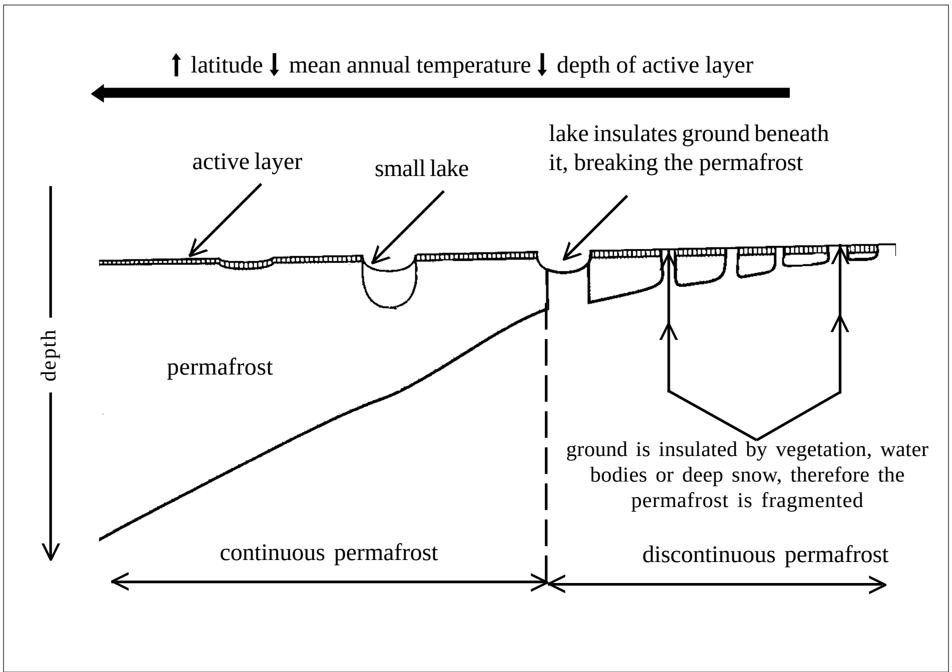
Geo Factsheet

Number 21

Assessing The Evidence For Periglaciation

Periglacial areas are those which, although not actually glaciated, have been exposed to very cold conditions with intense frost action and the development of perennially frozen ground or permafrost. This Factsheet summarises the main features and processes of periglacial areas and reviews the evidence for past periglacial processes in Britain.

Fig 1. Permafrost



What evidence is there that periglaciation has affected Britain?

Firstly, it is possible to analyse present-day periglaciation processes which are occurring in parts of upland Britain and to examine the landforms and deposits which they produce. These include blockfields, talus slopes and tors. Secondly, it is possible to identify many landscape features of lowland Britain which represent relict features of periglacial activity. These include ice wedge casts, polygons and other surface patterns, cryoturbation structures, pingo scars, thermokast features, slope structures and mass-wasting deposits.

Despite some overlap (solifluction features and patterned ground occur in both uplands and lowlands) these two areas of Britain provide different sorts of evidence of past periglaciation. Features such as avalanche boulder tongues occur only at the base of steep upland slopes whilst the lowlands, usually covered in thick glacial, perifluvial or periglacial deposits, have allowed the formation of features such as ice wedge casts.

Permafrost

Periglacial areas can be identified using two diagnostic criteria:

- They experience seasonal freezing and thawing of the ground surface
- They contain permafrost

Permafrost can be defined as ground in which the temperature remains at or below 0°C for at least two years. Such ground is usually frozen and ice-rich but not always, because earth materials may be below 0°C in temperature but remain unfrozen. This is because the freezing point of groundwater is reduced by the dissolution of minerals. Significant amounts of unfrozen water may therefore exist in frozen ground and frozen ground may not contain ice. Permafrost is therefore best defined as **cryotic** ground i.e. ground below 0°C which often, but not always contains ice. Continuous permafrost occurs within the Arctic Circle, where the mean annual temperature is never above -5°C, but even here the permafrost may thaw below lakes which effectively insulate the ground. Unfrozen areas such as this are known as **taliks.**

Further south, permafrost occurs in 'islands' separated by warmer areas which receive insulation from lakes, rivers, vegetation or man-made structures. This is known as discontinuous permafrost (Fig.1).

Further south still, permafrost may be described as sporadic; mean annual temperatures are only just below freezing point and frozen ground occurs in isolated patches.

Above the permafrost lies the **active layer**, 3mm to 3m thick which freezes and thaws seasonally. Although the depth of the active layer varies greatly with latitude, its significance in shaping the periglacial environment is difficult to over-estimate.

Some processes are unique to periglacial environments; the formation of permafrost, frost-heaving and the development of thermal contraction cracks, for example. Other processes such as ice segregation, seasonal frost action and rapid mass movement are not unique to periglacial environments but are significant because of their severity or frequency. Before we can assess whether such processes have occurred in Britain, i.e. assess the evidence for past or present periglaciation, we need to analyse these processes and the landforms which may result in a little more detail.

Active layer processes

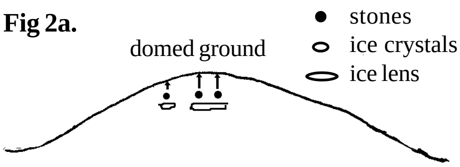
A. Frost Heave As the active layer starts to refreeze ice crystals begin to develop. This increases the volume of the soil and causes an upward expansion of the soil surface. This is known as frost heave and is most significant in fine-grained materials.

> ***Exam hint** - Mere lists of periglacial features will not suffice. Processes should be explained and A grade candidates will be expected to be able to select examples of a wide range of landform effects - the chalk landscapes of S. Britain (Fig 3a) should only be part of the answer.*

B. Sorting Due to active frost shattering, periglacial areas can be very stoney. Repeated freezing and thawing in stoney soils can raise, sort and arrange the stones into distinctive patterns, whilst **fines** (sands, silts and clays) tend to migrate downwards. The upward migration of stones or **clasts** to the surface has been explained in two ways;

- **Frost pull** - occurs when a stone adheres to ice within a freezing active layer and is drawn upwards as the ground heaves.
- **Frost push** - since stones have a lower specific heat capacity, they heat up and cool down faster than the surrounding soil. A descending freezing front will therefore move through a stone more quickly than it will move through the soil on either side of the stone. This means that the soil immediately beneath a stone is likely to freeze and expand, pushing the stone upwards (Fig.2a).

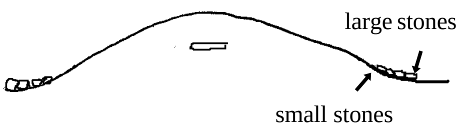
Fig 2a.



If frost heave produces a doming of the ground, any stones which are raised to the surface are likely to roll off the top of the dome and accumulate in between mounds (Fig.2b).

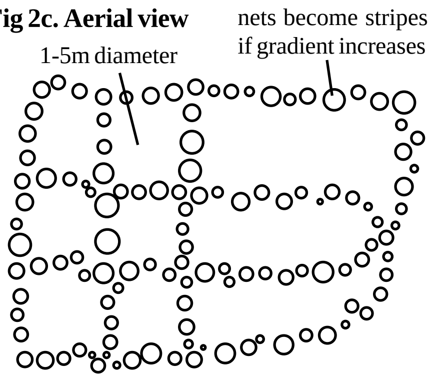
> ***Exam hint -*** *Do not confuse ice wedge formation with freeze-thaw weathering*

Fig 2b.



Large, heavier stones with greater momentum will roll further than small pebbles, effectively sorting the stones, which, viewed from above may form 'nets' or polygons (Fig.2c).

Fig 2c. Aerial view



C. Ice wedges
Intense cooling and contraction of the permafrost in winter may cause **polygonal patterns** of cracks to form. In summer the cracks fill with meltwater and some loose material and, upon refreezing the following winter, the crack will be enlarged. Such **ice wedges** may extend to a depth of 3m and reach 1m in width at their surface. Ice wedge polygons differ from those formed by frost heave in that they are larger (30m diameter) (compared with 1-5m) and their edges are slightly higher than their centres (the edge of the ice deforms the adjacent sediments), whereas frost heave polygons are domed. Any stones in an ice wedge polygon will therefore roll into the **centre** of the polygon with the biggest stones often occupying the central position. If ice wedge cracks fill with sand or silt, **sand wedge** casts result. These effectively preserve the crack long after periglacial conditions have ended (Fig 3b).

D. Cryoturbation structures
Repeated freezing and thawing of near-surface deposits may result in involutions i.e. distortions resulting from expansion and contraction of the ground by freezing and thawing. Many types of cryoturbation structure exist but the most common in Britain are those caused when thawing, ice-rich sediments liquefy (solifluction) as they consdidate. Such liquid sediments may then be injected into the overlying sediments to produce flame-like structures.

Landscape features

Pingos
Pingos are gently domed hills, reaching heights of 50m, which have a core of ice. When the ice core of a pingo melts the surface slumps inwards to form a slight depression surrounded by near-circular ramparts.

Thermokarst features
The thawing of sub-surface ice, whether as a result of climate change, forest fires or the removal of any insulating layer may lead to sporadic ground slumping and the formation of **thermokarst** landscape; hummocky terrain consisting of a series of mounds and hollows.

Frost shattering
Frost shattering is particularly intense under periglacial conditions and can produce huge volumes of large, angular boulders which form a 'rock sea' or **blockfield**. In granite areas e.g. Dartmoor, these blocks are known as **clitter**. **Tors** may also result from the frost shattering of surrounding, less resistant rocks and its removal by solification.

Dry valleys
Dry chalk valleys are believed to have been formed by the action of highly erosive rivers flowing over frozen and therefore impermeable chalk. Almost all of the dry valleys of southern England contain extensive deposits of frost shattered rock debris known as **coombe** rock, which is at its thickest downslope. The **asymmetry** of many of these valleys is thought to result from the differential heating and hence freezing and thawing of slopes of different aspect under periglacial conditions. The cold east-facing slopes may have been perennially frozen whilst the west-facing slopes, with greater insolation would have experienced greater freeze/thaw activity, resulting in asymmetry.

Fig 3a. Sites of periglacial patterned ground on chalk

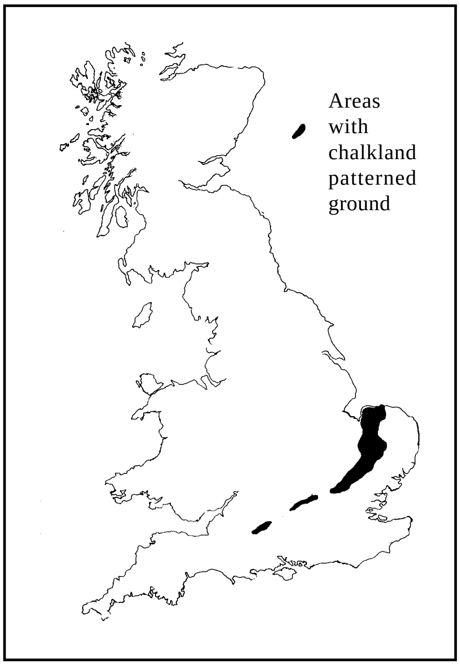
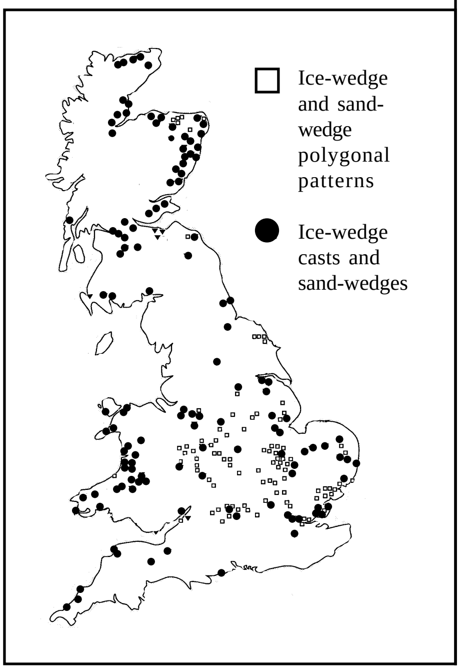


Fig 3b. Distribution of wedge casts and polygonal crop marks.



FEATURE	EXAMPLES	USEFULNESS
Ice wedge casts.	Giant ice wedge casts at **Stanton Harcourt** and **Baston** in **Lincs.**	Wedges in-filled with silt or sand may form through processes such as chemical solution or root activity and thus have nothing to do with periglaciation. True ice wedge casts form polygonal patterns and extend downwards from the bottom of a cryoturbated horizon which corresponds to a former active layer. The casts are pointed and in-fill material is vertically aligned. However, ice wedges only develop in permafrost so relict features provide strong evidence of past periglaciation.
Patterned ground.	Stripes in **Lincs** and **Yorks**, wolds. Nets and stripes on **Thetford Heath, East Anglia**. Centre of nets correspond to chalk-loving grasses whilst the 'net' reflects heathers growing on thick sands.	Relict polygons are a result of the cracking of permafrost - very strong evidence of past periglacial conditions
Cryoturbation structures (deformation of sediments near surface, for example, frost heave).	**Isle of Thanet, Kent** **East Anglian chalklands.**	Infer seasonal freezing and thawing of near-surface sediments which does not necessarily imply periglaciation techniques.
Pingos.	**Walton Common, Cambs** where 'scars' are superimposed indicating that several cycles of ground-ice growth are represented Many rampart represions in valleys of **SW Wales e.g. Cletwr valley** **Llangurig, Wales.** **Thames Basin.**	Not all rampart circular depressions represent pingo scars, there are many possible causes.
Thermokarst scenery-slumps and depressions caused by melting ground-ice.	**Walton Common, Grunty Fenn, Cambs** **Conington Fen, Peterborough.** **Vale of York.**	Most thermokarst features will have either been buried or destroyed by agriculture but absence of evidence is not necessarily evidence of absence
Head deposits formed through frost shattering, solifluction and sliding.	Sarsen stones - streams of surface boulders running along the valley bottom of the **Marlborough Downs** e.g. **Coombe rock** consisting of chalk, flint and mud .	Head has often accumulated on slopes with such low gradients that gravity-led processes alone cannot be responsible. Seasonal thawing and consequent high pore-water pressure is thought to be responsible.
Asymmetric valleys (periglacial processes acting unequally on slopes as a result of their aspect).	**Chilterns.**	Several processes could be responsible for asymmetric valley formation.
Nivation terraces (steps cut into the slope profile caused by prolonged nivation) - frost-action, mass wasting and meltwater erosion beneath melting snowdrifts.	Slopes of **Cox Tor, Dartmoor.**	Suggest intensified physical and chemical erosion, which certainly features in periglacial conditions but such features, in themselves, do not conclusively indicate past periglacial conditions
Tors.	**Penine tors** - gritstone **Stiperstones, Shropshire** - quartz site **Dartmoor tors** - granite.	Tors are not exclusive to periglacial environments, there are several theories proposed to account for their formation

Wind action
In periglacial environments a lack of complete vegetation cover means that soils are particularly vulnerable to both wind and water erosion. Extensive deposits of windblown silt, known as **loess** along with much more restricted deposits of **coversands** (windblown sand) are often cited as important evidence of past periglacial conditions.

Slope processes

Mass wasting processes are greatly accelerated in periglacial conditions. Because permafrost is largely impermeable, water tends to accumulate above it and the active layer is usually saturated. The permafrost layer may then effectively act as a lubricating surface over which the active layer can flow. The slow, downslope flow of water-saturated soil is termed **solifluction** and can occur on slopes as gentle as 1^o. Note that, since this definition of solification does not need freezing conditions, the term **gelifluction** is used to describe solification over frozen ground.

Frost creep refers to the net downward displacement which occurs when soil particles expand at 90^o to the surface during freezing but, upon thawing fall back to the ground more or less vertically. Very slowly, this moves soil particles downslope. Taken together, gelifluction and frost creep greatly accelerate slope wasting.

Periglacial slope deposits **(head)** are common in many parts of England and Wales and are thought to have formed through a variety of periglacial mass-wasting processes, solifluction and sliding being the most common.

Nivation is used to describe the localised denudation of a slope at the edges of and beneath, melting snowdrifts. Such denudation may be a result of frost-action, mass-wasting and erosion by meltwater. Chemical weathering may also be important, particularly in limestone areas, since carbon dioxide becomes increasingly soluble as temperatures fall, thereby increasing the acidity of snow. The concentration of these processes in, for example a hollow, will lower the base to produce a **nivation cirque**. Nivation in elongated snowbeds stretching across hillslopes may produce **nivation terraces** or benched hillsides, steps interrupting the slope profile.

Acknowledgements;
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