INTRODUCTION TO JORDANIAN DESERTS

A: REASONS FOR ARIDITY

Jordanian deserts are what we call Mid-Latitude deserts because they lie between 35° and 45 ° North of the Equator. The region is dry for four reasons:

1: Jordan is in a zone of high pressure (Fig. A12). This means that air descends from the upper atmosphere (Fig. A13). This air will be dry and will become increasingly warm as it comes under pressure (As much as 40°C at Easter). As a result there will be little cloud cover to reflect incoming solar radiation. Conversely there will be little cloud to hold heat in during the nights, which can be extremely chilly (February - April).

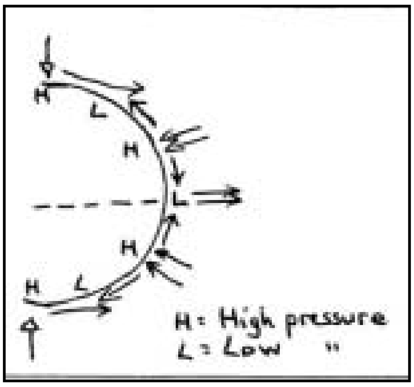

Fig. A12: Global Wind Systems

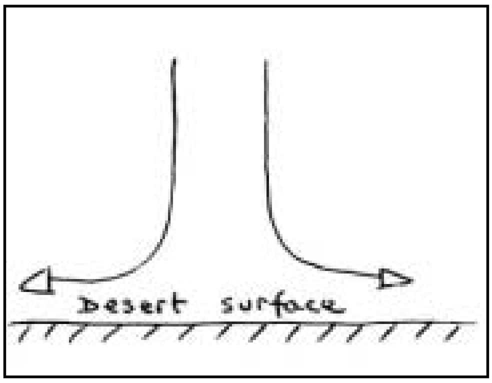

Fig. A13: Descending air is warmed

2: Jordan is almost entirely land-locked. This means that any air that does flow from an ocean will have lost some of its moisture on the surrounding land surfaces.

3: Jordan is in the rain shadow of the western highlands. This means that any air from the Mediterranean will rise, condense and precipitate its moisture before reaching the desert areas (Fig.A14).

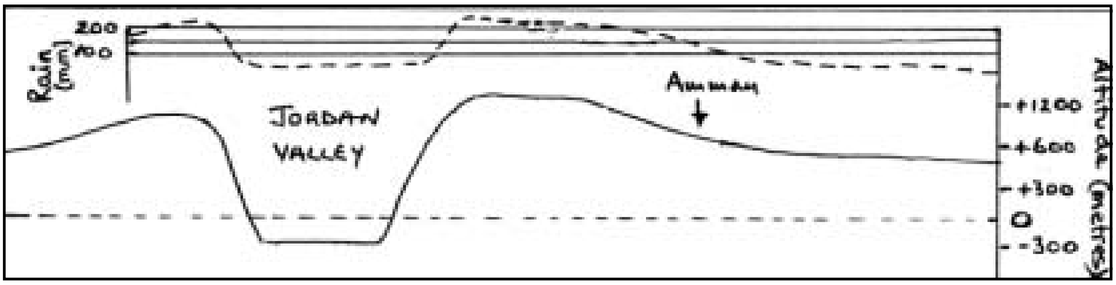

Fig. A14: The rain shadow effect

4: Jordan lies east of the Dead Sea. Because the Dead Sea, the Jordan Valley and the Wadi Araba lie some 300m below sea level any air mass passing across them must descend before rising again over the higher ground either side. Any air forced to descend must warm up. Dry air warms up faster than damp air (dry air: 10°C per 1000 metres; moist air: 5°C per 1000 metres). When it rises again over the highlands east of the Wadi Araba it will start off warmer than it was before. Having risen over the eastern highlands it will then descend again across the desert only to be warmed still further. Rainfall therefore decreases eastwards (Fig.A3).

B: The DESERT CLIMATE

Jordanian deserts have three characteristics:

1: A large diurnal range of temperature. For the reasons given in A.1 above the daytime temperatures can be high and the night time temperatures quite low. At Wadi Rum, at Easter time, this daily range may be from 40 °C to 5 °C. The effect of this range is increased by the fact that there is very little vegetation and the rocks are laid bare to the heating and cooling effects of the sun's rays. Bare rocks heat up more quickly and cool down more quickly than a vegetated surface.

2: An irregular (aperiodic) rainfall regime. The rainfall is so irregular that average values have no meaning. If rain does fall it is usually for one of two reasons:

a) Air that is heated over the desert rises and cools to fall as convection rainfall.
b) Depressions occasionally move east across the North African coast bringing cooler, wetter weather. This often happens in March when snow is recorded in Amman and the western highlands. This cool wind is known as the **Khamsin**.

3: Evaporation exceeds precipitation. This inevitably means that any moisture that has been held in the rocks will be drawn upwards towards the surface only to be evaporated. This can mean that salts extracted from the rocks may be deposited at the surface as hard crusts (**duricrusts**) .

C: EFFECTS OF THE CLIMATE

(a) Weathering:

The weathering of the rocks is predominantly mechanical. This means to say that the rock is physically attacked by the effects of expansion and contraction (because of temperature changes), the growth of salt crystals within the rock, **hydration** and **dehydration** (caused by water swelling when it does rain), and even **freeze-thaw** in the cold winter nights. The rocks are thus disintegrated by the processes that we call **exfoliation**, **block weathering**, **granular disintegration**, **frost shattering** and **salt weathering**. Exfoliation is the process whereby a rock peels like an onion to produce rounded forms and slabs and slithers of rock fall to the ground around it. As the rock weathers, the weight of the overlying rock is slowly reduced. Once released from this pressure the joints in the underlying rock may begin to spring upwards allowing greater access for weathering processes. Some rocks, especially those with thin beds, are more susceptible to this process (**pressure release** or **dilatation**) than others.

Inspite of the aridity the desert is also subject to chemical weathering processes because there is plenty of moisture around. You have only to dig a few inches into the sand to find a cooler, damper layer where ground water has collected either from rain, dew, or from snow melt. Even Wadi Rum has snow periodically. As this water is drawn towards the surface by evaporation and capillary action it brings with it minerals that have been extracted from the rocks. Most noticeable of these is manganese which can form a dark, paper thin layer on rock surfaces. This **patina** is known as **desert varnish**. All rocks are made up of collections of different minerals and these will react with water in different ways. Iron is particularly susceptible to rusting (**oxidation**). The chemical decay of rocks creates cavities and weird shapes within the rocks, and causes fine particles to fall to the ground ready to be used by wind as an erosive tool.

(b) Erosion

(i) Wind Erosion:

This is the most quoted process. Certainly it is a more continuous process than water erosion but its effects are restricted to about one metre above the ground because sand particles are too heavy to be lifted by the wind. Instead they tend to creep or bounce (**saltation**) along the ground along. The processes of wind erosion are **abrasion** (when sand blasts rocks like sand paper), **attrition** (whereby sand particles wear one another down), and **deflation** (whereby the wind literally blows material away to create hollows). Where a rock surface has been blasted by sand it may become highly polished to form **desert pavement**. If the dominant wind directions come from more than one quarter, rocks and pebbles may become polished on more than one side to form what are known as **dreikanter**. Sand blast can be very selective, like an etching tool, and will wear away the softer parts of a rock leaving the more sturdy parts outstanding. The result can be a fascinating series of honeycombed features. In extreme cases the sand will undercut rock outcrops to create **rock pedestals** (Fig.A15).

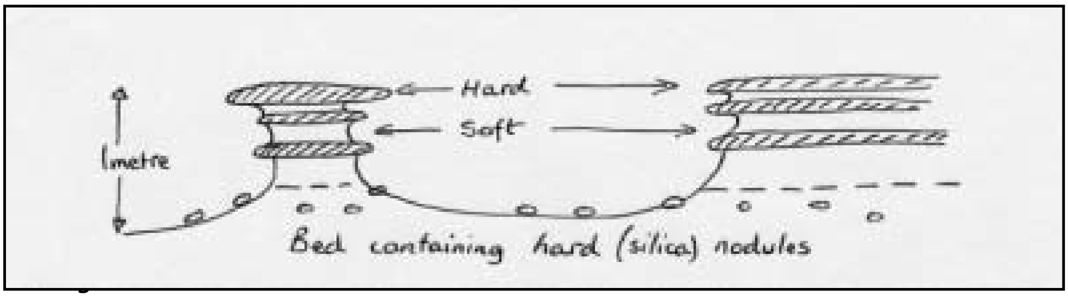

Fig A15: Rock pedestals

(ii) Water Erosion:

Desert rain may be rare and sporadic but when it comes the flow is vigorous and the effects much more significant than wind erosion. The absence of vegetation and the steep highland slopes encourage rapid run-off into gullies whence flash floods can carry a large amount of material in a short space of time. Streams that react rapidly in this way are said to be 'flashy' (Fig.A16), You will find plenty of evidence for water flow in the desert, most notably on the floors of the large **wadis**. These valleys are characterised by steep sides, caused by parallel retreat (see Section E(b)3. below) and flat floors caused by the deposition of material brought by flash floods, under both present and past (Ice Age) conditions (Fig.A16 and Fig.A21).

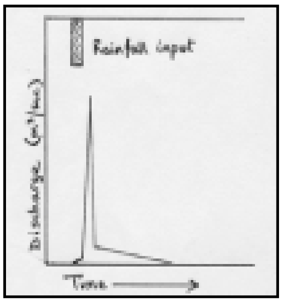

Fig.A16: A 'flashy' hydrograph

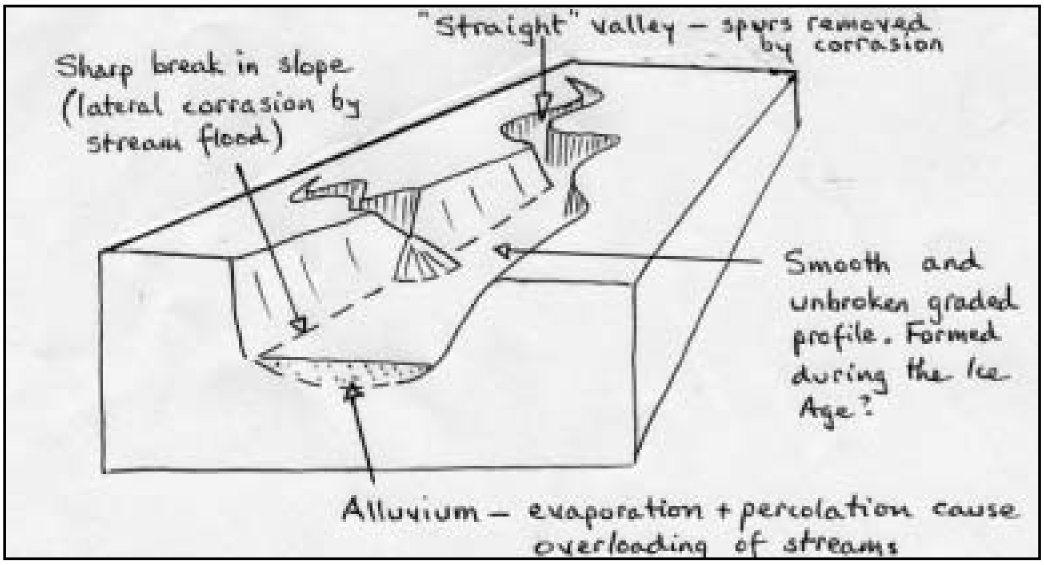

Fig.A17: The characteristics of a wadi

Where wadis emerge onto the lowlands they are often marked by huge fan-shaped aprons of debris created when the debris-laden stream was no longer confined by the wadi walls. The flow then spreads out, reducing the energy of the stream, causing it to drop its load. Desert streams rarely flow out of their desert basins because they become choked with debris and the water evaporates (Section E(a) below) so that these fan-shaped aprons can grow to a considerable size.

D: THE STRUCTURE OF JORDANIAN DESERTS

The deserts of Jordan fall into the three categories that, in addition to the factors referred to above, are also determined by their geology and rock structure. A simplified geological map is shown in Fig.A2.

(a) The Rift Valley Floor:

This is the section of the Earth's crust that dropped during massive earth movements. The floor is essentially flat being the flood plain of the River Jordan and the basin containing the Dead Sea. At the margins of the rift huge dry deltas of material (alluvial fans or **bajadas**) spread out from the wadis that lead down from the mountains on either side. The material from these is derived from streams similar to that seen passing through the gorge in the lower section of Wadi Mujib (Fig.A26-A).

(b) The Mountains:

The mountains east of the rift valley represent the uplifted edges of the rift. At the southern end they consist of Palaeozoic (ancient) granites and sediments which form impressive mountain masses. At the northern end the rocks are softer and more recent forming a smoother landscape which becomes increasingly farmable to the north. The earth movements caused the base level for streams to be rapidly lowered. As the streams readjusted to the new base level they incised deep, steep-sided gorges such as the impressive canyon of Wadi Mujib north of Kerak. The amount of water in these wadis depends upon the position of the water table (Fig.A18).

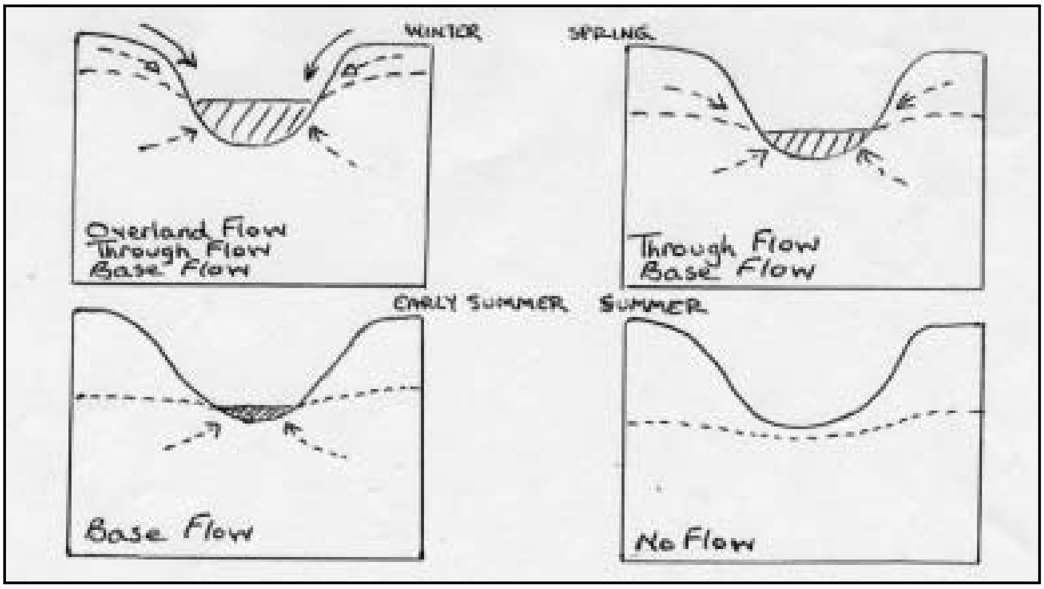

Fig.A18: Changing positions of a wadi water table

(c)The Eastern Deserts:

The rest of Jordan, east of the King's Highway, is desert underlain by gently folding limestones and sandstones. Huge geological downfolds (synclines) create sweeping, open, often featureless desert. Eroded and weathered volcanic cones and lava flows occasionally come to the surface, mainly in the western part where they can be seen alongside the Desert Highway. These are the relic of eruptions that took place while the earth movements were disrupting the crust. To the north-east the Azraq depression dips low enough to intercept the water table and to trap seasonal snow melt carried from the higher volcanic mountains of Syria. One of the most striking of landscape features at Azraq is the huge plain of basalt lava that has weathered into remarkable football-size boulders (Fig. A6-A)

To the south the edge of another huge depression rises southwards towards the vicinity of Wadi Rum. In its structure Ice Age water has been trapped to supply the farm irrigation at Disi. South of the rim of this depression the Palaeozoic rocks come through to the surface to form the sandstone blocks of the Wadi Rum district. These sandstones sit on top of a basement of even older granite, which is higher to the west (closer to the uplifted edge of the rift valley) and dips steeply east and south. Because of the faulting these huge mountain blocks (jebel) such as Khazali have, near vertical sides and are arranged in a regular pattern that is closely related to the intersecting fault lines (Fig. A19 and Fig A26-B).

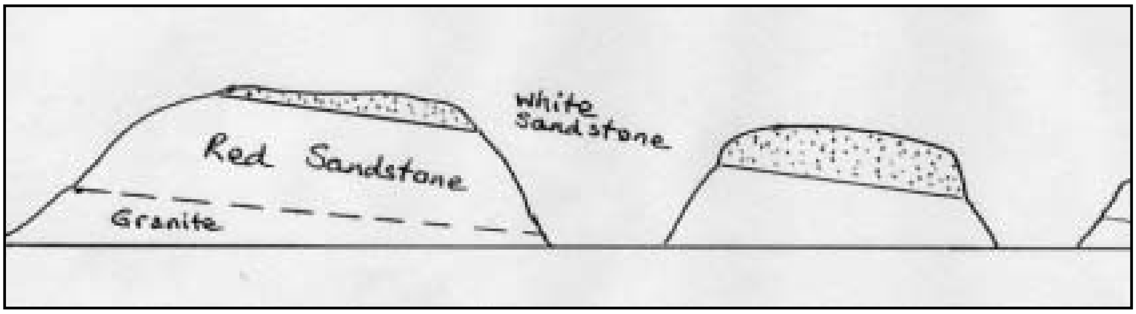

Fig A19: Generalised geological section through the 'jebels' of Wadi Rum

E: THE MAIN DESERT FEATURES

(a) Plains

These are probably the most outstanding feature of the deserts; vast areas of endless rock and loose material. In North Jordan, north of the Azraq basin, this phenomenon is at its most bizarre: a huge plain of football-size boulders derived from a weathered basalt lava flow. Some of the plains are simply flat, or gently inclined, geological rock structures. Some are the remains of former river valleys (wadis) that were occupied by regular water when the climate was more temperate during the Ice Age. These range from small wadis to the huge valley of the River Jordan. The River Jordan is an example of an **exotic river** - one that receives its water from outside the desert and proceeds to flow into it. Unluckily for the Jordan it never gets out at the other end!

Many of the flat areas are zones where rivers and flash floods have deposited material over thousands of years to create **pediments** (rocky slopes at the foot of uplands) (see Fig.A22), **bajadas** (huge alluvial fans of material washed out of gullies and wadis by flash floods) (see Fig.A25 and A26-B) and **playas** (Qa) (dried up lake beds) (see Fig.A28).

Even today periodic rains will cause flash floods and vast quantities of material will be moved in a very short space of time (e.g. at Easter 1992, Aqaba suffered a huge flash flood that claimed six lives and damaged a section of the city. The basement of the Alcazar Hotel was flooded). In Britain all streams ultimately reach their base level (the sea) and while doing so they erode and deposit to create a smooth, graded long profile. In deserts, however, neither base level nor grade are achieved because the streams become so heavily choked by debris that they become viscous and die. Evaporation will cope with any excess water. The river Jordan does not reach sea level because its floor has been faulted down below sea level.

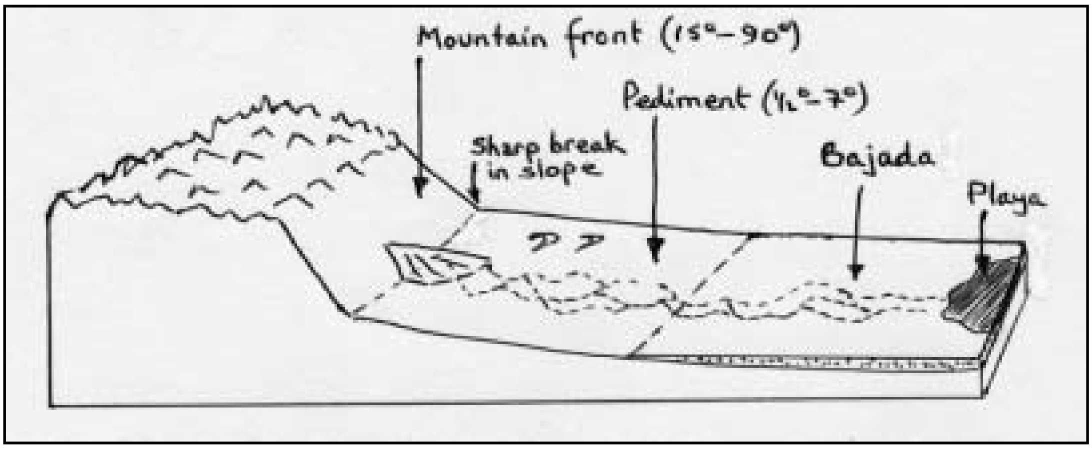

Fig. A20: Some typical desert landscape elements

(b) Inselbergs (Literally: 'island rocks')

These are isolated rock masses that stick up from their pediments. The finest examples in Jordan are the huge rock masses around Wadi Rum which owe their origin to a combination of factors:

1: Earth movements (tectonic activity):
At first it may seem strange to think that the Wadi Araba (Dead Sea) was created because the Earth's crust was pushed up into a dome but, of course, the top of the dome cracked and subsided. This left some very fractured (faulted) sections of crust upstanding on the margins of the rift valley. The area around Wadi Rum shows these faulted inselberg blocks very well.

2: Wetter climatic conditions: During the Ice Age the World's climatic belts were squeezed southwards towards the Equator (Fig.A21). This introduced a wetter climate into the deserts and produced permanent streams across the fractured surface. The streams sought out the weaker, faulted zones, incised their valleys into the rock, leaving the intervening blocks as isolated uplands. You may not experience any rain while in Jordan but it does occur and in some areas snow contributes to the surface run-off. There is plenty of evidence for stream flow: alluvial fans, dry water courses, sorted sediments in canyons, gullies and on wadi floors.

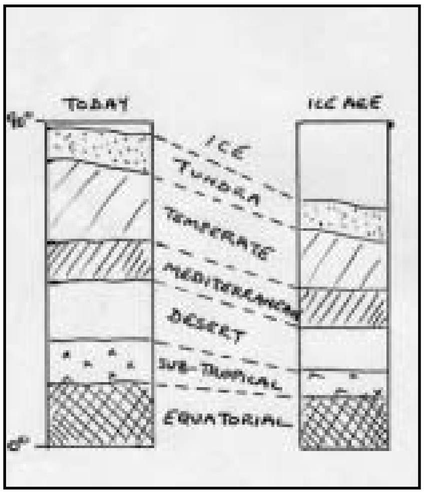

Fig. A21: The relative positions of glacial and present day climatic belts

3: Parallel retreat of slopes: In our temperate climate the rainfall attacks our slopes and constantly, but slowly, washes material from the tops to the bottoms. This has the effect of wearing them down and making them increasingly rounded. In deserts this cannot happen because there is little regular water available. This means that gravity is more important than rainwash; rocks simply crumble and fall down with the net effect of causing the slopes to wear back rather then down (Fig.A22). When a flash flood comes along much of this debris is washed away to lower collecting areas.

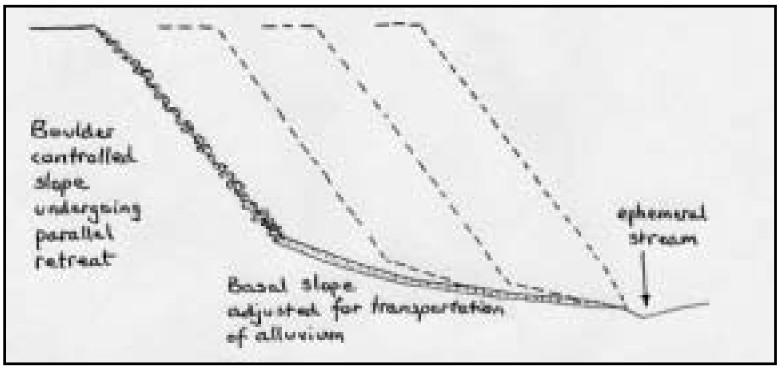

Fig.A22: The parallel retreat of desert slopes

4: Overlying hard strata: In some cases the overlying rock is harder than the ones underneath. It thus protects the underlying rock, maintaining a steep profile while the sides are worn back. Where the resulting landform is flat topped this is called a **mes**a (a smaller one is a **butte**). There are no specific examples but there are many instances where harder layers are responsible for significant features (see Rock Pedestals & Fig.A28).

(c) Rocky (hamada) or stony (reg) desert:

This sort of surface is very common in Jordan. The expansive flat areas have frequently had their fine material blown away by the wind leaving only the coarsest material at the surface. (See Fig.A26-C)

(d) Sand Dunes:

Sand dunes are not common features in Jordan. There is plenty of sand and quite a few isolated dunes but there are no sand seas (ergs). In reality, sand seas represent only 10% of all the world's deserts. Near Wadi Rum there are some fine dunes drifted into the shelter of wadis (e.g. Wadi um Ishrin) or drifted against isolated rock outcrops. The commonest forms of sand dunes are those known as **barchans** (crescent-shaped dunes), and **seifs** (longitudinal dunes). Neither of these are significant in Jordan but, if anything, the largest ones are longitudinal in that they are elongated dunes piled high along the walls of wadis. The key to the occurrence of dunes is the shepherding effect of the wind but, of course, there must also be an adequate supply of sand. In the Wadi Rum area the source of the sand is the friable sandstone that makes up the mighty rock walls. (Fig.A26-D)

(e) Problem:

One of the biggest problems in the study of desert landforms is the very marked break in slope that occurs between the mountain blocks and the flat plains. In a humid environment, the greatest frequency of slopes occurs between 0° and 10°. This is because water is always present to wash and sort material down a slope. Slopes therefore tend to be predominantly convex-concave. In a desert there are two peaks, one between 0° and 10° and the other between 30° and 40° representing the two extremes of desert land form (Fig.A23). The first group represents the vast open plains (see Plains above). The second represents the steep faces of the inselbergs and those mountain slopes that have been caused by parallel retreat (see above). Between the two extremes there is a sharp break in slope (see Fig. A24).

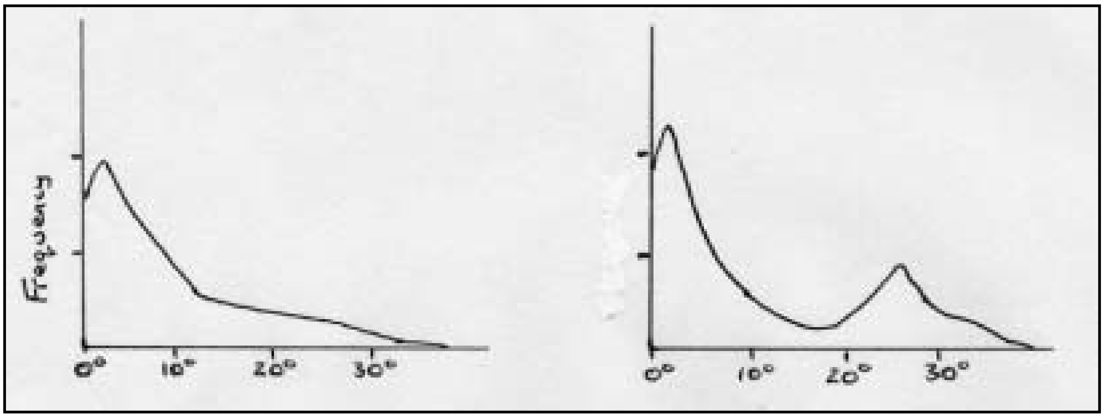

Fig.A23. Frequency of slope angle in temperate and desert regions.

Some would say that this break in slope is caused by sheet flood whereby water, suddenly released from the constriction imposed by its mountain channel, spreads over the pediment (Fig.A24). Others say that it is caused solely by parallel retreat. In reality it is probably caused by a combination of processes and circumstances.

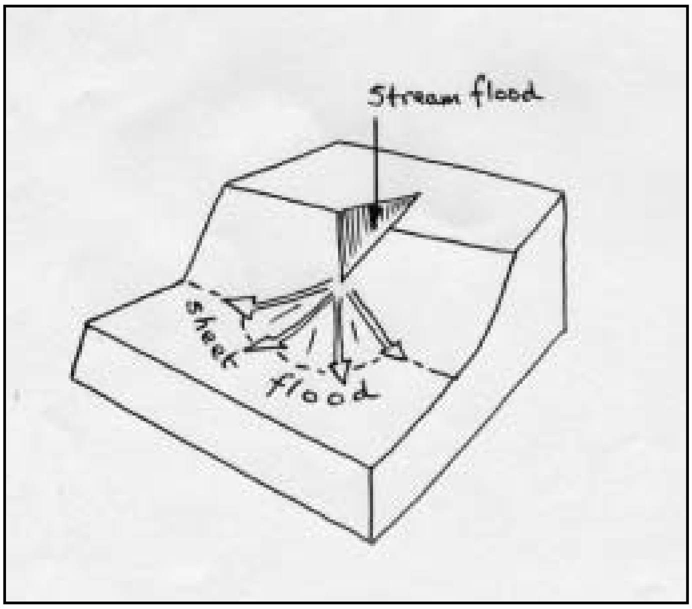

Fig.A24. Sheet flood and the break in slope

Fig. A25: Bedouin encampment in *reg* desert south of Safawi