Changing Landscapes: Glaciated Landscapes

Glacial deposition landforms

What you need to know

c. Transport and deposition
   i. Processes of glacial and fluvioglacial transport including supraglacial, englacial and sub glacial transfers and their resultant sediment characteristics (size, shape and sorting)
   ii. Landforms and landscapes of glacial deposition including types of till (ablation, lodgement and deformation) and types of moraine (terminal, recessional, lateral, medial and push) and drumlins
   iii. Processes of fluvioglacial transport and deposition lead to ice-contact features both for and beyond the UK including eskers, kames, kame terraces
   iv. proglacial features including sandurs, varves, kettle holes and kettle lakes

Glacial Transport

How might sediment come to be on top of the glacier (supraglacial)?

Glaciers ‘pick up’ (or entrain) sediment subglacially…how?

How can subglacial and supraglacial sediment become incorporated into the body of the glacier (englacial)?

What happens to sediment as it transported by a glacier?

How is this different depending on where the sediment is in the glacier?

Glacial Transport

Moraine – general term for material transported or deposited by glaciers

Lateral moraines – sediment accumulations along the sides of the glacier

Where two valley glaciers meet, the two inside lateral moraines join to become a **medial moraine**. Large valley glaciers can have many medial moraines:

Aletsch glacier, Switzerland

Glacial Transport

Basal moraine – sediment transported subglacially at the ice bed:

Leverett Glacier,
Western Greenland

Glacial Deposition

…happens in two main ways:

1. **Lodgement**

   Subglacial sediment becomes stuck or lodged in the ice bed when…

   - friction between debris and rock bed > between debris and ice (caused when more pressure exerted as ice thickens, or where water pressure in sediment decreases making it ‘stickier’)
   - the glacier slows down

   Can occur during glacier advance or retreat

2. **Ablation (or melt-out)**

   Debris is left behind by melting ice, caused by:

   - geothermal melting of basal ice
   - supraglacial melting at ice margins (more important)

Moraine characteristics

Till – debris directly deposited by glaciers

- Aka boulder clay (UK)
- Technically it's a **diamicton** as it's unsorted, unstratified and unconsolidated
- Characteristics vary, reflecting the way it's been deposited…

Till characteristics

Characteristic	Lodgement till	Ablation till
Clast shape (individual stones)		
Sediment size distribution		
Particle fabric (clast orientation)		
Compaction		
Clast appearance		

Till characteristics

Relatively weak till can also be pushed/squashed/squeezed as the glacier flows over it

Folding and faulting that results is called **glaciotectonic deformation**

Pieces of bedrock can also be pushed/dragged into the till by this process, e.g. near Cromer on the Norfolk coast where pieces of chalk (*chalk rafts*) are found in the till

Glacial Deposition - research

Ice-marginal moraines (i.e. found at the edge of the glacier/ice sheet):

Terminal, Recessional, Lateral, Medial, Push

For each of the above:

a. Find a clear photo and either annotate it to describe its appearance or write a description underneath
b. Describe where it is found in relation to the ice
c. Explain how it has been deposited (using appropriate terminology)
d. Describe the sediment characteristics (clast size and size distribution, particle fabric, compaction)

During your Supervised Study, undertake the November Review – any areas where you are not confident should then be targeted for a more detailed revision, using the Student Guide and other resources.

Glacial Deposition Landforms

Subglacial moraines

The result of an accumulation of glacial debris beneath the ice:

Till plain (aka **till sheet** or **ground moraine**)

E.g. extensive areas of East Anglia – ave. depth 30m but up to 70m in places

Result of repeated periods of deposition (of basal moraines) and may exhibit:

Fluting (or **fluted moraine**) where ice flows around boulders producing long strips of moraine parallel to ice flow, tens of cm to a few m high/wide, and tens of m long

Ribbed or **rogen moraine**: numerous, parallel, closely-spaced ridges, *transverse* to ice flow usually found in central areas of former ice sheets. Typically 10-30m high, 300-1200m long and 150-300m wide. Straight to arcuate planform, concave in the down-ice direction. There are a number of different theories to explain their formation…

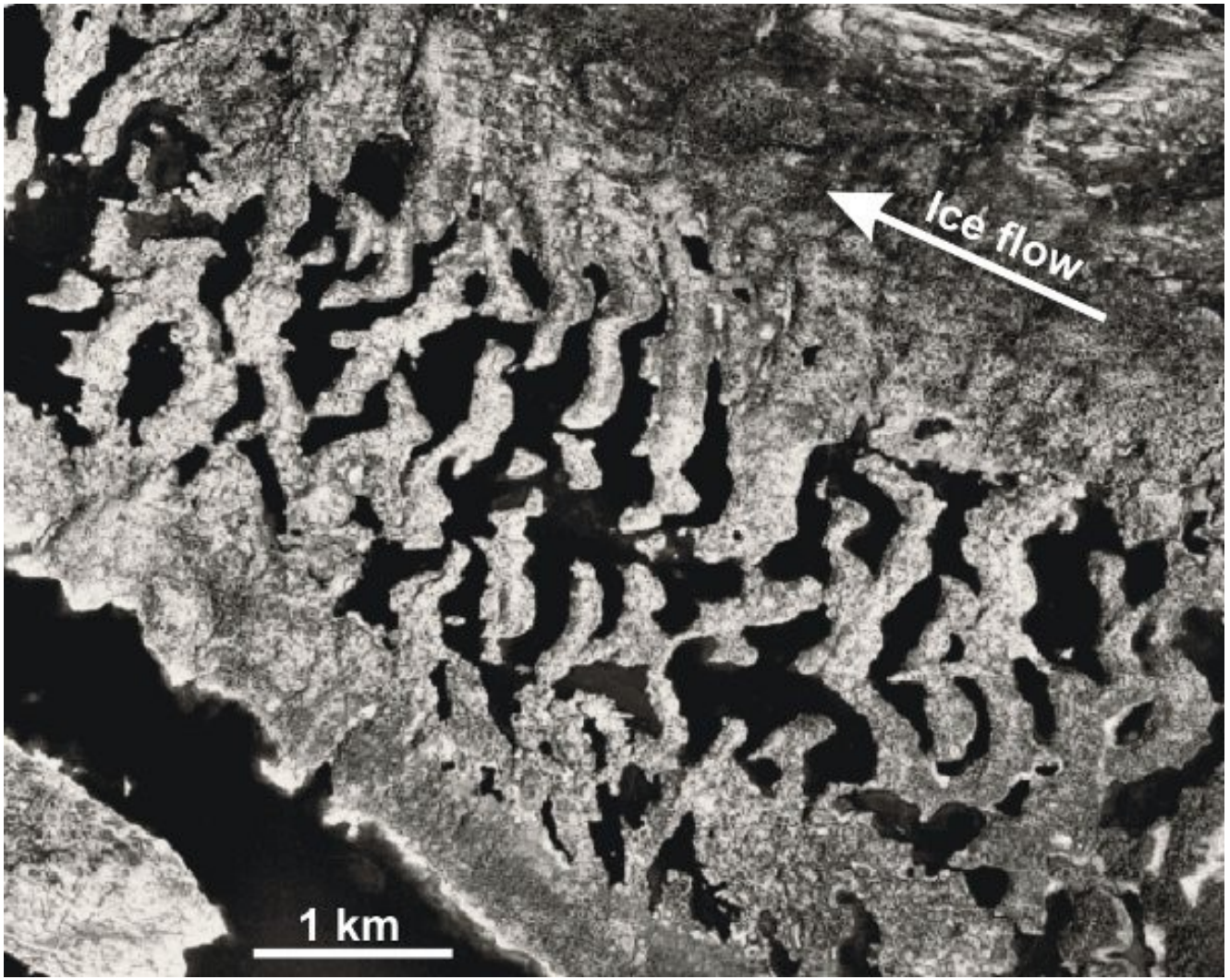
Glacial Deposition Landforms

Fluted moraine

https://www.sheffield.ac.uk/drumlins/flutes

Glacial Deposition Landforms

Ribbed or rogen moraine



https://www.sheffield.ac.uk/drumlins/rogen

Glacial Deposition Landforms

Subglacial moraines

Drumlins

Streamlined mounds formed beneath active glaciers/ice sheets

From 15-50m high, 25-600m wide and 50-1200m long

Elongation ratio (long axis / max width) never > 50

Steeper (*stoss*) end points upstream, tapered end (*lee*) downstream

Usually found in groups (swarms)

Typically found in lowland areas relatively close to upland centres of ice dispersal where there's a high supply of glacial debris

Formation is undecided as there are many forms with an array of internal compositions. Two main theories, though [separate sheet – see also: https://www.sheffield.ac.uk/drumlins/drumlins]

Fluvioglacial Deposition

Fluvioglacial (or glaciofluvial) describes transport and deposition by meltwater

Sediment is transported, eroded and deposited in much the same as in rivers… though there are some differences where meltwater is englacial/subglacial or supraglacial/proglacial

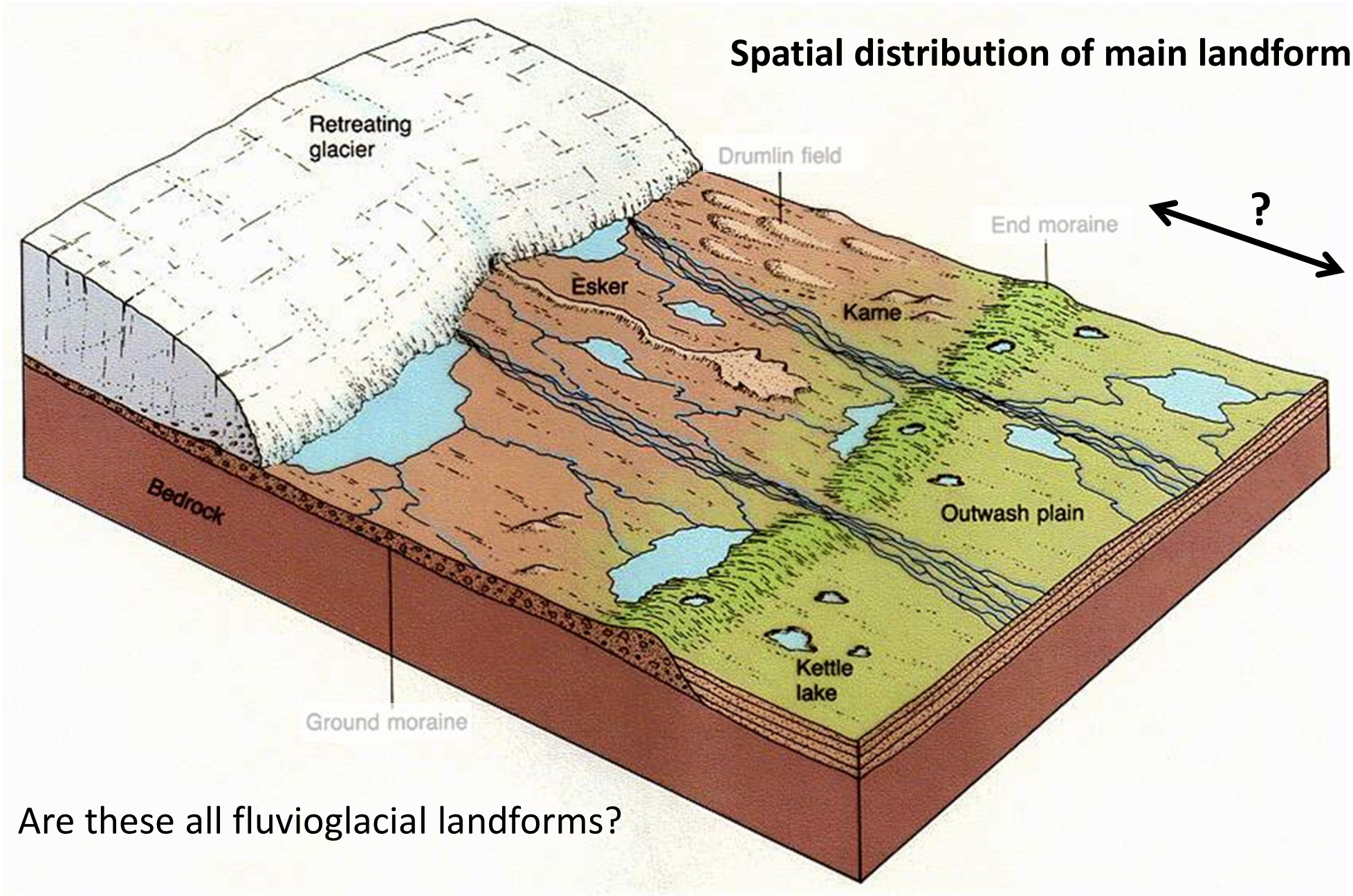
All fluvioglacial sediments will exhibit some degree of **sorting** (by size) and **stratification** (i.e. have more/less distinct layers).

Clasts will be **more rounded** than through glacial deposition (eroded by ?)

These landforms can be formed in contact with the ice, or **proglacially** (i.e. beyond the ice margin)

Fluvioglacial Deposition

Spatial distribution of main landforms



Are these all fluvioglacial landforms?

Ice-contact stratified drift*

**drift is the general term for all sediment deposited by ice and/or meltwater*

These are landforms created in/by meltwater next to/underneath the glacier:

Eskers

Kames and kame terraces

Eskers

Eskers

Esker revealed by rapidly retreating Stagnation Glacier, Bylot Island, Nunavut, Canada

Eskers

The Trim Esker, Meath, Eire
(Picture taken 26th June 1963)
One of 12 – 14.5km long, 4-15m high – formed by retreat of central Irish ice cap at end of Devensian

Deposition in subglacial tunnel

Esker characteristics

Sinuous ridges of relatively coarse sands and gravels

Formed in meltwater channels in/beneath the ice during deglaciation (glacial retreat)

Usually in same direction as ice flow

Can cut across contours

May be single or multiple ridges

10-50m wide, 5-20m high and can be hundreds of km long

Common in lowland areas underlain by hard bedrock – e.g. Canada or Scandinavia

Sorting/stratification evident but may be disturbed during formation

Imbrication and cross-bedding may also be seen

Imbrication and cross-bedding

Sorting, stratification and imbrication in esker sediments, Ontario, Canada

Eskers

Formation is not clear, as meltwater in a subglacial tunnel would be expected to be under high pressure and have high velocity

Two theories to explain why velocity falls:

1. Seasonal variation (high flow summer, low flow winter) or widening of channel under ice (reduces efficiency) or shifting ice upstream obstructs/restricts the tunnel reducing flow leading to deposition under ice
2. Deposition occurs as meltwater stream emerges at snout of continually retreating glacier – may help explain **beaded eskers** (ridges with frequent variations in height and width): beads = greater deposition - during summer or when retreat temporarily slows

Kames and kame terraces

Kame, Northern Canada

Kames and kame terraces

Kame terraces in the Cairngorms

Kames and kame terraces

Mounds of sand and gravel

Formed mainly from supraglacial deposition near glacier's snout in pools/lakes in ice-surface depressions and crevasses (kames), and between glacier and valley side (kame terraces)

Can also be deltas formed as sediment is transported by supraglacial streams into pools/lakes

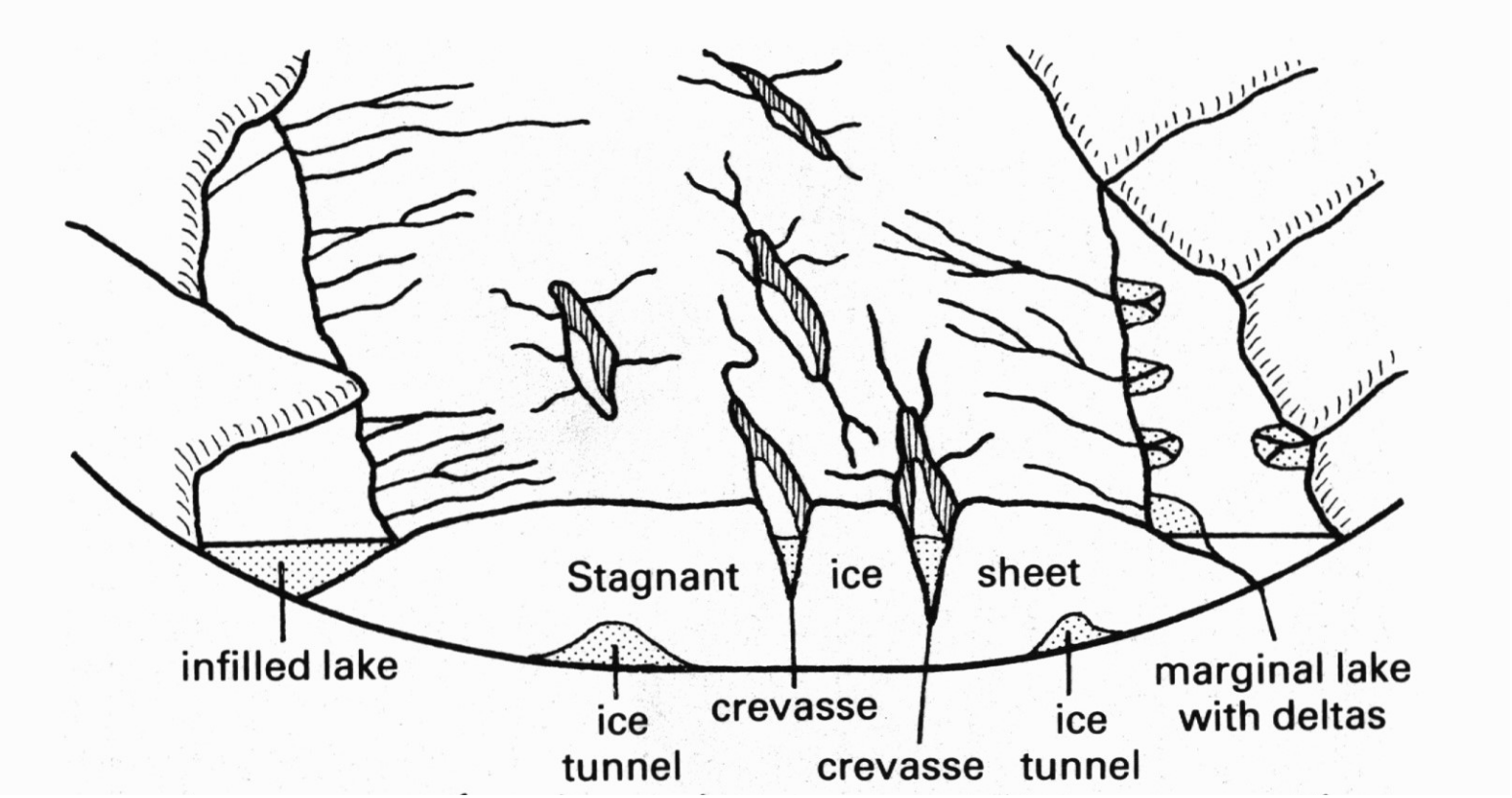
Deposits are then lowered to valley floor as stagnant ice (inactive/stationary) melts

Evidence of sorting/stratification but likely to be disturbed during formation.

Kame terraces are longer, more continuous bench-like features…and can appear similar to lateral moraines

Very common in East Lothian, Scotland where they reach 1.5km in length and 200m wide

Formation summary



Proglacial features

These are landforms/features that develop beyond the ice front:

Sandur (aka **outwash plain)**

Kettle holes and **kettle lakes**

Varves

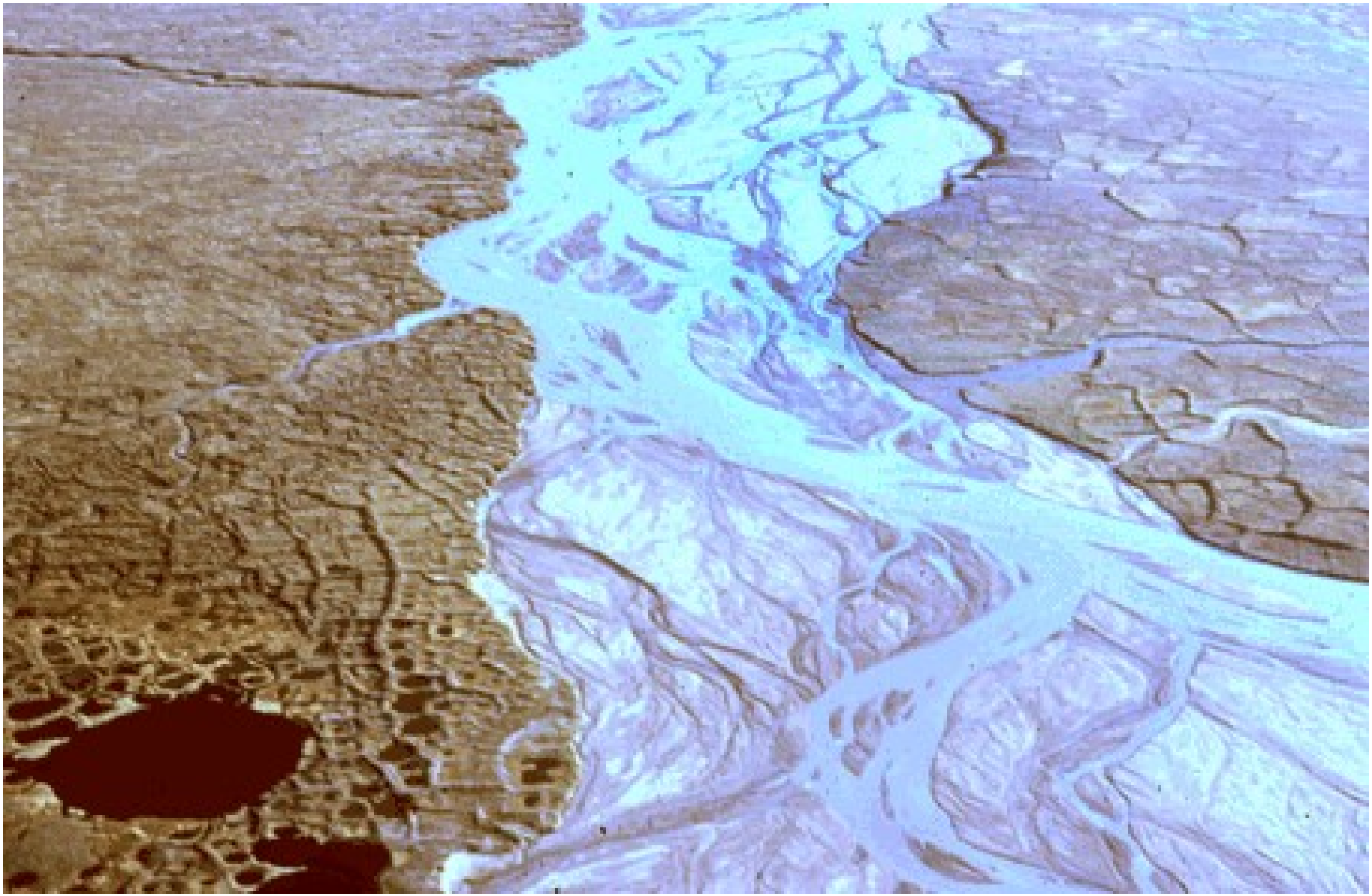
Sandur, S Iceland

Sandur, S Iceland

Stratified outwash, Solheimajokull, Iceland

Outwash deposits

Alaska



A braided river system, northern Canada

Proglacial features

Sandur (aka **outwash plain)**

As meltwater streams emerge from snout of glacier there's a sudden drop in pressure/velocity

? sediment is deposited first, creating an outwash fan

Outwash fans merge to form larger plains

Meltwater streams flow over previously deposited debris, transporting, eroding and re-depositing the sediment producing an outwash plain or sandur (Icelandic)

Debris is **?**, **?** and **?** through **?**

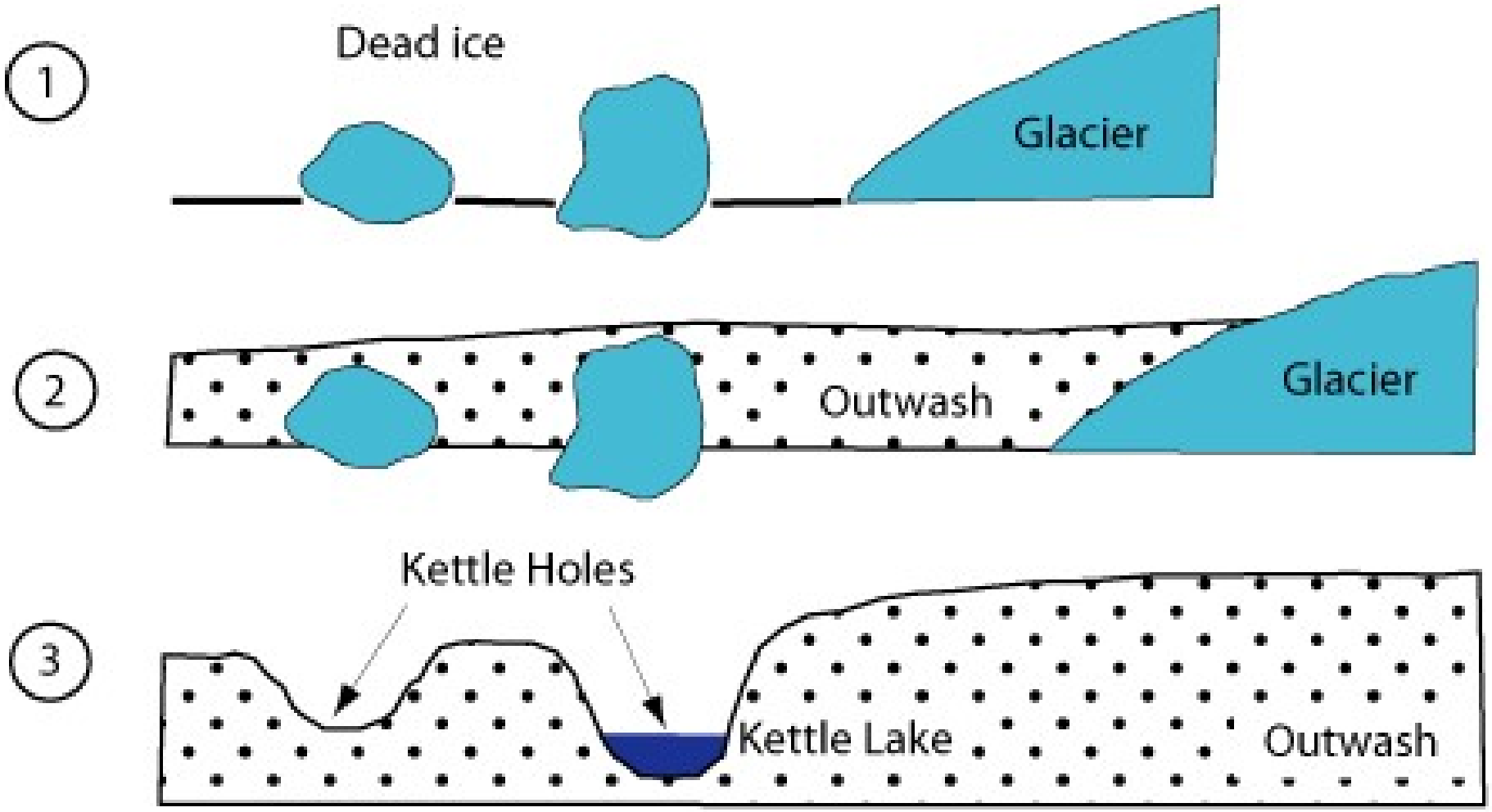
Size decreases with distance from the ice front

Kettle holes and kettle lakes are often found on sandurs

Proglacial lakes can also form, dammed by moraines

Sediments in these lake beds can often exhibit varves

Kettle hole, Iceland


1
Dead ice
Glacier
2
Outwash
Glacier
3
Kettle Holes
Kettle Lake
Outwash

Mere Tarn (kettle), Gleaston, Cumbria

Varves

Varves at Aberogwen, N Wales

https://www.field-studies-council.org/media/2617020/background_information_-_other_north_wales_sites.pdf