Geo Factsheet

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BRITISH SOILS: A BASIC GUIDE

Soil constituents and formation:

Soil is formed when mineral matter reacts with the organisms, air and water present at the surface of the earth.

1. **Mineral matter.**
   This is derived from the weathering of parent material and forms the bulk part of the soil. Broken down particles are often classified according to size: clay, silt and sand. The relative proportions of these particles give the ***soil texture*** *(Fig. 3). A series of sieves are used to separate out the constituent parts in order to characterise soil by texture class.*

2. **Organic matter.**
   This includes both living and non-living organisms. Soil biota, such as worms, help mix the soil and break down organic matter into ***humus****. This process of decomposition and* ***humification*** *is key to the development of a humic layer. There are different types of humus, characterised by variations in pH.*

3. **Air.**
   This is found in the pore spaces between soil particles and the soil texture will often determine how much air is present. Soil air is usually saturated with water vapour and rich in carbon dioxide.

4. **Water.**
   Soil water is normally held as a thin film around soil particles (again, soil texture will control the amount of soil water). The water can be acid, neutral or alkaline, often determined by the soil surface vegetation and underlying geology. When saturated conditions occur water fills the pore spaces.

In Britain soils can be extremely variable over space. As can be seen from *Fig. 1* Britain can be split into two major provinces, approximately drawn from the Tees to the Exe, separating highland and lowland Britain, with many local variations within each province.

The major British soils are shown in *Table 1*. They belong to one of **three** groups.

1. ***Zonal soils*** *are formed by factors such as climate and the resulting vegetation which operate at a macroscale. Thus Britain shows a major NW/SE division between podsols and brown earths, with many gradations in between (podsol → acid brown → leached brown → brown earth).*

2. ***Intrazonal soils*** *are formed by a factor which operates locally, such as bad drainage (gley soils) or parent material such as limestone and chalk which produce* ***calcimorphic*** *soils (rendzina and brown calcareous), that overrides the zonal influences. Podsols, for example, can also occur* ***intrazonally*** *where sandstones lead to very acidic conditions locally.*

3. ***Azonal soils*** *are young immature soils which lack zones. For instance lithosols (raw soils) form on very steep slopes where constant map movement leads very shallow thin soils. Another example are fluvisols found on the flood plain of a river.*

Fig. 1 Map of British soils.

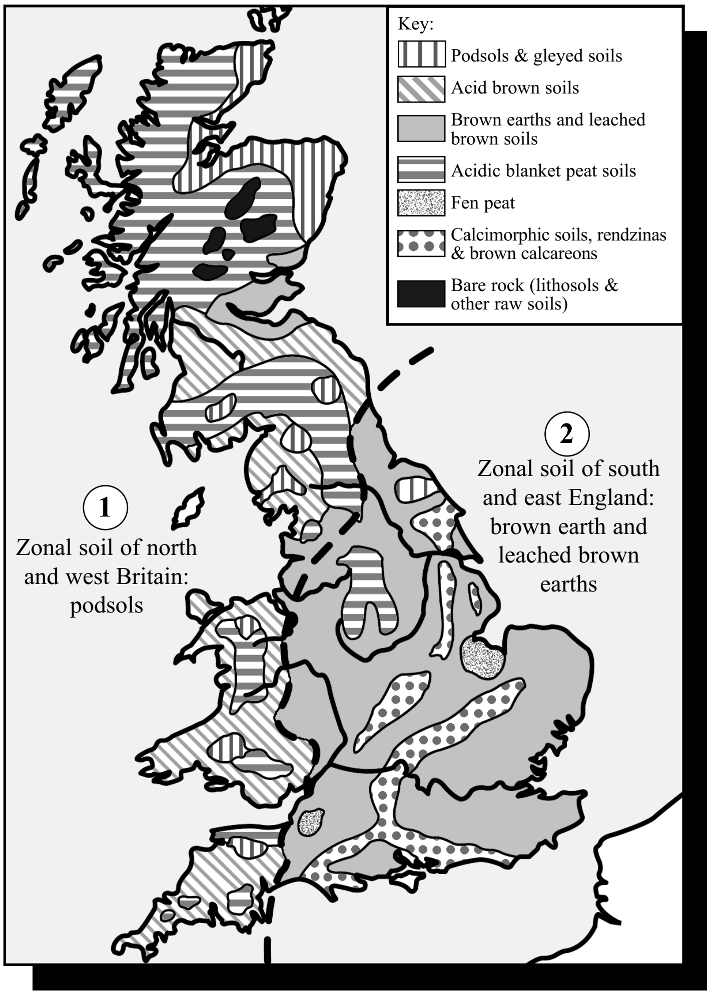
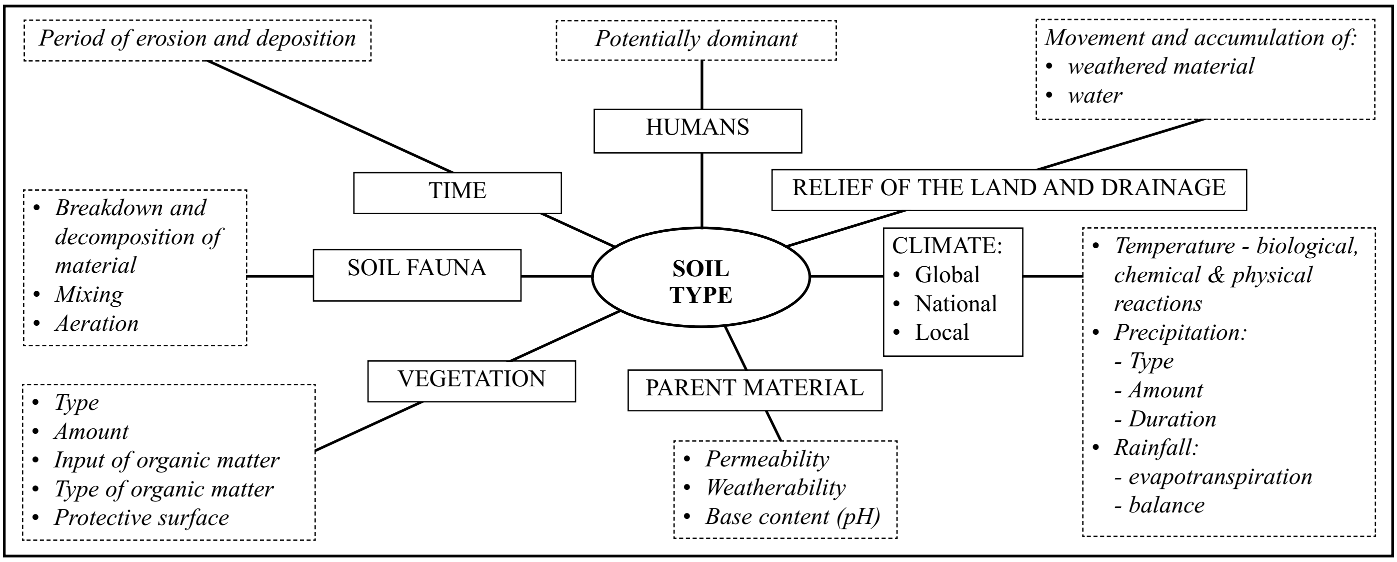


Table 1 The major British soil types.

Soil type	Group	Approximate number of horizons/depth	Location
Podsol ↑ Acid brown	Zonal	4 - 6 shallow - medium	Found in hilly, wet areas of upland Britain
Leached brown ↓ Brown earth	Zonal	3 - 4 medium - deep	Found in lowland England - heavily cultivated
Gley	Intrazonal	4 - 5 medium - deep	Found in badly drained areas
Rendzina	Intrazonal	2 shallow	Found on chalk
Peat *(organic soil)*	Intrazonal	2 deep	Hill and lowland and peat
Raw soils	Azonal	1 shallow	Steep mountain slopes
Lithosols	Azonal	1 shallow	

Fig. 2 Factors affecting soil formation.

- **Climate:** Climate is the prime factor and broad belts of soil related to particular climate types (zonal) are found around the world. In particular the movement of water through a soil is a major consideration, leading to the development of different soil types based on precipitation, temperature and evapotranspiration.
- **Organisms (including people):** Although surface vegetation is usually a function of climate, it is also controlled by soil type, and exerts an influence on soil type and chemistry. People can have a significant influence on soils, modifying vegetation and land-use, in addition to draining soils (agricultural improvements) and in some areas irrigating.
- **Relief:** Altitude can affect climate/microclimate, aspect can influence solar warming and slope angle can control drainage, run-off and soil erosion.
- **Parent material:** This influences soils in a variety of ways, for example sandy parent material tends to produce soils which are coarse in texture and well drained, whereas clay soils (derived from softer, easily weathered, parent material) are commonly waterlogged and cold. Granite tends to weather slowly producing a shallow profile, but many sandstones often break down to produce red-coloured soils, such as those in parts of Devon. Granite also produces soils which tend to be low in nutrients, but clay weathers to release relatively fertile clay-humus complexes.
- **Time:** Soils form over very long periods of time (hundreds and even thousands of years) – some soils are not fully developed under certain conditions. These are termed immature.



***Exam Hint:** Remember the mnemonic CL, O, R, P, T… so you can help to develop structured accounts of soil formation.*

***Exam Hint:** Soils are a topic for which you need to have a good grasp of terminology. The glossary below represents the basic essentials.*

Fig. 3 Glossary of soils.

Azonal soils: Immature soil with poorly developed horizons and other pedogenic characteristics. Azonal soils may be found on steep slopes, in mountainous environments, on flood plains and on newly exposed land surfaces such as salt marshes.
Chelation: Organic compounds washed down through the soil detach and remove plant nutrient and mineral ions such as iron and aluminium from the upper layers of the soil. This is most effective in wet and warm climates.
Eluviation: The process of washing down material such as organic matter and minerals through the soil. Eluviation is partly responsible for the development of the sandy, bleached Ea horizon in podsol soils. It also contributes to the extremely acidic environment of these soils.
Gleying: In the anaerobic conditions of a waterlogged soil the process of reduction produces a gley soil.
Humification: The breakdown/decomposition of organic matter by bacteria and fungi and its incorporation into the upper A horizon.
Illuviation: Deposition or washing-in of minerals, nutrients and humus from a surface to a sub-surface soil horizon. Illuviation involves the down-washing of both solid particles and those in solution (leaching). The B horizon in podsolized soils is an illuviated horizon.
Intrazonal: Soils affected by some local conditions not involving climate or vegetation, such as poor drainage, e.g. gleyed soils or those where parent material exerts a strong influence such as calcimorphic soils (soils which exhibit distinct features as a result of the parent rock being limestone).
Leaching: A downward transfer of soluble materials through the soil and beyond to the water table. The dissolving and washing down of calcium and other bases through the soil is a result of percolating rain water. Bases are substances which react with an acid to form a salt and water. Some bases dissolve in water and are then called alkalies, e.g. the hydroxides of sodium, calcium and potassium.
Lessivage: The mechanical movement of suspended clay downwards in the soil in a humid free-draining environment.
Moder: An intermediate form of humus where decomposition has been quite rapid at around five years and with some degree of layering.
Mor Humus: Humus formed by slow decomposition in an acid soil. The process is slow, taking over 10 years, and with little mixing distinct layers can form, i.e. L, F and H.
Mottling: The process whereby the usually reduced conditions of an anaerobic (usually gleyed soil) are changed by the introduction of oxygen. This results in streaks of orange colour.
Mull Humus: Humus formed by rapid humification in a free-draining aerated soil. The process is rapid, 2-3 years, and the humus is well mixed.
Regolith: The layer of weathered rock fragments which covers most of the earth's land area. It varies in thickness from place to place and the surface layers are called soil.
Sesquioxides: Mainly iron (Fe) and aluminium (Al) oxides that are present in the soil. The relocation/translocation of these has important impacts on the nature and colour of the soil. It is the movement of these ions that is fundamental in the process of podsolisation.
Soil Catena: The relationship of soil types to the local topography. The changes depend mainly on changes in gradient, hydrological conditions and vegetation.
Soil Profile: A section through the soil showing the different layers or horizons. The horizons are usually given a letter, i.e. A, B, C etc. depending on the dominant process within each layer. Roadside cuttings and river cliffs provide good examples of places where horizons are evident.
Structure: This is important to the soil's fertility since the structure affects aeration and workability. There are five types: structureless, platy structures, prismatic structures, blocky structures and crumb structures. All these result from the nature of the organic matter and the properties of the soil.
Texture: This is determined by the percentages of sand, silt and clay which are present. Soils with a large proportion of clay are plastic, sticky and cohesive. Sandy oils are the opposite and feel gritty when rubbed between the fingers.
Zonal soils: Soils occurring over wide areas on well-drained land which have been there long enough for the climate and organisms to have expressed their full influence. The zonal soil classification recognises broad belts of soil at the global scale which correspond with climate and vegetation. The balance between precipitation and evapotranspiration is the critical factor in zonal soil development (depth, horizonation, acidity etc.). The primary UK zonal soils are podsols and brown earths.

Major Zonal Soils of Britain

Podsol

A large soil group of the zonal order consisting of soils formed in cool-temperate to temperate, humid climates, under coniferous or mixed coniferous forest. In Britain podsols are found in the cooler, wetter upland areas of the north; they are also found intrazonally, for example near Bagshot on tertiary sands.

Podsols are recognised by a light coloured 'ashen' layer a short distance below the surface. Acidic conditions are produced because of plentiful precipitation and chemical bases are then leached (or translocated) further down the soil. The boundaries between the horizons are normally distinct and well defined; the acidic conditions tend to limit the mixing activity of earthworms and other soil organisms. The light-coloured Ea horizon results from the loss of soluble bases such as calcium, magnesium and iron along with organic matter – through the process of **eluviation**. These chemicals are then re-deposited at a deeper layer within the soil (controlled by a change in pH as the soil environment becomes less acidic) – this is a zone of **illuviation**. In the process of podsolisation humic acids, acting as chelating agents, attack the clays to release iron and aluminium which are then carried down the profile and then redeposited.

Podsols also occur where coniferous or heathland vegetation produces an acid (**mor humus**) which decomposes to release humic acids and few bases. Alternatively they may be found where the soil is free draining, as on steep slopes, and where the acidic underlying rock, such as granite or sandstone, weathers to produce an infertile soil with few bases.

Note: where the rainfall is less effective, the parent material non-acid or the vegetation less acidic (mixed wood) an acid brown soil occurs.

Fig. 5 Three types of horizon in a podsol.

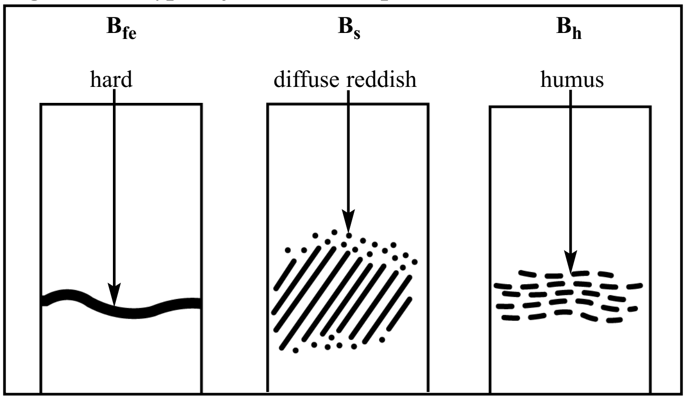
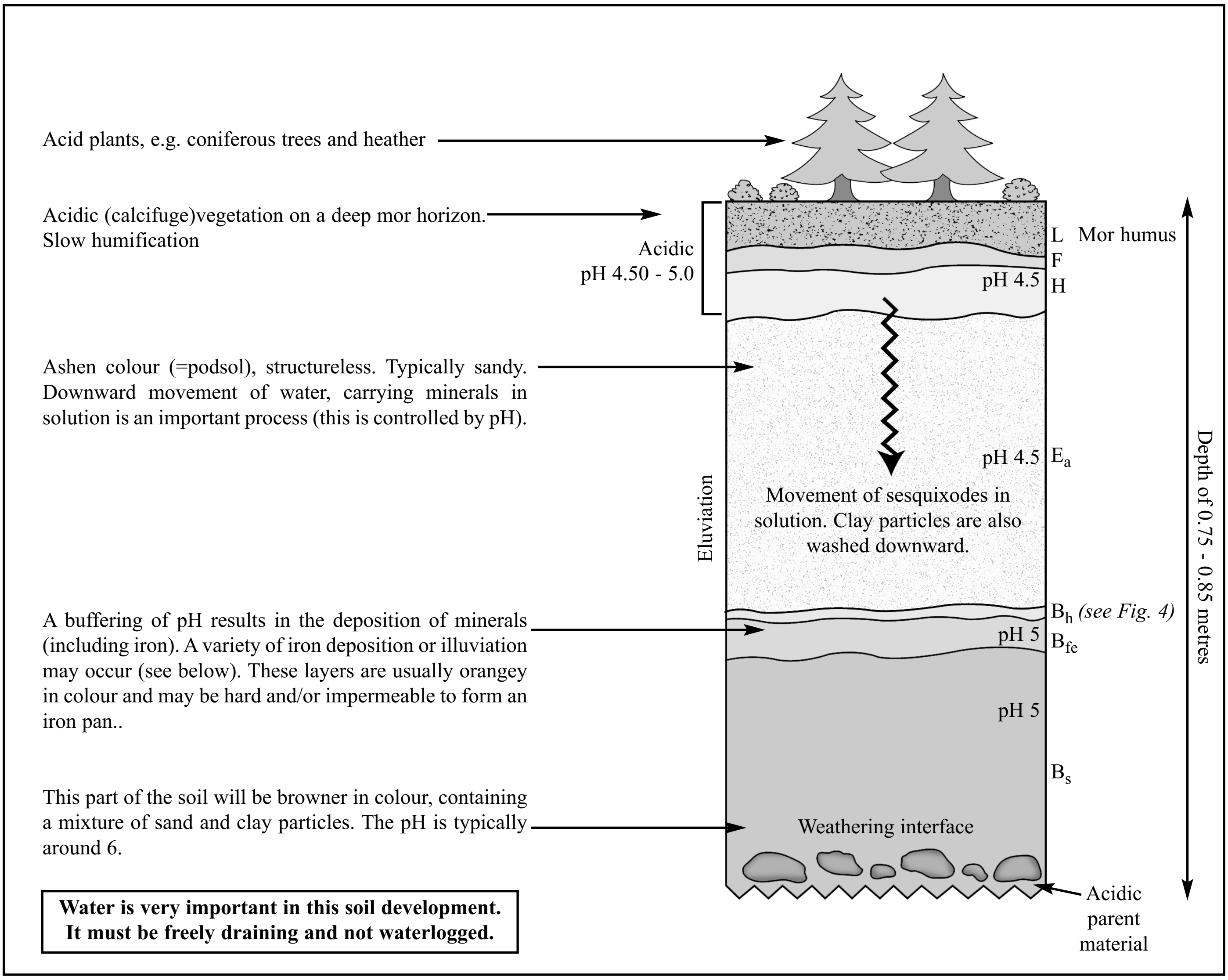


Fig. 4 Podsol development.



Brown Earths

Most brown earth soils are fertile and are now largely cleared of forest and used for cultivating crops. They are found on a number of rock types, particularly those rich in clay. Brown-earths are so called because they contain ferric oxide and are in general brown in colour with little differentiation between the horizons. Under wooded conditions, leaf litter from the forest vegetation forms a dark brown **mull** humus, which contrasts with the yellow-to-reddish brown iron-rich B horizon. Clay is sometimes removed from the upper layers to some extent, and is deposited in the B horizon, giving the lower layers a somewhat heavier texture.

The two upper horizons are often not clearly differentiated and may merge one into the other. Also, as a result of leaching, calcium ions are partially removed from the A horizon and this is consequently mildly acid with a pH below 6.5. Acid brown earths occur in cooler and wetter climates (mean annual rainfall above 1000mm is roughly the transition point). Because of the higher rates of precipitation, they are more leached and have a higher degree of acidity, with light brown eluviated horizons. The nutrient levels and near neutral conditions provide an ideal environment for organisms that incorporate humus into the soil.

Fig. 6 Brown earth development.

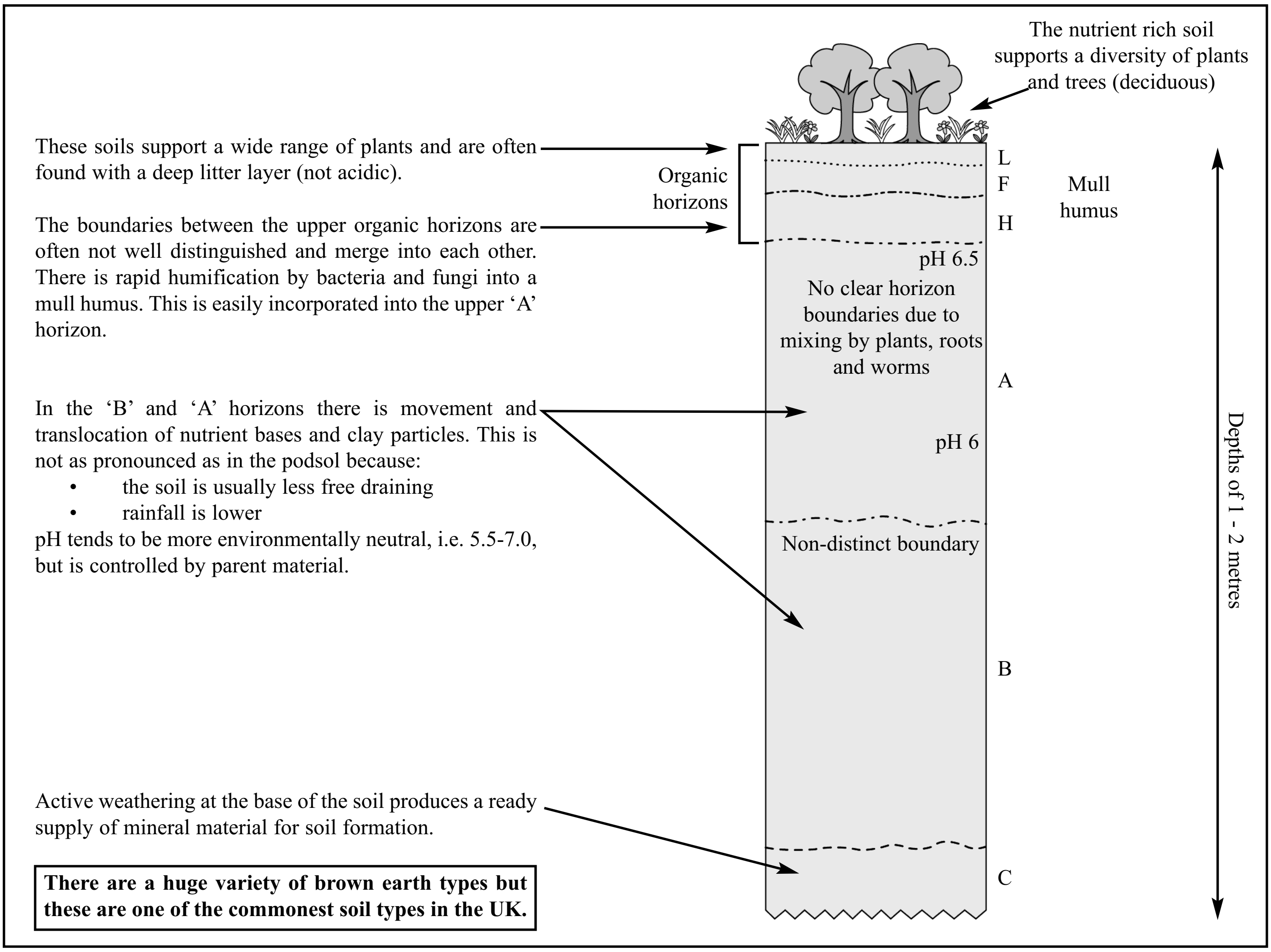


Fig. 7 provides a summary of the nomenclature used to describe soil horizons within a soil profile.

Fig. 7 Soil Nomenclature – horizon letters

L	=	Leaf litter – gradually decomposing surface layer
F	=	Fermentation – a decomposition layer below the 'L' horizon
H	=	Humus layer – where plant remain are no longer recognisable
O	=	Organic horizon – if the 'H' layer is very thick (>15cm), it becomes an 'organic' layer, with a new classification 'O'
A	=	Mixing horizon – when the organic matter becomes mixed with the mineral matter below
B	=	Weathered layer – this horizon is usually altered by weathering, e.g. oxidation. Note there are a number of categories of 'B' horizon
E_a	=	Eluviated horizon – pale, bleached mineral horizon. The colour has literally been washed out of this layer.
B_g	=	Gleyed horizon – usually dark blue / black in colour, may have orange 'mottles'. Conditions are waterlogged and anaerobic.
B_f	=	Iron pan – associated with podsolisation, this is a podsolic B horizon.
B_s	=	Sesquioxides - a diffuse reddish layer, again a podsolic B horizon
B_h	=	Organic layer - dark / blackish organic matter horizon. This is also a podsolic B horizon
C	=	Weathered rock horizon
D	=	True parent material

Common Intrazonal and Azonal Soils of Britain

There are many different intrazonal and zonal soil types found within the British Isles. The details below only cover the main groups; note the box on organic soils.

INTRAZONAL SOILS

Gley soil

These intrazonal soils are developed under conditions of poor drainage, such as valley bottoms, where there are changes in the water level from season to season. Owing to the lack of oxygen in the water-logged layers of the soil, ferric iron salts are reduced to ferrous salts, thus giving a grey or bluish grey colour throughout the gleyed zone. In soils in which the levels of water-logging change periodically, both the reduction and oxidation of iron salts can occur. This may give rise to the characteristic mottled patches which are rust-brown in colour as a result of a rising ground water table. In other cases, waterlogging occurs from the surface because of an impermeable horizon.

Rendzinas

These are very shallow soils developed over calcareous rocks such as limestones and chalk. It has a well decomposed humus layer, but the upper A horizon is leached by rainwater and soluble bicarbonates, forming a thin but mineral-rich alkaline layer usually at 10-20cm depth. Below this is commonly the C horizon, which is the weathering interface, containing large fragments of rock, usually chalk. On some limestones, deeper brown calcareous soils develop.

AZONAL SOILS

Raw soils

These are young soils and true azonal types, often found in mountainous areas, or in places where the upper layers are suffering erosion are being moved rapidly downslope by mass movement. Their characteristics are little unchanged from the original parent material.There are ***three*** *main types:*

- *raw alluvial soil (found in close proximity to estuaries/river basins)*
- *raw sand (sand dune soils)*
- *raw skeletal soil (on screes and other fractured rock).*

Ranker

This soil is similar to the rendzina as it only has an A and C horizon, but it occurs on non-calcareous rocks. The upper horizon is dark brown to blackish. Often these soils are immature or azonal and very shallow.

Saline soils

Saline soils occur in close proximity to the sea, where there is periodic flooding at high tides or wind-blown sea water carries salt inland. These are high salt content soils - they may also exhibit the characteristics of the raw, azonal soil.

ORGANIC SOILS

There are a number of categories of this soil type, which can be either intrazonal or partially azonal. All organic soils are characterised by a thick organic horizon.

Peat / Peaty soil

These are true organic soils as they are developed primarily from organic matter and contain none of the soil particles of the substrate / parent rock over which they are developed. Peat is the partially decomposed remains of vegetation where waterlogged conditions slow the rate of decomposition. As a result peat accumulates year by year, sometimes up to depths of several metres. Depending on the source of water, these soils can be acid, neutral (hill peat) or alkaline (fen peat).

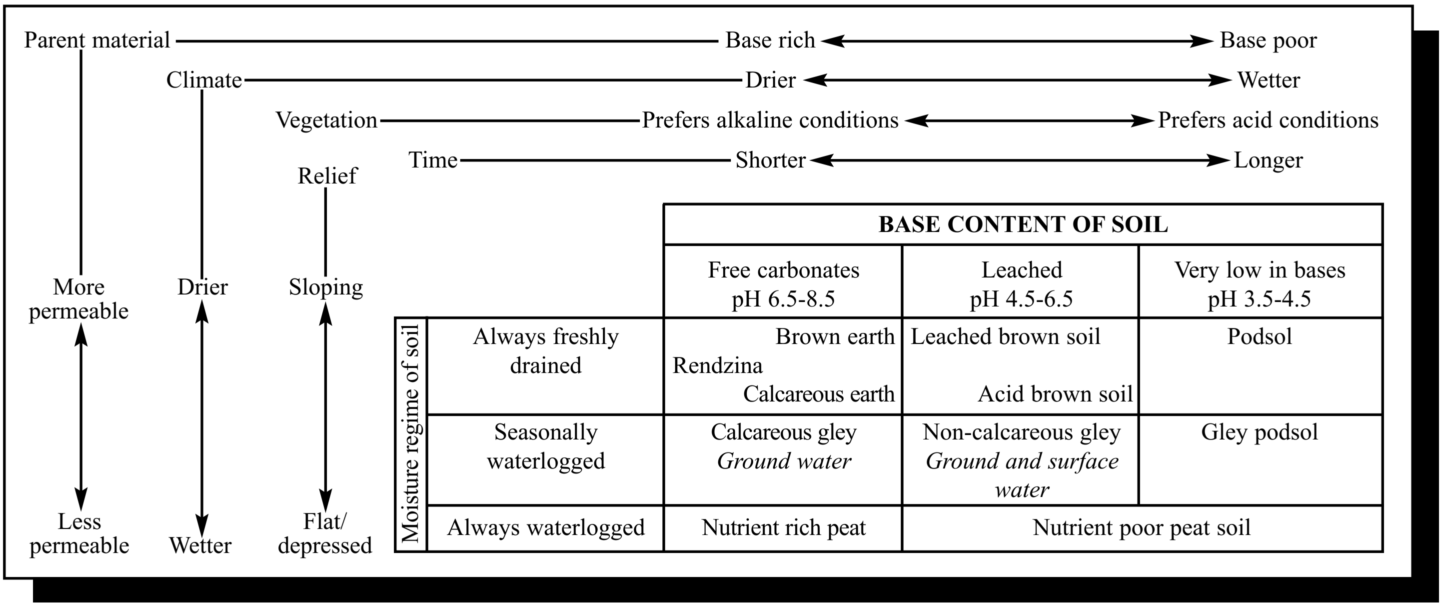
Conclusions

Soils are the complex products of the interaction of the earth, ground and water; they can also change significantly in very small spatial areas, for example a catena down the side of a hill.

Many British soils have been significantly altered by people, in particular by agriculture and changes in land-use caused by the removal of the original deciduous tree cover. This is especially true in lowland Britain.

Fig. 8 summarises a range of factors which influence the formation of British soils. It is a very useful summary diagram to learn.

Fig. 8 Inter-related factors influencing soils in Britain.



Moisture regime of soil	BASE CONTENT OF SOIL		
	Free carbonates pH 6.5-8.5	Leached pH 4.5-6.5	Very low in bases pH 3.5-4.5
Always freshly drained	Brown earth Rendzina Calcareous earth	Leached brown soil Acid brown soil	Podsol
Seasonally waterlogged	Calcareous gley *Ground water*	Non-calcareous gley *Ground and surface water*	Gley podsol
Always waterlogged	Nutrient rich peat	Nutrient poor peat soil	

Practice Exam questions

1 a. Explain the principle processes involved in the development of a brown earth and a podsol. Use illustrated diagrams to help explain your answer.
(10 marks)

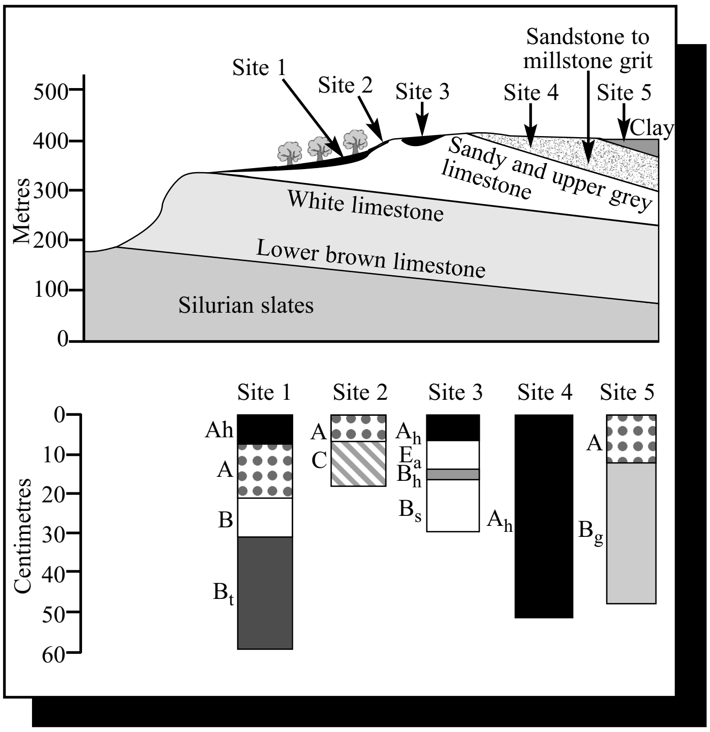
b. Describe the main human activities that might influence and modify soils within a named area.
(10 marks)

2 Study *Fig. 9*.

a. Identify the soils found at the five sites.
(5 marks)

b. Choose two of the soils and examine the factors which helped to form them.
(15 marks)

Fig. 9 Cross-section of Eglwyseg Mountain.



Advice on answering the questions

1 a. Use the diagrams *Figs 4 & 6* as a basis for your answer. Include the key features such as a scale and the horizon nomenclature. Marks will be awarded for a detailed, but brief description of the processes involved in these two contrasting soil types. Ensure that the correct terminology is used throughout *(see Fig. 3 for glossary)*.

b. Agriculture is very important (very little natural soil areas left): ploughing, drainage, artificial fertilisers / dressings, construction for housing / infrastructure and other types of land-use. Try to include a range of examples in your answer (this will probably be necessary to obtain the top 'level' marks.

2 a. 1: Brown earth
2: Rendzina
3: Humus iron podsol
4: Organic soil
5: Gley soil

b. Select brown earth or podsol and look at factors such as parent material, relief and drainage, height and even vegetation *(see Fig. 2)*

Further reading

Holmes, D (2001) *Investigating soils*, in *Geography Review, Vol 14, no. 4*
Payne, J (1995) *Soil Development: Using Annotated Profiles*, in *Teaching Geography, Vol X* July 1995
Trudgill, S (1989) *Soil Types: A field Identification Guide*, in *Field Studies 7, pages 337-363*. This can be obtained as an off-print from www.field-studies-council.org

Suggested websites

http://www.soils.org/sssagloss/index.html - good soils glossary
http://www.bsss.bangor.ac.uk/Teach.htm - links from the UK Soil Science Association to teaching resources on soils
http://www.eosc.osshe.edu/peers/lessons/soils.html - student notes on soil topics such as texture, pH, structure etc.

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