CHAPTER - 2

PHYSIOGRAPHY OF THE CHAMBAL AND SIND DRAINAGE BASINS

The physiography of the Chambal and Sind river drainage basins can be broadly divided into four physiographic units namely, (i) Malwa Plateau (ii) Madhya Bharat Pathar (iii) East Rajasthan Uplands and (iv) Aravalli Range. These units are shown in Plate No.4.

2.1 MALWA PLATEAU

The Malwa plateau lies to the north of the Vindhyan range which strikes nearly east–west. This plateau is bordered to the north–east, north and to the north–west by Madhya Bharat Pathar.

The Chambal drainage basin occurs mostly in the Malwa plateau and partly in other units, whereas the Sind drainage basin mostly lies in the Madhya Bharat Pathar and partly in the Malwa plateau. The major part of the Malwa plateau is characterised by the presence of gently rolling grounds, flat topped hills and conical hills. The southern part of the plateau is hilly and
mountainous towards the Vindhyan range. To the south of Mhow town, some of these hills have elevation of 850 metres or more above the Mean Sea Level. The major part of the plateau is characterised by the presence of clay soils with good soil profiles except for a few flat topped and conical hills with scrub jungles.

2.2 MADHYA BHARAT PATHAR

Madhya Bharat Pathar consists of mostly the Vindhyan rock formations of Purana age. The Shivpuri and Morena level plateaus form the dominant features of this Pathar. At its western margin, the pathar is characterised by the presence of mostly flat grounds. The Shivpuri and Morena plateaus are separated by the presence of bold scarps consisting of sandstones, limestones of Bhandar Group of the Vindhyan Super Group. These are underlain by soft Ganurgarh shales. The Kunu valley has been carved out of this shale. To the east of the Kunu river valley, two other east facing scarps occur consisting of sandstones of Rewa and Kaimur Groups of the Vindhyan Super Group. The rivers and streams follow more or less the contacts between the soft and the hard rock formations.

The Chambal river cuts across the Vindhyan, giving rise to two gorges. One such gorge is found to
the north of Mandsaur town (24°6' : 75°6'), and the
other occurs nearby Kota town. Between the towns Kota
and Dholpur, the Chambal river meanders in the alluvium.

The border hills of the Pathar are arcuate in
plan on the western side. The southern part of the
western boundary forms monoclinal ridges near Chittorgarh
(24°51' : 74°40'). They are parallel ranges consisting
of sandstones of the upper Rewa and Bhandar Groups. The
prominent hill ranges alternate with longitudinal valleys
made up of soft shales of Sirbu, Simaria, Jhiri and Panna.
A piedmont plain formed of Gwalior Group lies to the
western foot of the border hills. The peneplanation has
also taken place. Wind gaps are to be seen in the Bundi
hills which lie to the north-east of Chittorgarh town.

2.3 EAST RAJASTHAN UPLANDS

This physiographic unit is an extensive alluvial
plain and lies to the north of the Madhya Bharat Pathar.
It is underlain by igneous and metamorphosed sedimentary
rocks. This unit is characterised by the presence of
dendritic drainage pattern and low monadnocks. To the
west of the east Rajasthan uplands lies the Aravalli range.
2.4 ARAVALLI RANGE

The Aravalli range acts as a barrier between the western and the eastern plains of Rajasthan. It separates the Ganga river system from those rivers draining into the Arabian Sea. It functions as a great surface water divide line. It is one of the oldest mountains having a very conspicuous landforms. It trends diagonally from north-east to south-west for about 530 kilometres. This range has a maximum height of about 1000 metres above the Mean Sea Level.

2.5 CHAMBAL DRAINAGE BASIN

The Chambal river (Photograph Nos. 7 and 8) takes its birth at the northern foot hills of the Vindhyans mountains near the town Mhow which lies to the south-west of the Indore city in Madhya Pradesh. Flowing towards the north for about 257 kilometres, the river enters into Rajasthan through a gorge near the historic Fort of Chaurasigarh. Then it turns towards north-east and flows past Kota town keeping up a straight course for 212 kilometres. It takes a bend towards south-east at the village Pinahat and joins the river Yamuna near the village Muradaganj after a total run of about 965 kilometres.
PHOTOGRAPH NO. 7 : A view of the Chambal river about 20 kilometres north of the Morena town.

PHOTOGRAPH NO. 8 : A view of the Chambal river about half a kilometre west of the village Kuthiyana.
The Chambal river flows for the first 273 kilometres entirely in Madhya Pradesh and the next 153 kilometres entirely in Rajasthan. From the village Palia up to the village Pinahat for a distance of 241 kilometres, the river marks the boundary between Rajasthan and Madhya Pradesh States. In its last lap of 105 kilometres, it joins the river Yamuna and forms the border lines between Madhya Pradesh and Uttar Pradesh States. Thus the river Chambal drains the north-western part of the Central Vindhyan Plateau (Madhya Bharat Pathar) of India and south-eastern portion of the Aravalli range.

The important tributaries of the Chambal river are Parbati, Kali-Sindh, Kunu, Gambhir, Shipra, Choti Kali Sindh, Parwan, etc., from the Madhya Pradesh side and the rivers Banas, Kural and Mej are from the Rajasthan side.

The first major tributary, the Parbati, originates to the south of the Siddiquiganj village and joins the Chambal about one kilometre to the south-east of the village Pali (25°51' : 76°37'), after a run of about 395 kilometres. The second major tributary, the Kali Sindh, originates near the village Bagli (22°40' : 76°20') and meets the river Chambal near Etawah town (25°40' : 76°25'), in Rajasthan after a run of about 346 kilometres, Kali Sindh and Parbati are the south-eastern tributaries of the
river Chambal. The third major tributary, the Banas, is the north-western tributary of the river Chambal. It rises from Aravallis and drains the south-eastern part of the Aravalli range. It falls in the Chambal river near the village Rameshwarghat after crossing the Sawai Madhopur (25°59' : 76°25') - Karauli (26°50' : 77°2'), line of hills after completing a journey of about 480 kilometres. The fourth major tributary the Kunu, originates to the north of Guna (24°35' : 77°20'), town and joins the river Chambal, near the village Nadigaon (26°10' : 77°2') in Madhya Pradesh after a run of about 176 kilometres. The river bed level at the Banas–Chambal confluence is about 178 metres above the Mean Sea Level whereas the Chambal confluence with the Yamuna river has a bed level of about 100 metres.

The other tributaries namely Gambhir, Shipra and Choti Kali Sindh which originate at the northern foot hills of the Vindhyans range are the small sized rivers of this basin. These rivers flow more or less from south to north, with their courses nearly parallel to one another. Their tributaries generally flow either from south-east to north-west or from south-west to north-east. The Kural and Mej are the small sized rivers from the Rajasthan side. The Chambal drainage basin has an area
of about 1,31,647 square kilometres and is nearly fan shaped. The major and minor tributaries of the river Chambal give rise to a dendritic drainage pattern as shown in Plate Nos. 5 and 17.

2.6 SIND DRAINAGE BASIN

The Sind river originates to the north of the village Nainwas in Vidisha District of Madhya Pradesh and flows towards the north-east. It completes a journey of about 395 kilometres before it joins the Yamuna river near the village Kaudholi (26°26' : 79°12') in Uttar Pradesh. It originates from Deccan Traps and flows for a long distance over Bundelkhand granitic complex and then crosses the sedimentary rocks of the Gwalior Group before it enters into the alluvium. It joins the river Yamuna about a distance of 5 kilometres downstream of the Chambal-Yamuna confluence. The river bed level at the Sind and Yamuna confluence is about 107 metres above the Mean Sea Level.

The important tributaries of the Sind river are the Kunwari, Vaisali, Pahuj, Asan, Choti Parbati, Sank, etc., out of which, the rivers Kunwari and Pahuj may be considered as major tributaries.
The Kunwari river (Photograph No.9), originates to the south-west of the village Behrar in Shivpuri District and after a run of about 273 kilometres, it meets the river Sind near the village Jakheta (25°26' : 79°10') in Uttar Pradesh. The river bed level at this confluence is about 100 metres above the Mean Sea Level. The rivers Asan and Shank are the important tributaries of the Kunwari river. The Asan river meets the Kunwari river near the village Porsa (26°35' : 78°25') in Morena District of Madhya Pradesh.

The Pahuj river originates to the south-west of Jhansi town (25°30' : 78°40'), and meets the river Sind near the village Dikauli (26°24'30" : 79°09'30") in Uttar Pradesh, after a run of about 136 kilometres. This river drains the Bundelkhand granitic complex for a small distance and then flows through the alluvium until it meets the river Sind.

The tributaries of the Sind river show a typical dendritic drainage pattern, which can be made out from Plate Nos.5 and 17. The Sind drainage basin is elongated in shape and covers an area of about 30,512 square kilometres.
PHOTOGRAPH NO. 9 : A view of the Kunwari river about half a kilometre north of the village Jawasa.

PHOTOGRAPH NO. 10 : Showing the lower reaches of the Chambal Command areas nearly barren of vegetation.
2.7 VEGETATION

It is necessary to point out that the vegetation of an area has a control over the rainfall, evapo-transpiration losses, humidity, temperature, wind velocity, infiltration and recharging conditions to the groundwater bodies, etc. The author, during his reconnaissance studies of the Chambal and Sind drainage basin areas, has noted that man has destroyed the natural forests of the hills, ridges, plateaus and the hill slopes of the rivers and their tributaries. As a consequence, most of these areas are nearly barren of vegetation (Photograph No.10) in spite of the fact that most of these areas come under reserved or protected forests. As a consequence, the natural relationships existing between the vegetation on one hand and the climatic parameters on the other have been altered.

The existing forests of both the drainage basins can be broadly classified into two categories namely, (a) the dry and humid mixed forests, and (b) the thorny jungles. The dry and humid mixed forests are mostly found in the southern parts (headward areas), of these drainage basins. Such forests are found in parts of the districts like Indore, Dhar, Guna, Shivpuri, Vidisha, . One of the most important flora of these forests is the Teak
(Tectona grandis). The Thorny Jungles are mostly confined to the northwestern parts of the Chambal drainage basin and to the eastern parts of the Sind drainage basin. These jungles are found in parts of the districts like Chittorgarh, Udaipur, Bundi, Sawai Madhopur and Kota in Rajasthan and Shivpuri, Guna, Gwalior, Morena, Datia and Bhind districts of Madhya Pradesh. The important flora of these Jungles are Sal (Shorearobusta), Sagon (Tectone grinds), Tinsa (Quenca dabberoides), Salai (Bos melli Serrata), Saj (Termatia tomentus), etc. Apart from these important flora, the flowering trees are also found in both the drainage basins. These are Palas or Chheola (Butea frondisa), Mahua (Bassia latifolio), Aonla (Phyllanthus emblica), Tendu (Diospyros tomentasa), Jamun (Eugenia-Jambolana), etc. In the plain country, Ber (Ficus bengalensis), Pipar (Ficus religiosa), Babul (Acacia arabica) and Neem (Melia azadirachta) trees are generally found (Photograph No.11).

2.8 PHYSIOGRAPHIC SETTING OF THE CHAMBAL COMMAND

As stated earlier the study area for hydrogeological investigations comes within the lower reaches of the Chambal Command. The surface and groundwaters of this area are controlled by the presence of alluvium and their adjacent hill ranges. Therefore, the description of the physiography
PHOTOGRAPH NO. 11 : Showing the trees of Babul (Acacia arabica) found in the Chambal Command, Madhya Pradesh.

PHOTOGRAPH NO. 12 : Showing more or less flat and undulating terrain of the Chambal Command in Madhya Pradesh.
of the Chambal Command becomes essential specially after
the advent of the Chambal Complex, for the Chambal
drainage basin gets separated into two parts with respect
to the Chambal run-off water-flows due to the coming in
of this complex. The run-off water-flows of the river
Chambal within the Chambal Command due to rainfall is
now mostly derived from the tributaries below the complex
and also from whatever the water spills into the river
Chambal from the Gandhi Sagar Dam. Thus the natural
hydrologic regime of the command is no longer the same
as it was prior to the coming in of the complex. This
fact has to be taken in conjunction with the irrigation
from the various canal systems within the command, while
considering the various aspects related to groundwaters
in the area under investigation.

The Chambal Command area in Madhya Pradesh begins
from the Parbati aqueduct (south-west of the village
Baroda), where the Chambal right main canal enters into
Madhya Pradesh from the Rajasthan side. The river Chambal
forms the boundary of the alluvium towards the north-west,
north, north-east and east. The Vindhyan and Gwalior hill
ranges lie at the southern boundary of the alluvium. At
the south-eastern part of the alluvium lies the river Sind.
The physiography of the lower Chambal valley is studied by Chatterjee and Bagchi et al. (1957) and Sharma (1970). Sharma (ibid) divides the lower Chambal valley into three micro-geomorphic regions which are as follows:

I. THE HILLY SECTION
   (i) The Bundi hills.
   (ii) The Rathambhore hills.
   (iii) The Mukundwara hills

II. THE PLATEAU SECTION
   (iv) The Dangland - the Chambal scarp.
   (v) The Kota plateau.

III. THE LOW LAND SECTION
   (vi) The Harawati plain.
   (vii) The Ramgarh Dome.
   (viii) The ravine belt.

According to his classification, a small part of the Chambal Command in Madhya Pradesh comes under the ravine belt of the low land section. The Chambal Command is mostly a flat terrain consisting of the alluvium with a few isolated outcrops of rock formations belonging to the Vindhyan Super Group and the Gwalior Group. These outcrops are mostly confined to the upper reaches of the
Chambal Command. A few of these are also found in the Gohad area occurring in the lower reaches of the Command. The Command area has a maximum elevation of 264 metres and the minimum elevation of 150 metres above the Mean Sea Level. The general ground slope of the command is towards the river Yamuna. The area devoid of ravines is mostly flat and undulating (Photograph No.12). The ravines are characteristic features of the Chambal alluvial margins towards the streams and rivers. The other characteristic topographic features of the Command from the Banas river water gap to the Yamuna confluence are the flood plains, alluvial knolls and bluffs.

To get a picture about the general aspects of the drainage characteristics which have an important bearing on the hydrogeological conditions of the study area (which lies in the lower reaches of the Chambal Command), a drainage map (Plate No.5), of the Chambal Command has been prepared. For preparing this map, the base maps used are the toposheet Nos. 54 F and J (scale 1 : 250,000), prepared by the Survey of India during the years 1967-74.

The major tributaries of the river Chambal within the Chambal Command are the Kunu river flowing from south to north and the river Banas coming from Rajasthan and
flows from north-west to south-east. The important tributaries of the river Sind within the Command are the rivers Kunwari and Vaisali. The description about the main drainage courses has already been given earlier in this chapter.

A glance at the drainage map brings out an important fact that the river Kunwari which flows from south to north-east takes a major turn near the village Daunar (26°32' ; 77°51'). It does this instead of joining the river Chambal, though the ravines of the Kunwari and the Chambal are only about 50 metres apart from each other. The Ambah ridge canal which is constructed in this section separates the ravines of Kunwari with those of the Chambal. Then the river Kunwari flows towards the east, more or less parallel with the Chambal river for a long distance and then both the rivers take a turn towards the south-east. The Kunwari river meets the river Sind just near its confluence with the Yamuna river, instead of joining the river Chambal during its course. The Chambal river meets the river Yamuna, upstream of the confluence of the rivers Sind and Yamuna. The probable reason appears to be that the river Chambal, following the contacts of the Aravalli range and the Chambal scarp with the alluvium has gently shifted southwards towards the river Kunwari due to the
formation of extensive ravines and the consequent headward erosion on the right bank side of it.

As already stated, after the coming in of the major Chambal Complex construction works across the river Chambal, the hydrologic regime of the rivers and streams of the Chambal drainage basin require to be separated into two units. The part of the drainage basin above the hydraulic structures form one unit and the part below the hydraulic structures forms the second unit, in which the Chambal Command area of Madhya Pradesh lies. This separation has a bearing on the surface and effluent water-flows of the Chambal river, which in their turn, have an effect on the recharging and infiltration grounds of the water-bearing formations within the Command. The recharge and infiltration effects of the surface water-flows in the Sind river drainage basin more or less remain the same, for no major hydraulic structures have been built for storage of water across the river Sind and its tributaries except for the small dams like Tighra and Pillua across the river shank and the Pagara and Kotwal across the river Asan. This indicates that the hydrologic regime of the Sind drainage basin is mostly undisturbed.

A glance at the drainage map further brings out the fact that the drainage patterns of the Chambal and the
Sind drainage basins are dendritic. The hilly terrain, which lies to the south and south-west of the study area, is characterised mostly by the presence of numerous low order streams which give a fine drainage texture. But in the alluvial plains, the drainage texture is coarse, which indicates the presence of the higher order of streams. This fact makes the area under investigation to come under the poor drainage density class, in spite of the fact that the rivers Chambal, Kunwari and Sind and their tributaries flowing through the alluvium have numerous ravines adjacent to their banks. Wherever the fine drainage textures are present on either side of the banks of these rivers and their tributaries, the headward erosion helps in the formation of new ravines (Photograph No.13). The intensities of the presence of the ravines increase towards the confluences of the Chambal river with the river Yamuna, Kunwari with the river Sind and, Sind with the river Yamuna. As a consequence, very deep ravines occur in the lower reaches of the Chambal Command (Photograph No.14). Based on this characteristic of the ravines, the alluvium part of the Chambal Command can be broadly classified into two parts; the upper part has a low density of ravine formation, whereas the lower part of the command is dense with the ravines. The headward erosion of the ravines makes the ravines come closer, and sometimes the erosion causes small parts of alluvium to occur as knolls within the ravines.
PHOTOGRAPH NO. 13: Showing the formation of ravines due to headward erosion.

PHOTOGRAPH NO. 14: Deep ravines on the right bank of the Chambal river about half a kilometre west of the village Kuthiyana.
The important peculiar feature that has to be noted is, that after the river Kunu joins the Chambal, no important major tributary joins the river Chambal. As a consequence, the Chambal drainage basin within the Command area is elongated in shape up to its confluence with the river Yamuna. Therefore, a major part of the study area comes within the Sind Drainage basin.

2.9 ORIGIN OF THE RAVINES

About the origin of the ravines, various views have been expressed by a number of authors from time to time, out of which the important ones have been considered. Bryan (1941), Antevs (1952) and Tuan (1966) state that the gullies are the result of climatic changes due to alternate dry and wet periods, resulting in degradation and aggradation conditions. Bennett (1955) and Brice (1966) believe that the ravines are due to the misuse of land, on account of which gullies form. Schumna (1956) has pointed out that the formation of rills in the badland topography is due to the channelling of water of steep slopes during rapid run-off. The rills get enlarged into the gullies and then into the ravines in course of time.

Sharma (1968), attributes the formation of ravines in the alluvial parts of the Chambal river and its
tributaries due to the rejuvenation phenomenon. In support of his contention, he states that in some areas, the ravines are 40 to 50 metres deep in the Chambal alluvium and, the ravines have extensive distribution, beginning from the Kota town and extending beyond the confluence of the rivers, Chambal and Yamuna. The distance between them is about 482 kilometres. As per him (1979, p.4), the area covered by the ravines in the Chambal river system is as much as 3 lakh hectares, out of the 36.69 lakh hectares of ravines present in the country.

In spite of the above mentioned views, to determine the origin of the ravines, the author has studied a number of ravine cross-sections at various localities of the rivers Kunwari, Chambal and Sind. The studies reveal that the uppermost part of a ravine consists of loose soils followed by a thick layer of clay-kankary horizon and then, by a clay bed in depth. A cross sectional traverse from Sabalgarh town to the river Chambal studying the groundwater levels in the existing dug-wells has indicated that the groundwater level which is about 8 to 10 metres below the ground surface suddenly falls down to a depth of about 18 to 20 metres in the dug-wells adjacent to the ravines.

A few auger holes driven into the clay-kankary layer in the vicinity of the village Mangrol indicated that the
PHOTOGRAPH NO. 15: Mudflows through the cracks and fissures at the bottom of clay bed just west of the village Gospur, Morena Tehsil, Morena District, M.P.

PHOTOGRAPH NO. 16: Mudvolcano at the floor of the ravines due to pressure bursts just west of the village Gospur.
PHOTOGRAPH NO. 15

PHOTOGRAPH NO. 16
clay-kankary horizon is water-bearing and the groundwater is under pressure. One hole indicated a pressure as much as 180 kilograms per square metre and the depth of the auger hole was only one metre below the ground surface. In the clay-kankary horizons of the ravines, leakages and seepages of the groundwaters are commonly seen. In the farmlands of the villages Gospur, Mrigpura, Rithona, etc., which lie at the banks of the river Chambal and form the floors of the ravines, mudflows have been seen through the cracks and fissures of the bottom clay bed (Photograph No.15). The dug wells and the flowing wells studied in these village farmlands indicated that the overburden loads over the confined aquifer just balance the uplift pressures caused by the confined aquifer below the clay bed. Wherever the overburden loads are less than the confining pressure of the aquifer underneath, the mudflows through fissures, mudvolcanoes through centres are seen at the floor of the valley of the ravines due to pressure bursts (Photograph Nos.16 and 17). Wherever the overburden loads are greater than the confining pressures of the aquifer, the features mentioned are not to be seen, as in the villages Mahua, Useth, Barhi, Ater, etc., which lie at the right bank of the river Chambal. From such studies, the author has come to the conclusion that there
PHOTOGRAPH NO.17: The supervisor, Shri K.N. Das, studying the mudflows formed by the pressure bursts at the floor of the ravines about 500 metres west of the village Gospur.

PHOTOGRAPH NO.18: Showing the clay-kankary material getting pushed out by the groundwater pressures about 500 metres west of the village Gospur.
PHOTOGRAPH NO. 19

Showing the clay-kankary material getting pushed out by the groundwater pressures about 500 metres west of the village Gospur.
are three stages in the ravine formation. The first stage is due to sheet washing of the loose soils capping the clay-kankary layer, leading to a minor depression. The second stage is the clay-kankary material getting pushed out by the groundwater pressures (Photograph Nos. 18 and 19) within them into the depressions, caused by sheet washing. As a consequence, the caving of the clay-kankary layer with roof collapses takes place. Thus the headward erosion of the ravine progresses. The third stage is the ground bursts (as earlier described), leading to the widening and deepening of the ravines.