Chapter 2
Soil Types

At the end of this chapter you should be able to:

- **Describe in detail the brown earth soils of Ireland.**
- **Describe in detail either the latosols of Brazil or the aridisols of desert climates.**

Contents

KEY THEME

Soils are affected by their immediate environment and by a combination of processes operating in that environment.

2.1 Irish brown earth soils

Soil type: Zonal

Ireland has a **cool temperate oceanic climate** and its natural vegetation is **mixed deciduous forest.** The zonal soil that develops in this climate is **brown earth soil.** Fig. 1 shows that brown earth soils dominate the soils of this country.

However, local conditions have modified the brown earth soil making **intra-zonal** soils that can be found in certain areas of Ireland. For example, waterlogging has created gley soils in County Monaghan and cool wet conditions after the last ice age prevented humification (rotting of plants into humus), thus allowing peat soils to build up in County Westmeath and County Offaly.

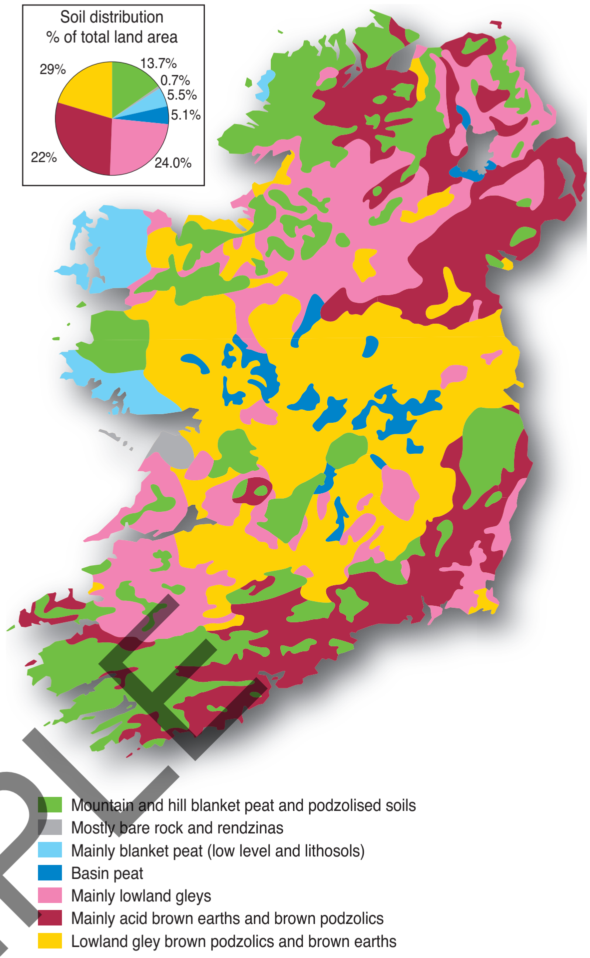

Fig. 1 The variety of Irish soils

Fig. 2 Irish deciduous woodland

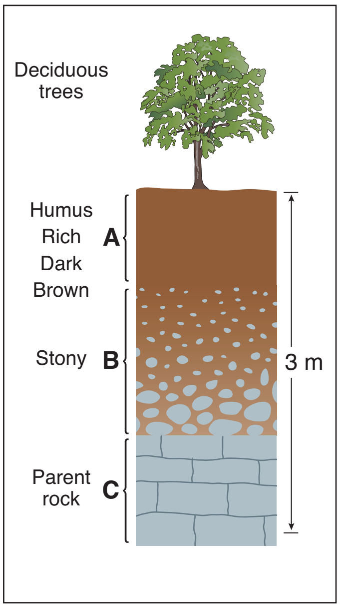

Fig. 3 Soil profile of Irish brown earth soils

Soil profile

This soil has no distinct horizons – it is uniformly brown in colour. This is due to the climate which encourages the presence and activity of living things such as worms and beetles within the soil. These mix the soil up and remove any horizons that may form due to leaching and humification.

Factors influencing brown earth soils in Ireland

1. Climate

The brown earth soil has developed in response to Ireland's cool maritime climate. This is a moderate climate. Temperatures range from 15˚C in July to 6˚C in January. Soil temperatures are rarely cold enough to stop biological activity completely. Rain falls throughout the year and amounts to an average of 1,500 mm per year. The climate encourages a long growing season and almost year-round bacteria, earthworm and fungi activity. Brown earth soils occur where the soil temperatures are above 0˚C for 9 months of the year.

2. Relief

Relief influences the depth and drainage of this soil. Brown earth soils formed on slopes tend to be thinner and well drained. Mass movement creates deep soils at the base of slopes. Relief also affects temperatures. High ground is colder than lowlands because temperatures decrease by 1°C for every 100 m climb in altitude. In soils formed on colder higher ground there is less animal activity and less humus is formed than in soils formed on warmer lowlands. South-facing slopes have warmer soils than north-facing slopes so agriculture is often possible on soils found on slopes with a southerly aspect.

3. Living organisms/vegetation

The natural vegetation found over brown earth soils is temperate **deciduous forest**. These trees include oak, ash, chestnut and birch. They lose their leaves each winter adding valuable humus to the soil. Due to the mild climate micro-organisms such as fungi and bacteria are active for at least nine months of the year adding to the fertility of the brown earth soil. Animals such as badgers, rabbits and hedgehogs burrow into the soil churning it up, removing horizons and making the soil uniformly brown in colour.

4. Parent material

The parent material is varied. In many areas, its parent material is boulder clay deposited during the last ice age.

In Ireland, local changes to parent material have created three variations (intra-zonal) in brown earth soil:

(a) Acidic brown earths **(b) Shallow brown earth (rendzina)** **(c) Podzols**

(a) Acidic brown earth soils occur on land 500 m above sea level on crystalline rock such as granite, schist or sandstone, e.g. County Waterford.

(b) Shallow brown earth soils (also called rendzina soil) occur in limestone areas such as the Burren in County Clare and in County Sligo.

(c) Podzolised brown earth soils are slightly leached and occur on glacial drift of the Irish lowlands. This type of soil covers 22% of the country, e.g. County Dublin.

5. Time

These brown earth soils have developed since the last ice age over 10,000 years ago. They are mature well developed soils but have local variations depending on slope, aspect and drainage.

Characteristics of brown earth soil in Ireland

Colour

As its name suggests, brown earth soils are uniformly brown in colour. This is due to both the presence of humus, which makes it appear dark, and the action of leaching, which washes some nutrients out of the soil so that it is not too dark brown in colour.

pH

The pH of brown earth soil in Ireland varies from slightly alkaline to slightly acidic due to the temperate climate and variations in parent material (see page 27). Living things thrive in this kind of pH.

Bacteria, fungi, earthworms and spiders help to raise the fertility of the soil by drawing humus into the soil and decomposing it, releasing nutrients. The cool temperate climate is warm enough to allow biological activity to occur for more than nine months of the year.

Fig. 4 Autumn leaves add humus to brown earth soils.

Humus content

Brown earth soils are rich in humus because the natural vegetation that grows in the cool temperate climate is deciduous forest. These trees lose their leaves each autumn and the leaves add nutrients back into the soil as they are decomposed by fungi and bacteria.

Structure

The brown earth soil has a good crumb structure that provides pore spaces for air and water, encouraging plant growth. As a result of its crumb structure, Irish brown earth soils are highly productive and are used for tillage and pasture.

Texture

Brown earth soils generally have a loam texture due to the presence of a variety of parent materials such as sandstone, shale and alluvium from river flood plains (e.g. River Shannon).

Water content

This depends on local conditions of relief and drainage. Because of its generally loam texture and crumb structure, brown earth soils are not too wet or dry. They have a water content that encourages plant growth. The cool temperate oceanic climate provides 500 – 2,800 mm per year depending on relief.

Processes affecting formation of brown earth soil in Ireland

Humification

This soil is very fertile due to **humification**. The cool temperate oceanic climate encourages humification throughout the year. The rate of humification will decrease in winter and speed up in summer. The presence of large amounts of humus (autumn leaves and dead animals) adds to the soil's fertility.

Fig. 5 Brown earth soil in an Irish strawberry field

Leaching

The year-round rainfall causes moderate amounts of leaching in brown earth soils. This adds to the fertility of the soil by gently washing nutrients down to the soil. Waterlogging can occur in poorly-drained areas causing brown earth soils to become gleys.

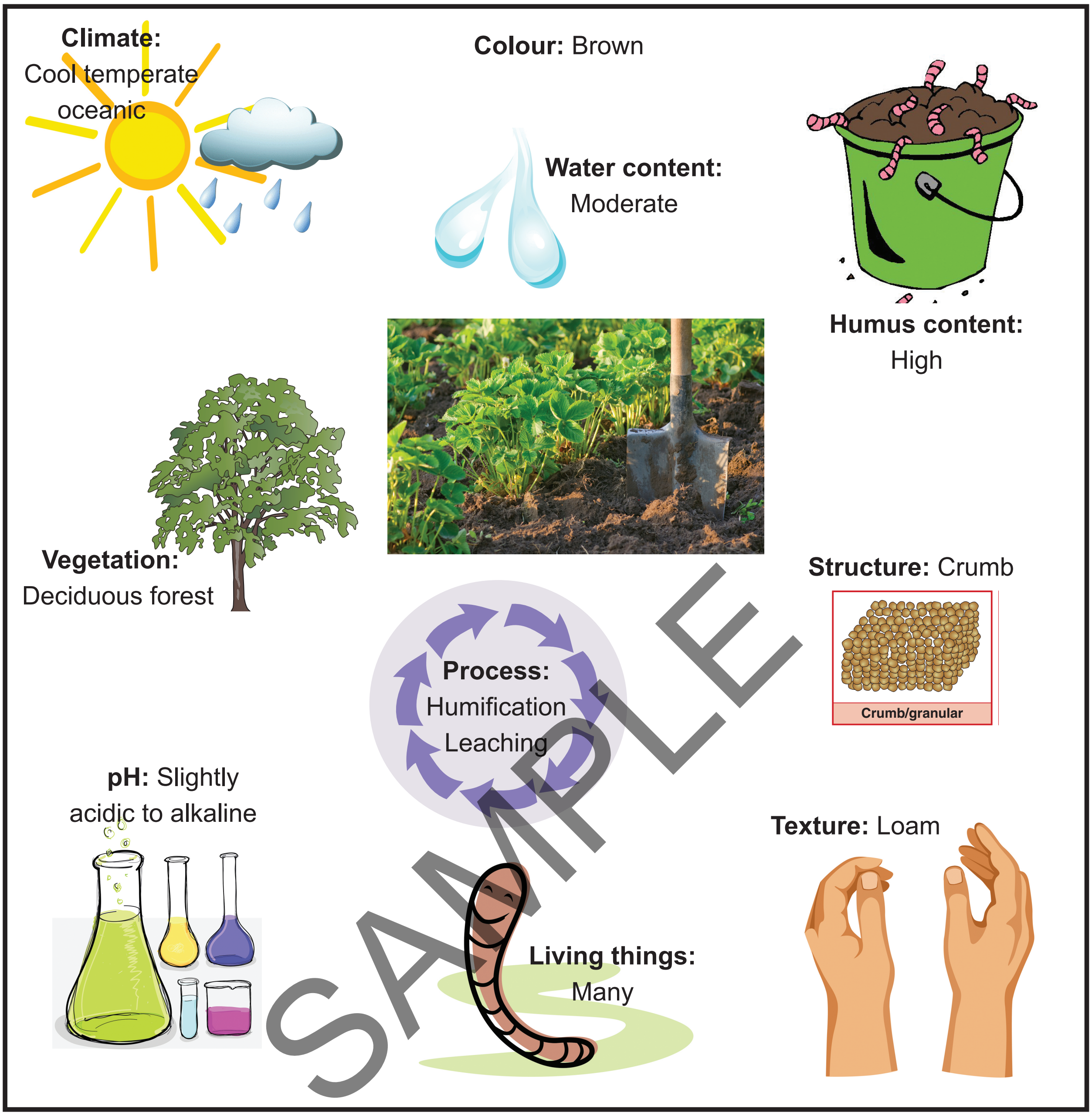

Fig. 6 Summary of brown earth soils

NOTE: You need to study either Section 2.2 or Section 2.3. If you intend to study the tropical rainforest biome in Chapter 4, you should study Section 2.2 (tropical latosols). If you intend to study the desert biome in Chapter 4, you should study Section 2.3 (aridisols).

2.2 Tropical latosols

Latosol – A tropical rainforest soil

Soil type: Zonal

Latosol soil is a zonal soil. It has developed in response to tropical and equatorial climates. These climates are hot (average 27°C), humid (88% humidity) and wet (up to 6,000 mm per annum) throughout the year.

Latosols are **red, heavily leached infertile zonal soils** that are found in the **tropical regions** of the world. They occupy 7.5% of the land area and cover large areas of South America, Africa and South East Asia. They are a major obstacle to the development of profitable agriculture in these regions. They are a fragile soil which can be easily damaged creating a useless laterite.

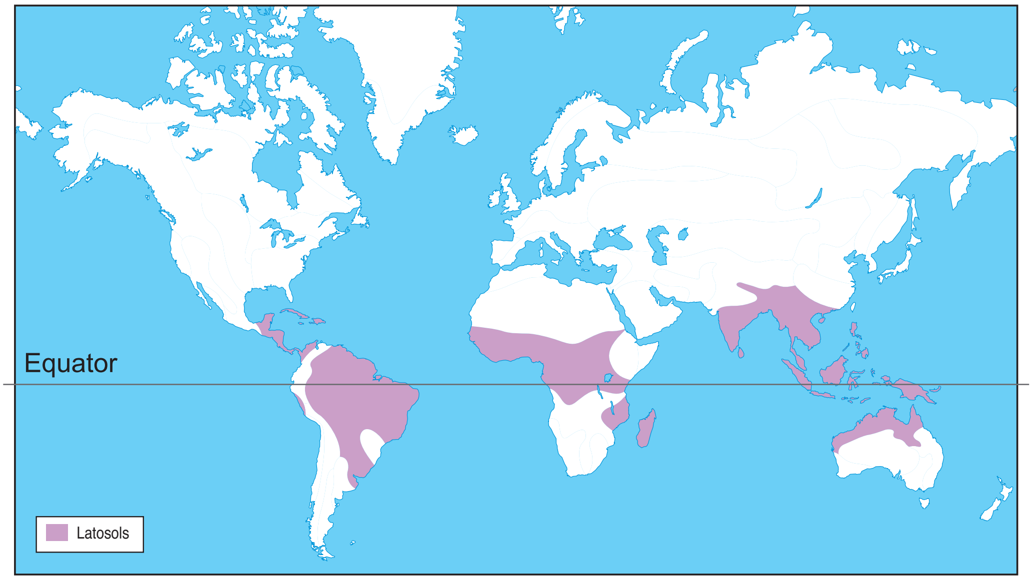

Fig. 7 Location of latosols in the world

Fig. 8 Forest clearance exposing latosols

Latosols support the richest vegetation on the planet – the **tropical rainforests**. Rainforests contain tall trees such as mahogany and teak. However, the latosol is not a fertile soil so how can such an infertile soil support such rich vegetation? The relationship between soil, climate and vegetation is possible due to the high rainfall and temperatures found in tropical regions. These conditions cause a short nutrient cycle. Plants grow rapidly, otherwise they will not get the nutrients before they are **leached** by the high rainfall.

If vegetation is removed, the soils quickly become infertile and vulnerable to erosion.

If the rainforest is cleared for agriculture, it will not make very good farmland as the soil will not be rich in nutrients and the soil becomes completely infertile within two or three years.

Soil profile

The latosol has a thin O horizon (humus layer) due to intense bacterial activity which rapidly decomposes dead organic matter.

The A Horizon contains aluminium and iron oxides. Sometimes iron and aluminium compounds build up in a hard layer lower down the profile.

The B horizon is very deep and uniform in texture due to intense leaching in high temperatures. Laterisation can reach many metres into the ground. These soils can be 40 m deep.

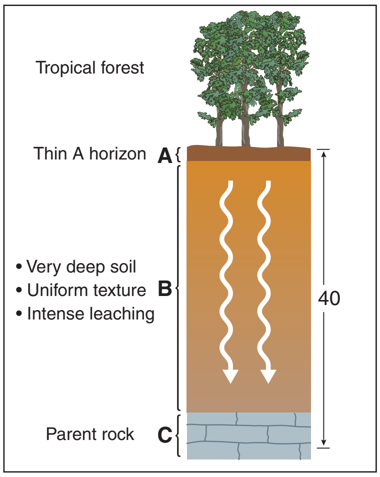

Fig. 9 Soil profile of a latosol

Factors affecting latosols

1. Climate

Because of their location in the tropics and equatorial regions of the earth, latosols form in very hot, wet conditions.

High rainfall, high humidity and high temperatures cause deep chemical weathering and rapid leaching of minerals down through this soil. Average rainfall is up to 3,000 mm (in some regions of Indonesia up to 6,000 mm of rain falls each year). Humidity is constantly high (88%) and the average temperature is 27°C. Because of the high temperatures and the permeability of the soil, heat and moisture reach great depths and rot the parent material into a deep soil. As a result latosol soils are very deep, e.g. 40 m in parts of Brazil.

2. Relief

These soils form under the rainforest on flat land and on slopes which allow tree growth. They are thicker on flat land and they are thinner and better drained where land is sloping.

3. Parent material

A variety of parent materials are found under latosols in Brazil. They range from metamorphic rocks to sedimentary limestone and river alluvium. These different parent materials cause the latosol to vary in colour from red to yellow and also influence its texture.

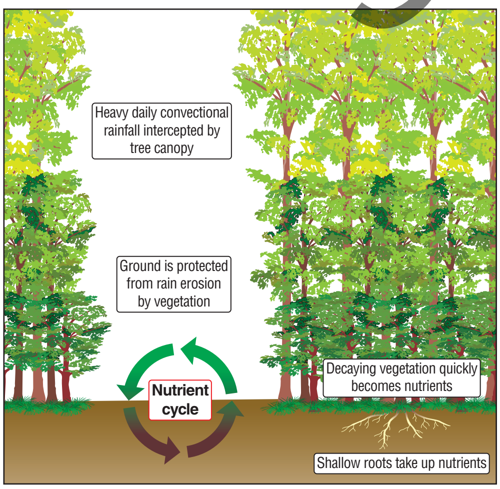

Fig. 10 Nutrient cycle in rainforest

4. Living organisms

The hot, damp conditions on the forest floor are perfect for fungi and bacteria to thrive and cause the rapid decomposition of dead plant material. This rapid humification provides plentiful nutrients that are easily absorbed by plant roots. However, as these nutrients are in high demand from the rainforest's many fast-growing plants, they do not remain in the soil for long and stay close to the surface of the soil. This cycling of nutrients is called the **nutrient cycle** and in latosols it is very short – a few days in some cases.

5. Time

Deep latosols result from the rapid weathering of parent material and the fast breakdown of organic material by fungi, bacteria and other living things which thrive in the hot, wet conditions of this region. Tropical regions were not affected by the last ice age and so have had many thousands of years to develop.

Characteristics of latosols

Colour

Latosols are red or yellow in colour. Leaching is so intense that only aluminium and iron compounds are left. These compounds give the soil its characteristic red or yellow colour.

Fig. 11 Laterite soil – note its hard surface.

pH

Due to the high rainfall the pH of latosols is moderately acidic. The rapid absorption of nutrients by vegetation growing in the soil helps prevent the latosol becoming more acidic. However once the forest is cleared, the latosol acidity rises.

Humus content

Latosols have a low humus content. This is due to the rapid breakdown of organic material by the many bacteria which thrive in the hot and wet conditions of this region and the equally rapid uptake of the humus by plants. Any humus formed is quickly absorbed by plants and does not make it below the O horizon of the soil.

Structure

Latosols lack a clearly defined structure. The structure of the latosol is often poorly developed due to the intense chemical weathering of mineral grains which prevents well shaped peds forming. Where the parent rock is granite, chemical weathering by hydrolysis causes clay minerals to form which give the latosols a platy structure.

Texture

Latosols may be any texture from loamy to clay to sandy. This is due to the variety of parent material and the fact that these soils lack silica. Latosols often show a combination of textures. Latosols formed on metamorphic or igneous rock tend to have a more sandy texture.

Water content

Latosols are wet due to high rainfall in the tropical region and are very permeable. However should the forest cover be removed this soil dries out rapidly and becomes impermeable to water and useless for farming.

Processes affecting latosol formation

Laterisation

Laterisation is the dominant process in forming latosols. Laterisation is a combination of deep leaching and chemical weathering by **carbonation, oxidation** and **hydrolysis**. Leaching and chemical weathering in the high temperatures of the tropics combine to dissolve all minerals except iron and aluminium oxides. These minerals give the soil its distinctive red/orange colour.

Due to the constant high temperatures, these soil-forming processes have reached deep into the ground and formed soils up to 40 m deep. Sometimes iron and aluminium compounds build up in a hard layer lower down the profile. If soil erosion removes the loose topsoil, the iron- and aluminium-rich lower layers are exposed. The high temperatures soon bake this soil into a hard bricklike surface which is impossible to cultivate even when wet. This type of soil is known as a **laterite**.

Humification

The hot, damp conditions allow for rapid humification which provides plentiful nutrients easily absorbed by plant roots. These nutrients stay close to the surface of the soil because they are quickly absorbed by the rainforest's many fast-growing plants.

Fig. 12 Nutrients stay close to the surface of the soil in tropical rainforests.

Fig. 13 Summary diagram of latosols

	Brown earth	Latosol
Zonality	Zonal soil, (cool temperate oceanic climate). Forms under deciduous woodland in temperate latitudes. Soil temperatures above 0°C for 9 months of year.	Zonal soil (tropical climate) rich in iron, alumina and silica forms in tropical woodlands in a very hot, humid climate. If deforested turns into hard laterite.
Main process	Humification	Laterisation
Humus content/ fertility	High: micro-organism activity high due to temperate climate	Low: lacks humus. Leaching is so intense that plants absorb any nutrients rapidly so they do not get carried into the soil. Nutrients provided by rapid decomposition of organic matter in hot climate.
Colour	Brown	Orange/yellow/red
Horizons	No distinct horizons due to mixing of soil by living things such as worms	Thin A horizon, deep B Horizon (40 m); Hard pan sometimes present
Texture	Loam	Varies depending on local conditions. Often loamy sand texture.
Structure	Crumb	Varies according to main soil constituent – can be blocky or platy.
pH	Slightly acidic to slightly alkaline depending on parent rock.	Acidic

Fig. 14 Table to compare/contrast Irish brown earth soils and tropical latosol soils.

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2.3 Aridisols – A hot desert soil

Soil type: Zonal

Aridisols have developed in response to the desert climate. This is a dry, (less than 250 mm of rain per year) hot climate. Hot deserts usually have a large **diurnal** temperature range, with high daytime temperatures (45 °C) and low night-time temperatures (0°C). Humidity is low.

Hot deserts occur between 15° and 40° north and south of the equator at coasts and interiors of continents. There is a huge variety of desert soils. In this section we are going to focus on one type of desert soil – the **aridisol**. These soils occur in hot desert areas of the world. See Fig. 16 in Chapter 4, page 62. Hot deserts are found in North Africa, California, Australia and South America and in the Middle East.

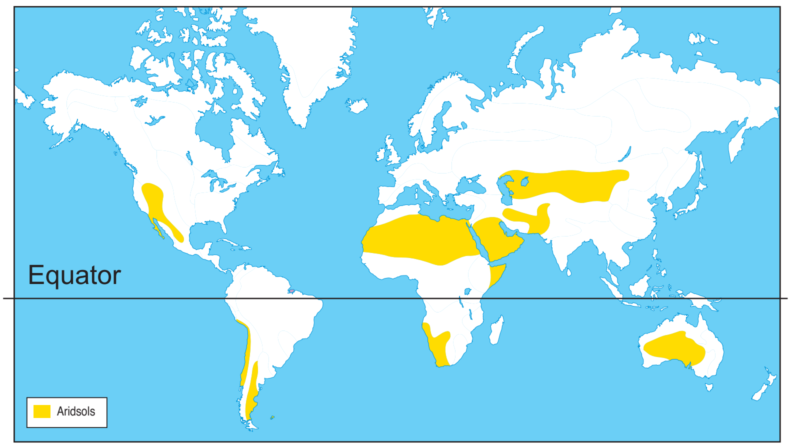


Fig. 15 Location of aridisols in the world

Aridisols are soils rich in calcium carbonate. Because of the dry climate in which they are found, they are not used for agricultural production unless irrigation water is available. Aridisols occupy 12% of the earth's land area.

Fig. 16 Aridisols occur in the desert biome.

Soil Profile

Aridisols show some horizon development. They may develop surface pebble layers called **desert pavement**.

They contain horizons in which clays, calcium carbonate, silica, salts and/or gypsum have accumulated. The A horizon is light in colour as there is little vegetation to add organic matter to the soil profile.

Aridisols may contain whitish layers called **calcic horizons**. These are accumulations of calcium carbonate, the same material found in chalk, concrete and agricultural lime. They form due to the process of calcification. Calcic horizons may vary from 15 cm to 1 m in thickness and form an impermeable, cement-like layer or **hard pan** in the soil known as **caliche**.

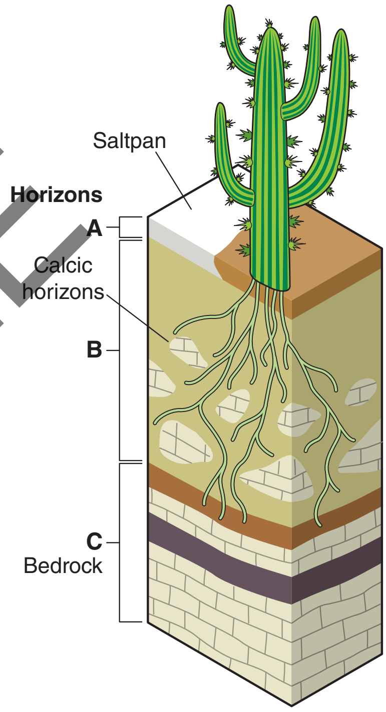


Fig. 17 Aridisol soil profile

Factors affecting aridisols

1. Climate

Aridisols form in arid and semi-arid regions in the world. These areas have little or no rainfall. Annual rainfall is less than 250 mm in arid places and up to 250-500 mm in more semi-arid regions. Generally desert precipitation occurs in short violent showers of rain and is totally unpredictable.

The sun is high overhead and skies are cloudless producing temperatures that range from between 20°C and 45°C down to below freezing at night. The bare rock and sand absorbs this intense heat. At night, the heat built up over the day is quickly lost into the atmosphere due to the absence of clouds. Temperatures drop very quickly.

This climate causes intense mechanical weathering especially **exfoliation** creating angular scree particles for soil formation. The lack of rainfall prevents chemical weathering from occurring. Strong winds and sand storm can often remove very fine sand particles leaving coarser and heavier soil particles behind.

Fig. 18 The desert climate is the most important factor affecting aridisol formation.

2. Relief

Relief has a major influence on aridisols. Valleys provide pathways for flash floods (the valleys are known as **waddis** in Arabia and Africa) which remove soils in the valley floors. Water flowing off mountainsides deposits mud, sand and gravel at the base of the slopes in huge fan-shaped deposits called **alluvial fans**. These alluvial fan sediments are an important parent material for aridisol soil and influence the texture and mineral content in soils nearby by providing sand, silt and clay particles.

Fig. 19 Relief influences the depth and texture of desert soils.

3. Living things/vegetation

Vegetation is scarce or almost completely absent, unless it has specifically adapted to this harsh environment. The plants that do thrive are mainly ground-hugging shrubs and short woody trees such as Yucca, Agaves, Cactus and Mesquite shrubs which have adapted to the dry conditions by storing water.

There is rapid growth in vegetation after the unpredictable torrential downpours of rain. Plants and animals are closely linked with many animals and insects using the plants as shelter and food sources. But this scarce vegetation cover is very limited and restricts the soil-building properties of micro-organisms that could convert the organic matter into humus. Consequently aridisols are mineral rich but lack humus.

4. Parent material

In desert soils parent material is quite varied. In some areas of the south-west USA, parent material is gravelly alluvium derived from old granite rocks. This parent material has influenced the colour of the soil here where it is dark red with white caliche deposits.

5. Time

Desert soils that have developed on older parent material are redder in colour than soils developed on younger materials which are often pale grey.

Characteristics of aridisols

Colour

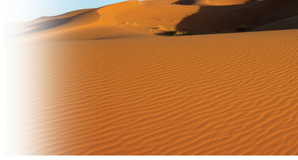
Some aridisols have the same pale, brownish colour from top to bottom, but others may be layered with browns, reds, pinks, and whites. The variation in colour is due to the action of living things, salinisation, weathering and parent material.

pH

Aridisols have high calcium carbonate and sodium concentrations making them alkaline.

Humus content

Aridisols contain little organic matter. This is caused by the low plant productivity, which in turn restricts the soil-building properties of micro-organisms that convert organic matter into humus.



Structure

Aridisols have a blocky structure and may also have a platy structure where the clay content of the soil is higher.

Texture

Aridisols have a coarse sandy or gravelly texture because there is less chemical weathering. The finer dust and sand particles are blown elsewhere, leaving heavier pieces behind. Coarse textured soils are found on lower mountain slopes and are fairly well drained. In lower-lying basin areas finer particles have been blown and accumulated creating a deep well-drained soil cover.

Water content

Aridisols are characterised by being dry most of the year and with limited leaching. The low water content is also related to the low humus content because soils with a low organic matter content have a low water-holding capacity – they cannot retain all the water that falls onto them.

Processes affecting aridisols

Calcification

Calcification is responsible for the formation of the chalk-rich hard pan or caliche within aridisol soils. Water is drawn up through the soil pores by capillary action driven by evaporation of water from the surface. Calcium carbonate is deposited in layers in the soil or near the surface. This hard pan makes the soil hard and difficult for plant roots to break through.

Salinisation

The intense evaporation of water from desert soils tends to bring dissolved salts to the surface. The high surface content of sodium and calcium ions can lead to extensive hard surface crusts of salt (**saltpans/salinas**) where little or nothing can grow because the salt is toxic to plants. Farmers need to break up this hard pan and dilute the salt with irrigation water to get the soil into production. In some countries the salt pans are put into commercial production for table salt.

Fig. 20 Salinised soil prevents vegetation growth in desert regions.