Chapter 7 Arid or Desert Landforms

Types of Deserts

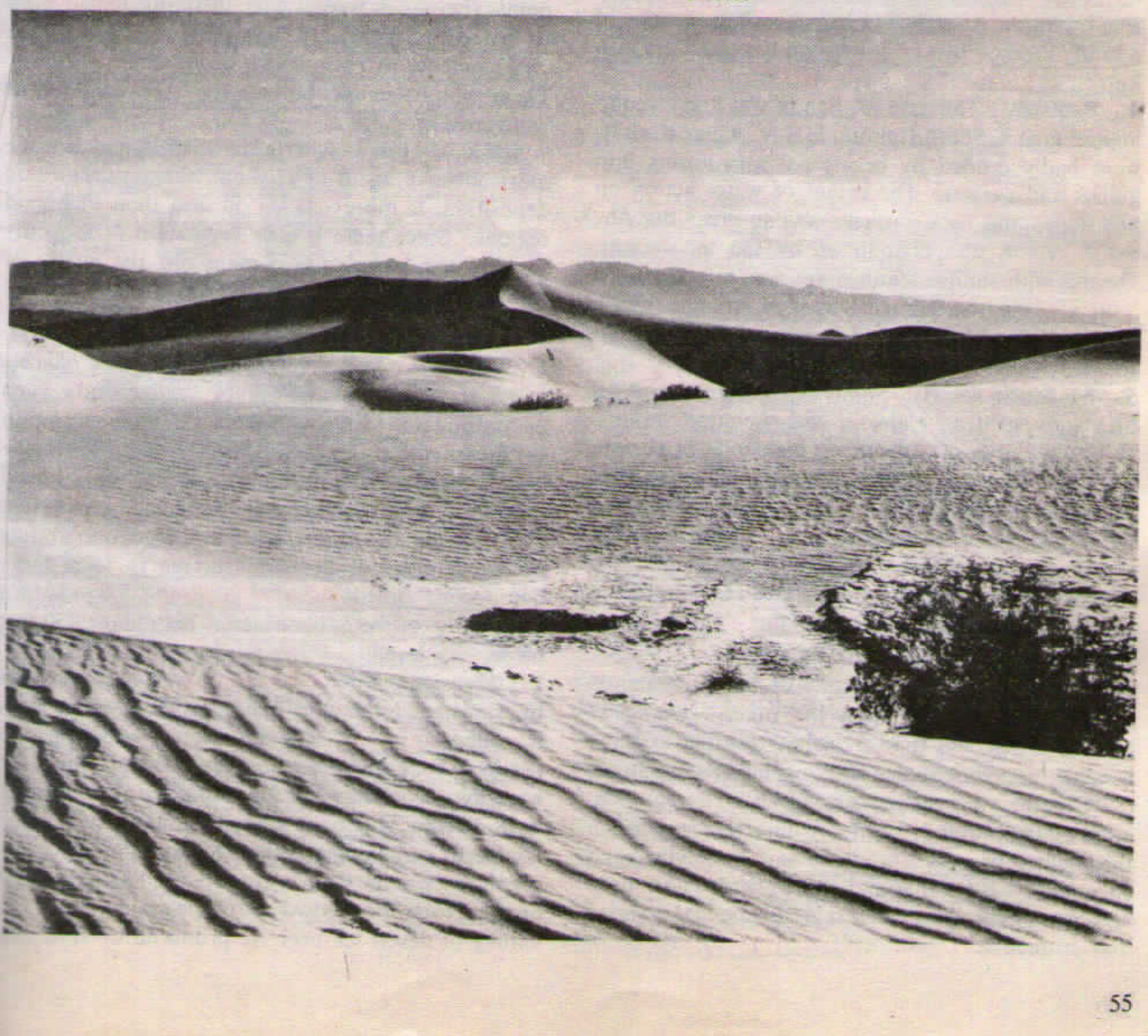
About a *fifth* of the world's land is made up of deserts, some rocky, others stony and the rest sandy. Deserts that are absolutely barren and where nothing grows at all are rare and they are better known as *'true deserts'*.

If you look at the world map carefully, you will find that there is a certain definite pattern to the location of the world's deserts. You will realise that almost all the deserts are confined within the 15° to 30° parallels of latitude north and south of the equator. They lie in the trade wind belt on the western parts of the continents where Trade Winds are off-shore. They are bathed by cold currents which produce a 'desiccating effect' so that moisture is not easily condensed into precipitation. *Dryness or* aridity is the key note. Such deserts are tropical hot deserts or 'Trade Wind deserts'. They include the great Sahara Desert; Arabian, Iranian and Thar Deserts; Kalahari, Namib, and Atacama Deserts; the Great Australian Desert and the deserts of south-west U.S.A. and northern Mexico. In the continental interiors of the mid-latitudes, the deserts such as the Gobi and Turkestan are characterised by extremes of temperatures.

The work of winds and water in eroding elevated uplands, transporting the worn-off materials and depositing them elsewhere, has given rise to *five* distinct kinds of desert landscape.

1. **Hamada or rocky desert.** This consists of large

A sandy desert area (erg) in Death Valley, California *U.S. Information Service*



stretches of bare rocks, swept clear of sand and dust by the wind. The exposed rocks are thoroughly smoothed and polished. The region is bare and sterile. The best known rocky deserts are those of the Sahara Desert e.g. the Hamada el Homra, in Libya, which covers an area of almost 20,000 square miles.

2. **Reg or stony desert.** This is composed of extensive sheets of angular pebbles and gravels which the winds are not able to blow off. Such stony deserts are much more accessible than the sandy deserts, and large herds of camels are kept there. In Libya and Egypt the term serir is used; elsewhere in Africa, stony deserts are called reg.

3. **Erg or sandy desert.** This is a sea of sand which typifies the popular idea of desert scenery. Winds deposit vast stretches of undulating sand-dunes in the heart of the deserts. The intricate patterns of ripples on the dune surfaces indicate the direction of the winds. The Calanscio Sand Sea in Libya is characteristic of a sandy desert. In Turkestan, sandy deserts are also known as koum.

4. **Badlands.** The term 'badlands' was first given to an arid area in South Dakota, U.S.A., where the hills were badly eroded by occasional rain-storms into gullies and *ravines*. The extent of water action on hill slopes and rock surfaces was so great that the entire region was abandoned by the inhabitants. Deserts with similar features are now referred to as badlands, e.g. the Painted Desert of Arizona, which lies south-east of the Grand Canyon of the Colorado River.

5. **Mountain deserts.** Some deserts are found on highlands such as plateaux and mountain ranges. Erosion has dissected the desert highlands into harsh, serrated outlines of chaotic peaks and craggy ranges. Their steep slopes are cut by wadis (steep-sided, often dry, valleys) and the action of frost has carved out sharp, irregular edges. In the Sahara Desert, the Ahaggar Mountains and the Tibesti Mountains are good examples of desert mountains.

The Mechanism of Arid Erosion

Arid landforms are the results of many combined factors, one reacting upon the other. *Insufficient rainfall* (often less than 5 inches) coming at most irregular periods, coupled with very high temperatures (87°F. is the average) and a *rapid rate of evaporation*, are the chief causes of aridity. Sub-aerial denudation through the processes of *weathering* (mechanical and chemical), *wind action* and the work of *water* have combined to produce a desert landscape that is varied and distinctive.

Weathering. This is the most potent factor in reducing rocks to sand in arid regions. Even though the amount of rain that falls in the desert is small, some manage to penetrate into the rocks and sets up chemical reactions in the various minerals. Intense heating during the day and rapid cooling at night by radiation, set up stresses in the already weakened rocks so that they eventually crack. As heat penetrates rocks slowly when the outer surface of rocks is being heated by the hot sun, the inner rocks remain quite cool. The heating of the rocks causes the outer surface to expand and so prise itself off from the interior rocks, so that it peels off in successive very thin layers. Such an *onion-peeling* process of mechanical weathering is called exfoliation. Angular rock debris is found in abundance as screes at the foot of upstanding rocks. Similarly, when water gets into the cracks and joints of rocks and the temperature at night suddenly drops to below freezing point, the water freezes and therefore expands by 10 per cent of its volume. Successive freezing will prise off fragments of rock which accumulate as screes. These rock fragments become the 'teeth' or *tools* of wind erosion.

Action of winds in deserts. The wind though not the most effective agent of erosion, transportation and deposition, is more efficient in arid than in humid regions. Since there is little vegetation or moisture to bind the loose surface materials, the effects of wind erosion are almost unrestrained.

Wind erosion is carried out in the following ways.

1. **Deflation.** This involves the *lifting and blowing away* of loose materials from the ground. Such unconsolidated sands and pebbles may be carried in the air or rolled along the ground depending on the grain size. The finer dust and sands may be removed miles away from their place of origin, and be deposited even outside the desert margins. Deflation results in the *lowering* of the land surface to form large depressions called deflation hollows. The Qattara Depression of the Sahara Desert lies almost 450 feet below sea level.

2. **Abrasion.** The sand-blasting of rock surfaces by winds when they hurl sand particles against them is called abrasion. The impact of such blasting results in rock surfaces being scratched, polished and worn away. Abrasion is most effective at or near the base of rocks, where the amount of material the wind is able to carry is greatest. This explains why telegraph poles in the deserts are protected by a covering of metal for a foot or two above the ground. A great variety of desert features are produced by abrasion.

3. Attrition. When wind-borne particles roll against one another in collision they wear each other away so that their sizes are greatly reduced and grains are rounded into millet seed sand. This process is called attrition.

Landforms of Wind Erosion in Deserts

In the combined processes of abrasion, deflation and attrition, a wealth of characteristic desert landforms emerge.

1. Rock pedestals or mushroom rocks. The sand-blasting effect of winds against any projecting rock masses wears back the softer layers so that an irregular edge is formed on the alternate bands of hard and soft rocks. Grooves and hollows are cut in the rock surfaces, carving them into fantastic and grotesque-looking pillars called rock pedestals (Fig. 56). Such rock pillars will be further eroded near their bases where the friction is greatest. This process of *under-cutting* produces rocks of mushroom shape called mushroom rocks or gour in the Sahara.

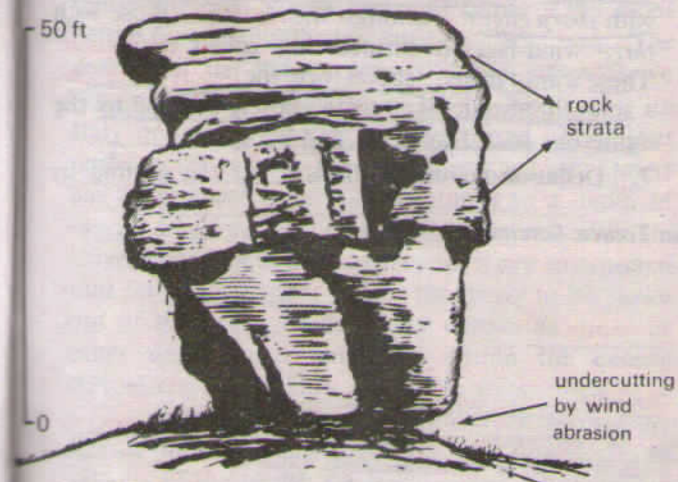


Fig. 56 Rock pedestals or gour

2. Zeugen. These are tabular masses which have a layer of soft rocks lying beneath a surface layer of more resistant rocks. The sculpting effects of wind abrasion wear them into a weird-looking *'ridge and furrow'* landscape. *Mechanical weathering* initiates their formation by opening up joints of the surface rocks. Wind *abrasion* further 'eats' into the under-lying softer layer so that deep furrows are developed. The hard rocks then stand above the furrows as ridges or zeugen (Fig. 57), and many even overhang. Such tabular blocks of zeugen may stand 10 to 100 feet above the sunken furrows. Continuous abrasion by wind gradually lowers the zeugen and widens the furrows.

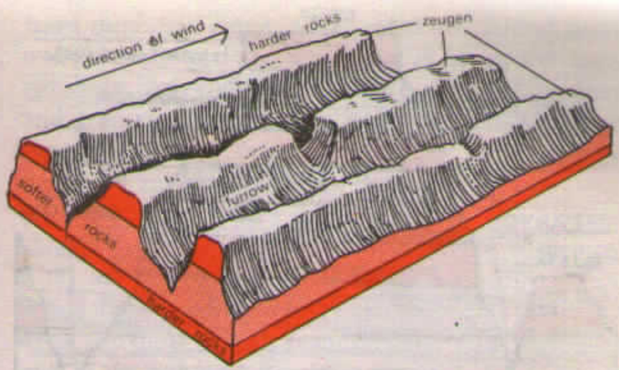


Fig. 57 Zeugen (with horizontal strata of hard and soft rocks)

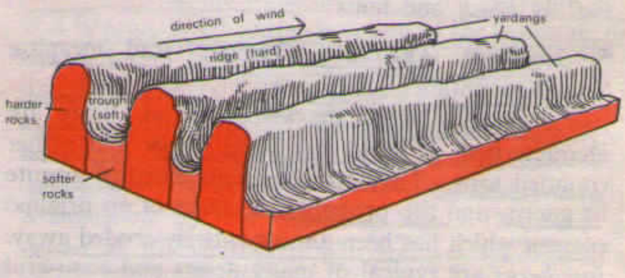


Fig. 58 Yardangs (with vertical bands of hard and soft rocks)

3. Yardangs. Quite similar to the 'ridge and furrow' landscape of zeugen are the steep-sided yardangs. Instead of lying in horizontal strata upon one another, the hard and soft rocks of yardangs are vertical bands and are aligned in the direction of the prevailing winds. Wind abrasion excavates the bands of softer rocks into long, narrow corridors, separating the steep-sided over-hanging ridges of hard rocks, called *yardangs* (Fig. 58). They are commonly found in the Atacama Desert, Chile, but the more spectacular ones with yardangs rising to 25–50 feet are best developed in the interior deserts of Central Asia where the name originated.

4. Mesas and buttes. Mesa is a Spanish word meaning 'table'. It is a flat, table-like land mass with a very resistant horizontal top layer, and very steep sides. The hard stratum on the surface resists denudation by both wind and water, and thus protects the underlying layers of rocks from being eroded away. Mesas may be formed in canyon regions e.g. Arizona, or on fault blocks e.g. the Table Mountain of Cape Town, South Africa. Continued denudation through the ages may reduce mesas in area so that they become isolated flat-topped hills called buttes. Many of them in arid countries are separated by deep gorges or canyons (Fig. 59).

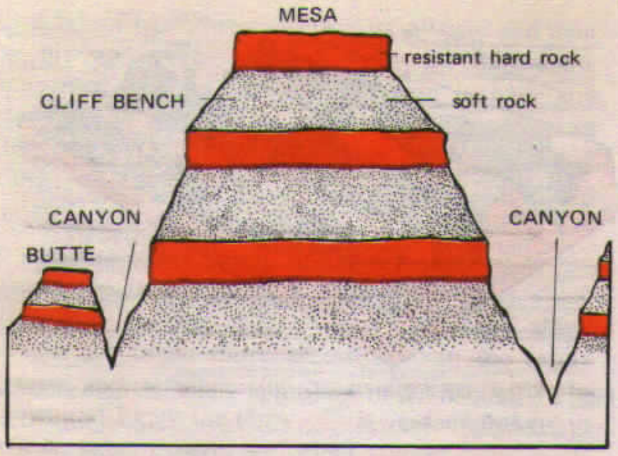


Fig. 59 Mesa and butte

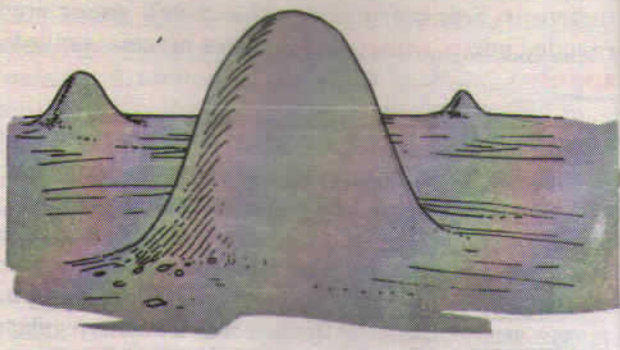


Fig. 60 Round-topped, steep-sided inselbergs

5. Inselberg. This is a German word meaning 'island-mountain'. They are isolated residual hills rising abruptly from the level ground. They are characterised by their very steep slopes and rather rounded tops. They are often composed of granite or gneiss, and are probably the relics of an original plateau which has been almost entirely eroded away. *Inselbergs* are typical of many desert and semi-arid landscapes in old age e.g. those of northern Nigeria, Western Australia and the Kalahari Desert (Fig. 60).

6. Ventifacts or dreikanter. These are pebbles faceted by sand-blasting. They are shaped and thoroughly polished by wind abrasion to shapes resembling Brazil nuts. Rock fragments, mechanically weathered from mountains and upstanding rocks, are moved by wind and smoothed on the windward side. If wind direction changes another facet is developed. Such rocks have characteristic *flat facets* with *sharp edges*. Amongst the ventifacts those with *three* wind-faceted surfaces are called dreikanter. These wind-faceted pebbles form the desert pavement, a smooth, mosaic-like region, closely covered by the numerous rock fragments and pebbles.

7. Deflation hollows. Winds lower the ground by

Ayers Rock, an inselberg in the Australian Desert *Australian Tourist Commission*

blowing away the unconsolidated materials, and small depressions may form. Similarly, minor *faulting* can also initiate depressions and the eddying action of on-coming winds will wear off the weaker rocks until the water table is reached. Water then seeps out forming oases or swamps, in the deflation hollows or depressions. The Faiyum Depression in Egypt lies 130 feet below the sea level. Large areas in the western U.S.A., stripped of their natural vegetation for farming, were completely *deflated* when strong winds, moved materials as dust-storms, laying waste crops and creating what is now known as the Great Dust Bowl. In a dust-storm, winds may lift dust hundreds of feet high and carry it thousands of miles away.

Landforms of Wind Deposition in Deserts

Materials eroded and transported by winds must come to rest somewhere. The finest dust travels enormous distances in the air, and may be moved completely out of the desert. It has been estimated that some dust grains travel as far as 2,300 miles before they are finally deposited on land or sea. The dust from the Sahara Desert is sometimes blown across the Mediterranean to fall as *'blood rains'* in Italy or on the glaciers of Switzerland. Dust that settles in the Hwang-Ho basin from the Gobi Desert has accumulated over past centuries to a depth of several hundred feet! As wind-borne materials are sifted according to their coarseness, it can be expected that the coarser sands will be too heavy to be blown out of the desert limits. They remain as dunes or other depositional landforms within the deserts themselves. Since they are *rarely static*, their migration pattern depends on a number of factors: the size of the particles they carry, the direction and velocity of the winds, the location and nature of the surfaces over which the particles are transported and the presence or absence of water and natural vegetation.

The following are some of the major features of wind deposition.

1. Dunes. Dunes are, in fact, *hills of sand* formed by the accumulation of sand and shaped by the movement of winds. They may be active or live dunes, constantly on the move, or inactive fixed dunes, rooted with vegetation. Dunes are most well represented in the erg desert where a sea of sand is being continuously moved, reshaped and redeposited into a variety of features. Because of their great contrast in shape, size and alignment, they have been given a long list of fanciful names, such as attached dune or head dune, tail dune, advanced dune, lateral dune, wake dune, star dune, pyramidal dune, sword dune, parabolic blow-out dune, hairpin dune, smoking dune and transverse dune. However, the following two types of common dunes, barchans and seifs, will be described in more detail.

(a) Barchan. These are crescentic or moon-shaped dunes which occur individually or in groups. They are live dunes which advance steadily before winds that come from a particular prevailing direction. They are most prevalent in the deserts of Turkestan and in the Sahara. Barchans are initiated probably by a chance accumulation of sand at an obstacle, such as a patch of grass or a heap of rocks. They occur transversely to the wind, so that their horns thin out and become lower in the direction of the wind due to the reduced frictional retardation of the winds around the edges. The *windward* side is *convex* and *gently-sloping* while the *leeward side*, being sheltered, is *concave and steep* (the slip-face) (Fig. 61). The crest of the sand dune moves forward as more sand is accumulated by the prevailing wind. The sand is *driven up* the windward side and, on reaching the crest, *slips down* the leeward side so that the dune advances. The rate of advancement varies from 25 feet a year for the high dunes measuring up to

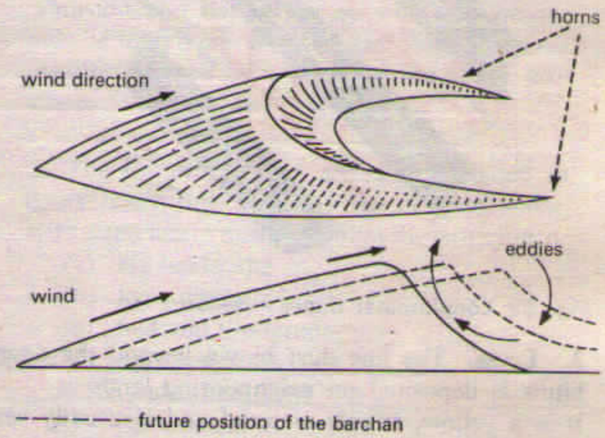


Fig. 61 Crescentic sand dune—barchan

100 feet high, to 50 feet a year, for the lower dunes which may be only a dozen feet high.

The *migration* of the barchans may be a threat to desert life for they may encroach on an oasis burying palm trees or houses. Long-rooted sand-holding trees and grasses are therefore planted to halt the advance of the dunes thus preventing areas of fertile land from being devastated. Under the action of winds, barchans take a chaotic changing pattern. Several barchans may coalesce into a line of irregular ridges, ever-changing with the direction of the winds. Ergs or sandy deserts are thus most difficult to cross.

(b) **Seifs or longitudinal dunes.** Seif is an Arabic word meaning 'sword'. They are long, narrow ridges of sand, often over a hundred miles long lying parallel to the direction of the *prevailing winds*. The high, serrated ridges may attain a height of over 200 feet. The crestline of the seif rises and falls in alternate peaks and saddles in regular successions like the teeth of a monstrous saw. The dominant winds blow straight along the corridor between the lines of dunes so that they are swept clear of sand and remain smooth. The eddies that are set up blow towards the sides of the corridor, and, having less power, drop the sand to form the dunes. In this manner, the prevailing winds increase the length of the dunes into tapering linear ridges while the occasional cross winds tend to increase their height and width. Extensive seif dunes are found in the Sahara Desert, south of the Qattara Depression; the Thar Desert and the West Australian Desert (Fig. 62).

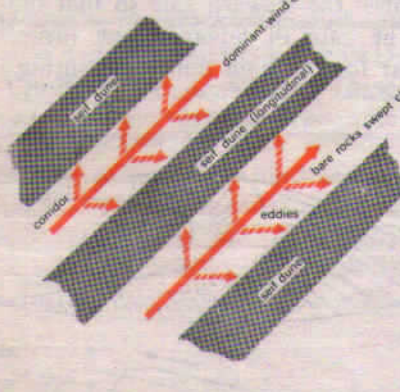


Fig. 62 Longitudinal dunes—seifs

2. Loess. The fine dust blown beyond the desert limits is deposited on neighbouring lands as loess. It is a yellow, friable material and is usually very fertile. Loess is in fact, fine loam, rich in lime, very coherent and extremely porous. Water sinks in readily so that the surface is always dry. Streams have cut deep valleys through the thick mantle of soft loess and badland topography may develop. It is so soft that roads constructed through a loess region soon sink and their walls rise steeply.

The most extensive deposit of loess is found in north-west China in the loess plateau of the Hwang-Ho basin. It is estimated to cover an area of 250,000 square miles, and the deposits have accumulated to a depth of 200 to 500 feet! In China, such yellowish wind-borne dust from the Gobi Desert is called *'Hwangtu' – the yellow earth!* But the original term *loess* actually comes from a village in Alsace, France, bearing that name, where such deposits occurred. Similar deposits also occur in some parts of Germany, France and Belgium, and are locally called limon. They are also wind-borne but were blown from material deposited at the edge of ice-sheets during the Ice Ages. In parts of the Mid-West, U.S.A. loess was derived from the ice sheets which covered northern North America and is termed adobe.

Landforms due to Water Action in Deserts

Few deserts in the world are entirely without rain or water. The annual precipitation may be small, 5 to 10 inches, and comes in irregular showers. But thunderstorms do occur and the rain falls in torrential downpours, producing devastating effects. A single rainstorm may bring several inches of rain within a few hours, drowning people who camp in dry desert streams and flooding mud-baked houses in the oases. As deserts have little vegetation to protect the surface soil, large quantities of rock wastes are transported in the sudden raging torrents, or flash-floods. Loose gravels, sand and fine dust are swept down the hill sides. They cut deep gullies and ravines forming *badland topography*. Subsequent downpours widen and deepen the gullies when they wash down more soft rocks from the surface. There is so much material in the flash floods that the flow becomes *liquid* mud. When the masses of debris are deposited at the foot of the hill or the mouth of the valley, an alluvial cone or fan or 'dry delta' is formed, over which the temporary stream discharges through several channels, depositing more material. The pasty alluvial deposits are subjected to rapid evaporation by the hot sun and downward percolation of water into the porous ground, and soon dry up leaving *mounds of debris*.

Apart from gullies there are many larger dry channels or valleys. These are deepened by vertical corrasion by raging torrents during the occasional cloudbursts. These are the wadis and are dry for most of the time. Some desert streams are fed by the melting snow of the distant mountains outside the deserts and rivers flow as exotic streams. The water carves out steep walls, which rise abruptly from the stream bed. In Algeria such gorges are termed chebka.

In arid and semi-arid areas the outflowing streams from the upland regions are both short and intermittent. They drain into the lower depressions so that

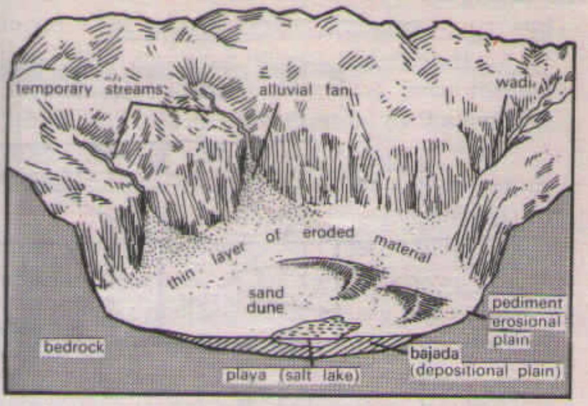


Fig. 63 Intermont desert basin

drainage is almost entirely internal. Sometimes water collected in a depression or a desert basin does not completely disappear by evaporation or seepage, and a temporary lake is formed. Such lakes contain a high percentage of salts, because of high evaporation, and are glistening white when they dry up. The lakes and the alluvial plains formed by them are called playas, salinas or salars in the United States and Mexico, and shotts in northern Africa (Fig. 63). The floor of the depression is made up of two features, the *bajada* and the *pediment*. The bajada is a depositional feature made up of *alluvial material* laid down by the intermittent streams. The pediment is an *erosional plain* formed at the base of the surrounding mountain scarps.

QUESTIONS AND EXERCISES

1. Draw annotated diagrams and explain very briefly any *three* of the following desert features.
   (a) yardangs
   (b) barchans
   (c) pediments
   (d) inselbergs
   (e) wadis

2. Attempt a simple classification of deserts. Justify your basis of classification by bringing out their distinct differences in appearance, formation and outstanding features.

3. With the aid of diagrams, explain the major differences between any *three* of the following pairs of desert landforms.
   (a) zeugen and yardangs
   (b) mesas and inselbergs
   (c) crescentic barchans and longitudinal seifs
   (d) bajadas and pediments
   (e) ventifacts and dreikanter

4. Explain concisely the processes of deflation, abrasion and deposition by winds. With the aid of diagrams explain *two* topographical features formed by any two of the above processes.

5. The following terms are closely related to desert landforms. For any *four* of them, define with reference to examples what the terms mean.
   (a) erg landscape
   (b) loess deposits
   (c) badland topography
   (d) rock pedestals
   (e) Great Dust Bowl
   (f) flash floods