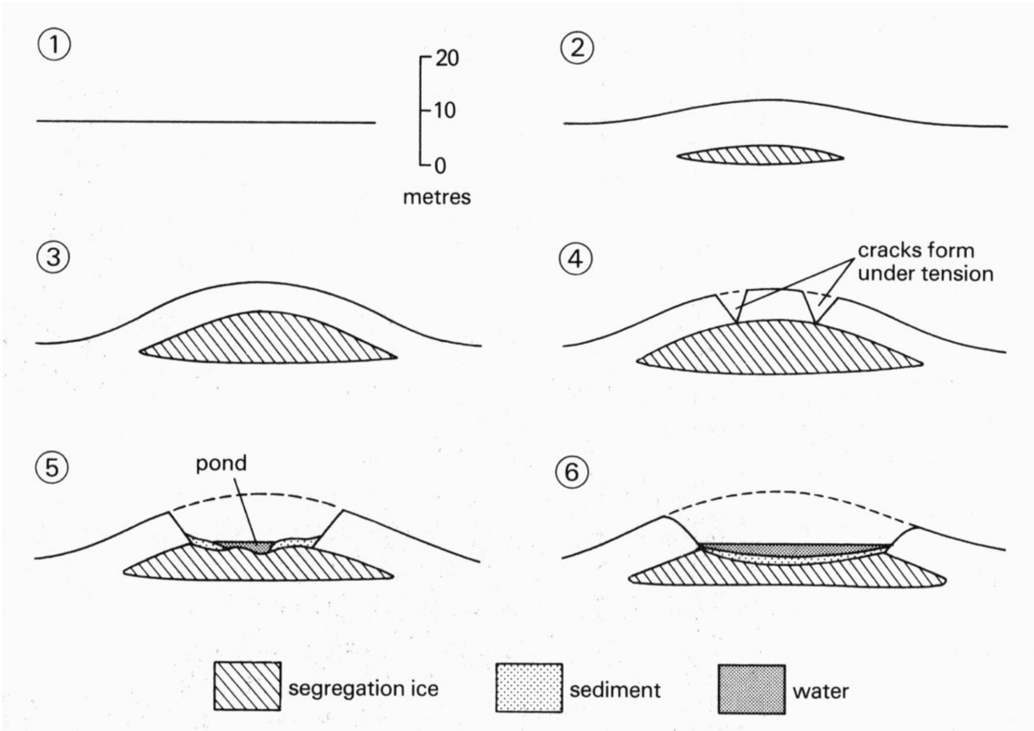
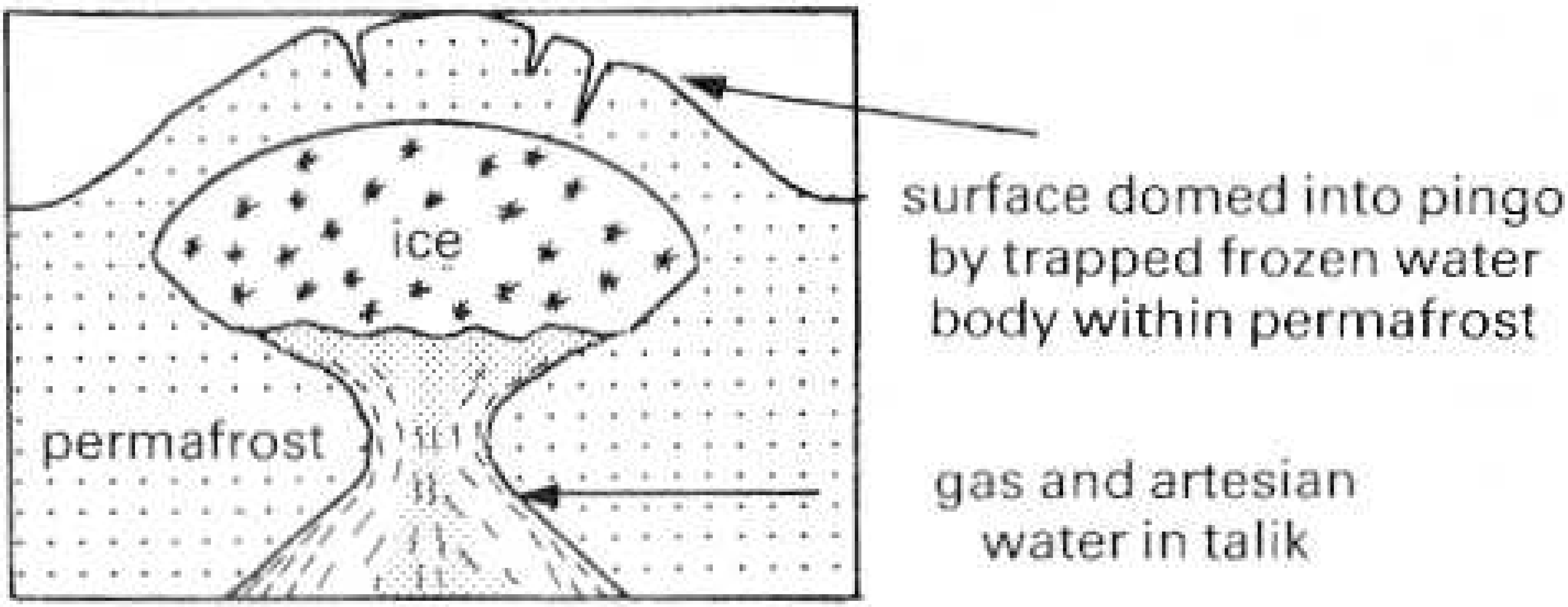
Closed-system pingos (MacKenzie type)



2. Water is drawn/pushed from sediment towards a freezing centre where an ice lens develops
3. Ice lens grows/expands upwards as more water is added, doming the ground surface
4. Ground surface ruptures exposing the ice lens
5. Pingo collapses as ice melts leaving pingo ramparts

Open-system pingos (East Greenland type)



Relict pingo, Tylwch, mid-Wales

Thermokarst

Thermokarst

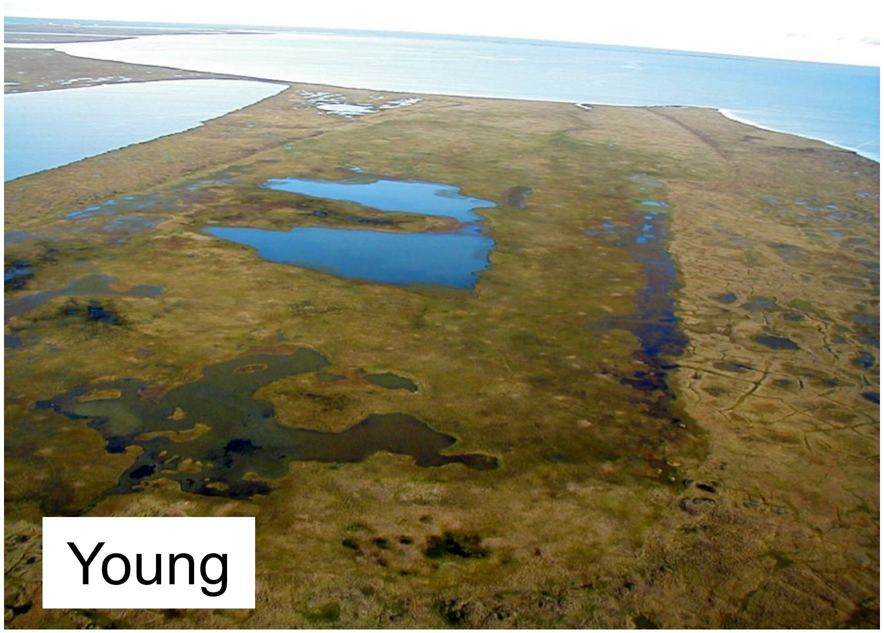
Landscape of irregular, hummocky ground interspersed with waterlogged hollows

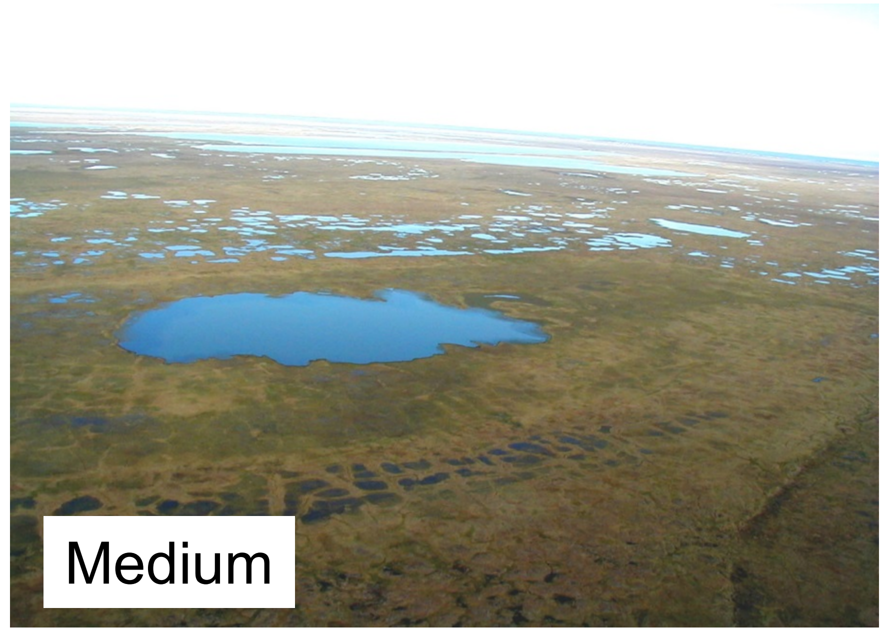
Caused by differential thawing of ground ice

Thaw lake

?

Thaw lake development





Thaw lakes

Water collects in depressions (e.g. low-centre polygon features)

The deeper water transfers heat to the ground leading to further permafrost thawing

Waves scour the sides causing the lakes to elongate perpendicular to the wind direction

Deposition on far shore prevents further thawing of permafrost

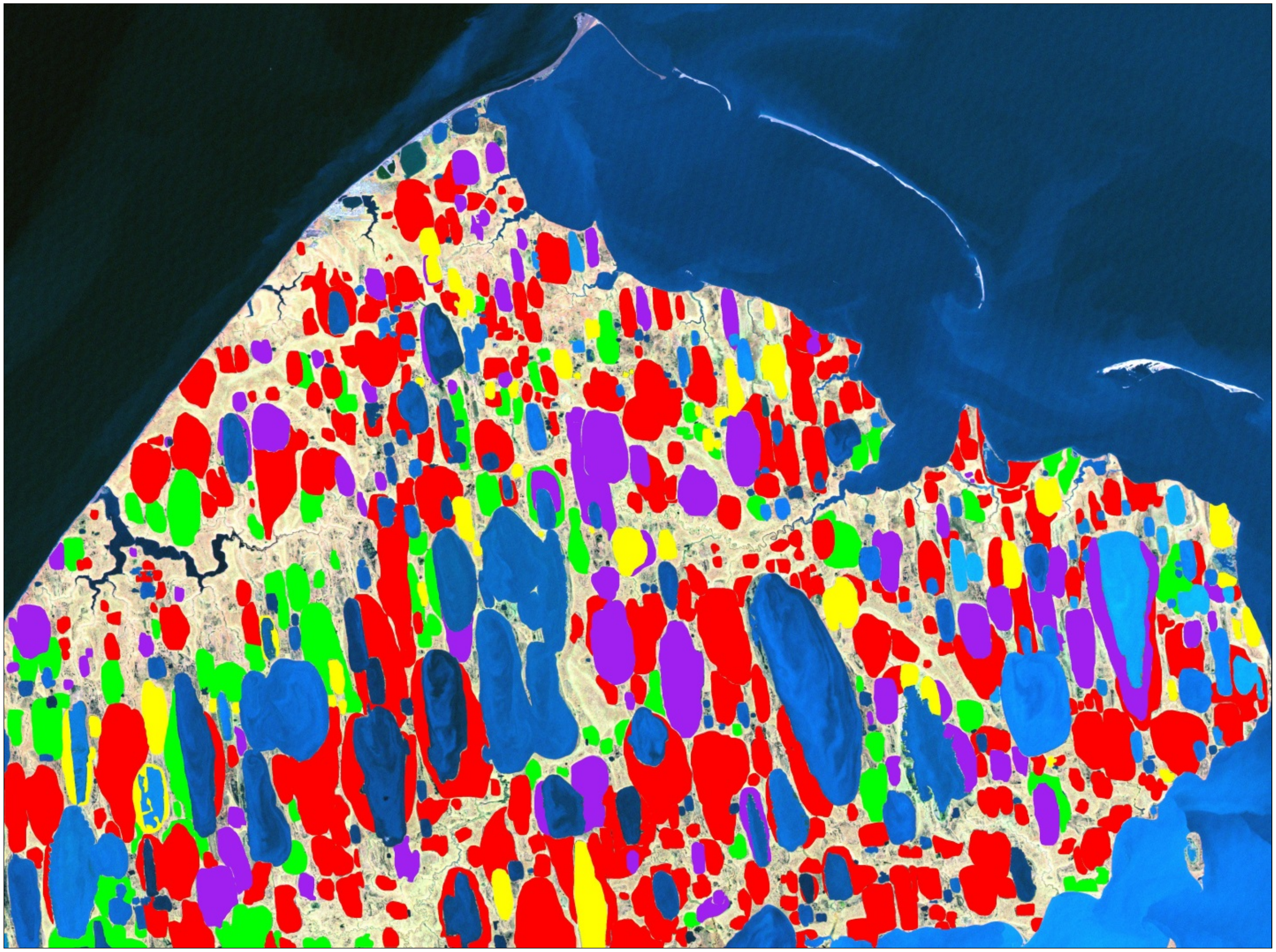
Lakes can range from 100m to over 10 km in diameter

Over time, the lake becomes shallower as sedimentation occurs (e.g. through build-up of organic matter)

As areas become dry land, they are susceptible to freezing and become part of the permafrost once more

In time, new lakes can develop and the cycle repeats

Thaw lakes



Yellow areas = **young** basins; purple areas = **medium** basins; red areas = **old** basins; and green areas = **ancient** basins.

The role of wind and water

Water erosion

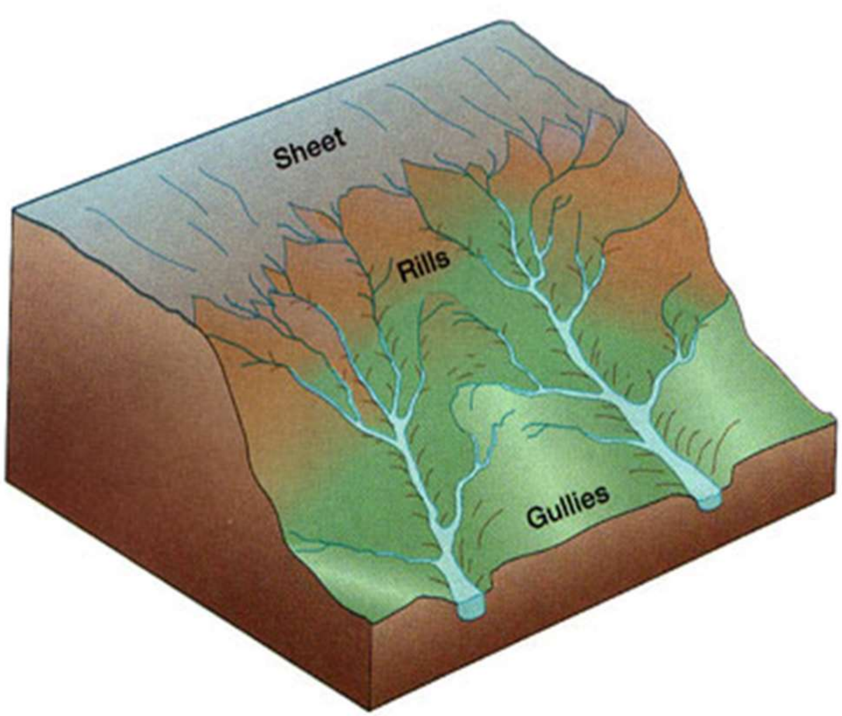
Highly seasonal (remember active layer cycles sheet?)

Braided rivers are typical (why?)

At top of slopes (gradient is shallow) water flows as a continuous body (sheetwash)

As slope increases in gradient sheet breaks into smaller channels that erode **rills**

These coalesce to form larger channels that erode **gulleys/gullies** (either spelling is acceptable, apparently)



Dry valleys

Permafrost = impermeable layer ∴ prevents percolation into permeable rock (e.g. chalk) allowing ↑ surface drainage and erosion

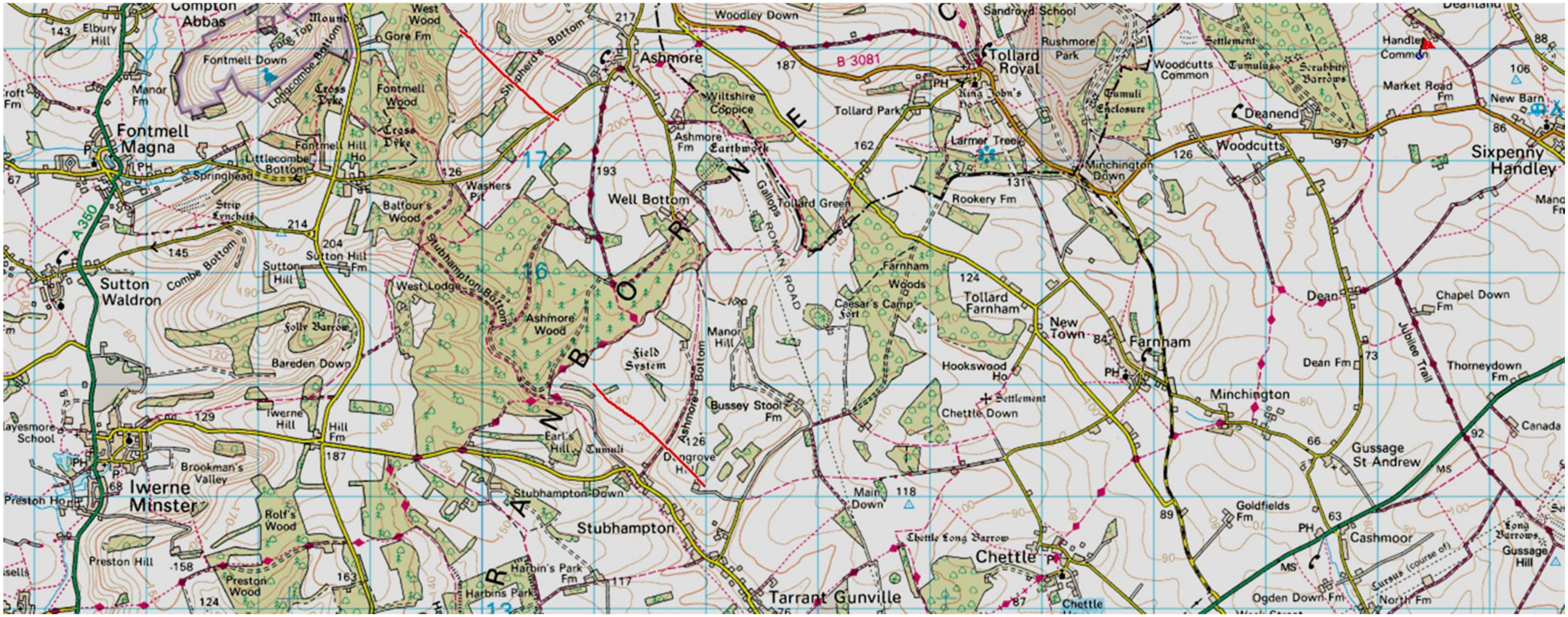
Valleys produced are v-shaped and clearly formed by flowing water but are often much steeper sided as large volumes of snow/ice meltwater would have eroded rapidly downwards

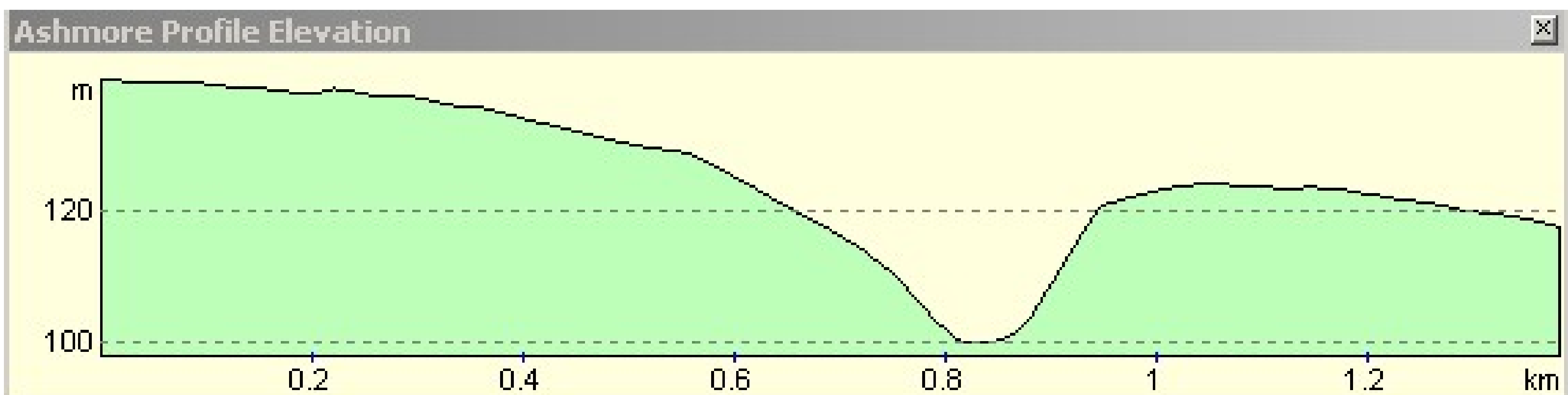
Once permafrost thaws, bedrock becomes permeable again so drainage reverts to sub-surface, ∴ no river, hence 'dry valley'

Very common in chalk downland (where called 'coombes' – various spellings) and limestone areas

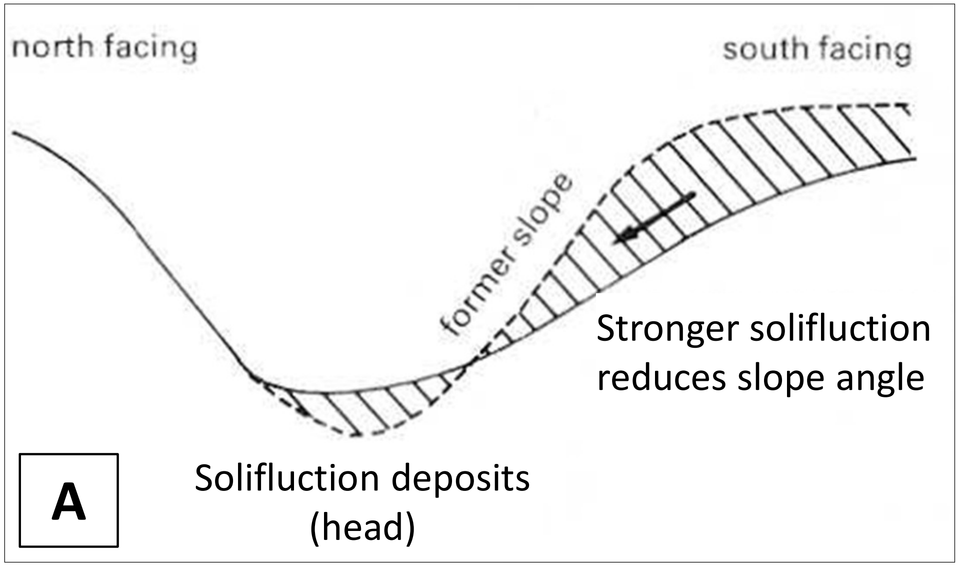
Cross-profile often exhibits asymmetry…

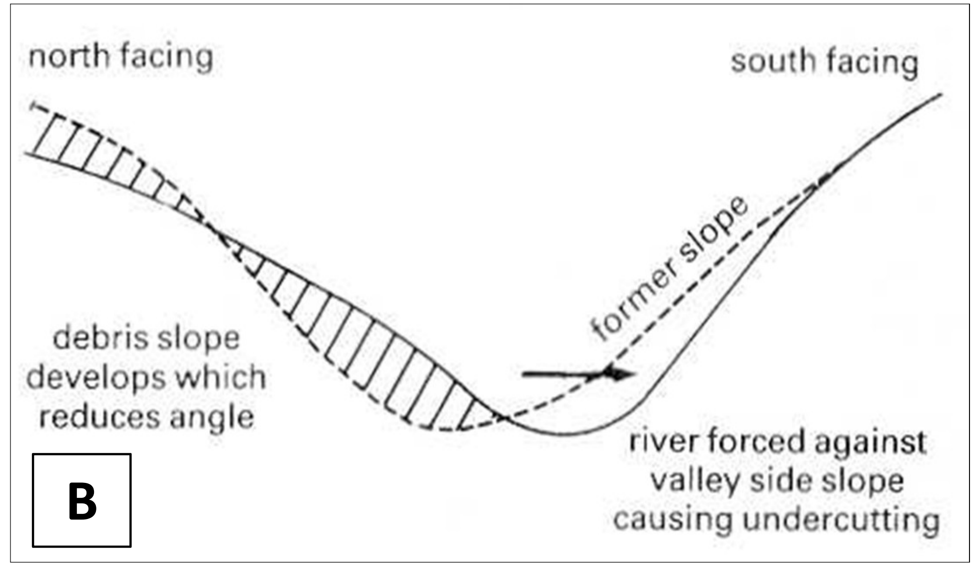
Asymmetrical valleys





Asymmetrical valleys: 2 theories





A: more solifluction on south-facing slope (why?) make slope less steep relative to north-facing slope

B: snow patches on north-facing slope remain for longer (why?) and increase nivation – mass movement forces river to undercut south-facing slope which increases the slope angle

Wind (aeolian) processes

Lack of trees allows for high velocity winds increasing erosion

Also seasonal variations (why?)

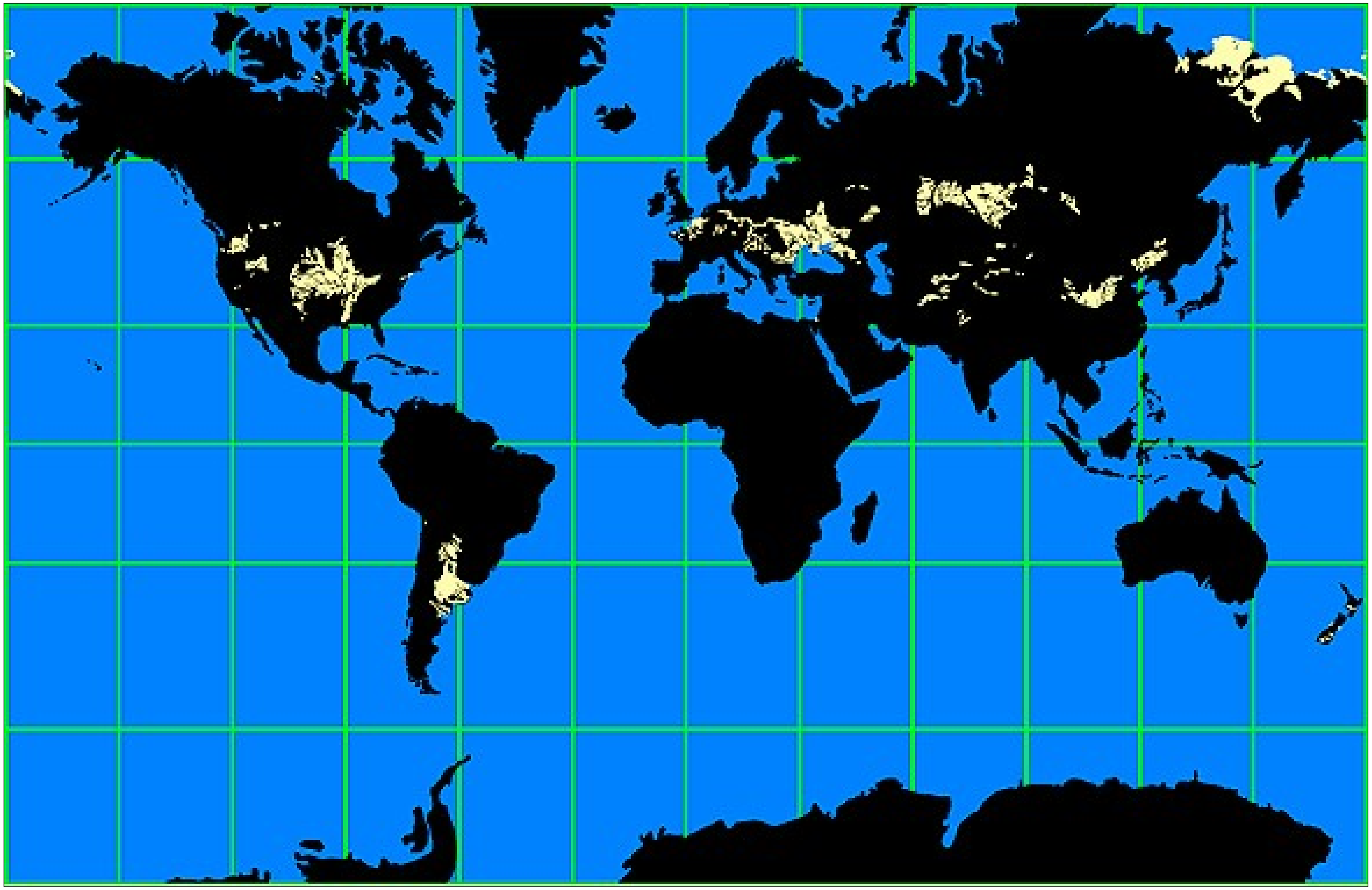
Fine unconsolidated material is blown away in process called **deflation** (common in all arid areas)

Wind-carried material increases abrasion, producing grooved & polished rocks: **ventifacts**

Fine wind-deposited material is called **loess** (German – 'loose')

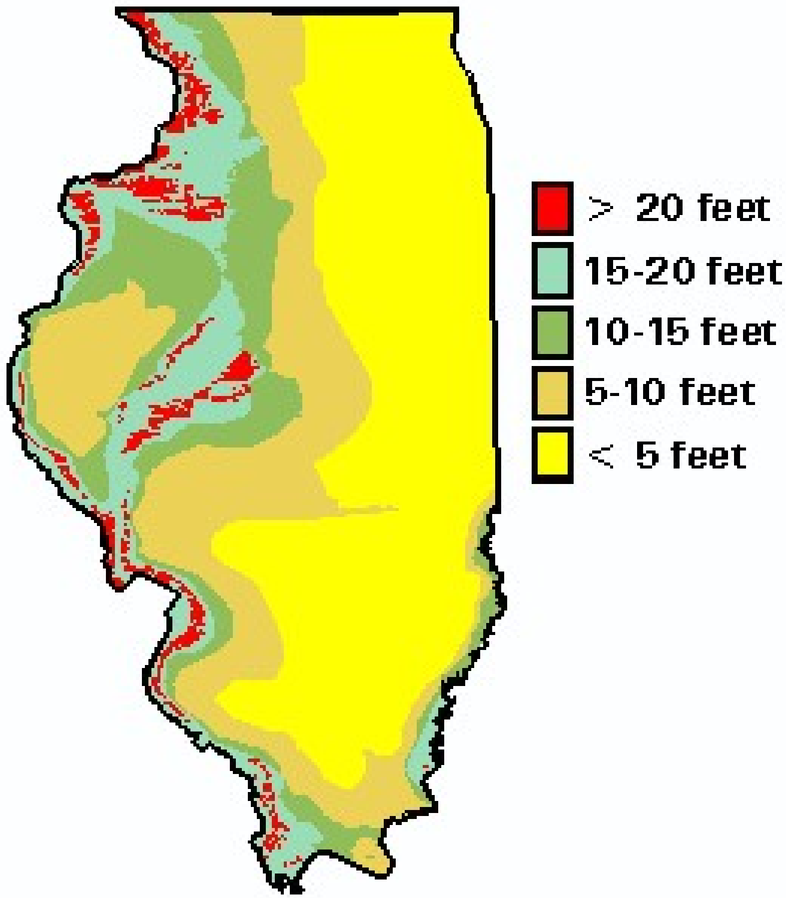
- Periglacial deposits in East Anglia & London Basin (aka brick-earth deposits) < 2m deep
- In China, deposits > 300m in places – the **Loess Plateau** or Huangtu (Yellow earth) Plateau, covers c. 640,000 km^2 masking the underlying topography
- High quality arable land – loamy texture and very fertile – but very easily eroded if not vegetated: loess from Huangtu Plateau is carried in suspension in the Huang He giving it its name: Yellow River

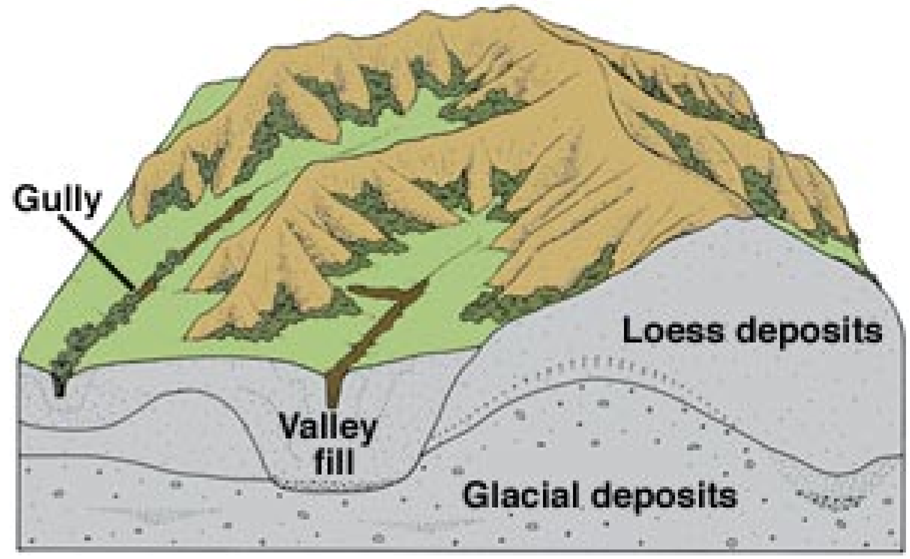
Wind processes



Global loess deposits

Wind processes





Block diagram of the present landscape of the Loess Hills showing features above and below the surface. Adapted from Landforms of Iowa, Jean C. Prior, Geological Survey Bureau, Iowa Department of Natural Resources.

Loess deposits in Illinois, USA

Loess deposits in Iowa, USA