A STUDY OF LANDFORMS NEAR JAISALMER, RAJASTHAN

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ABSTRACT

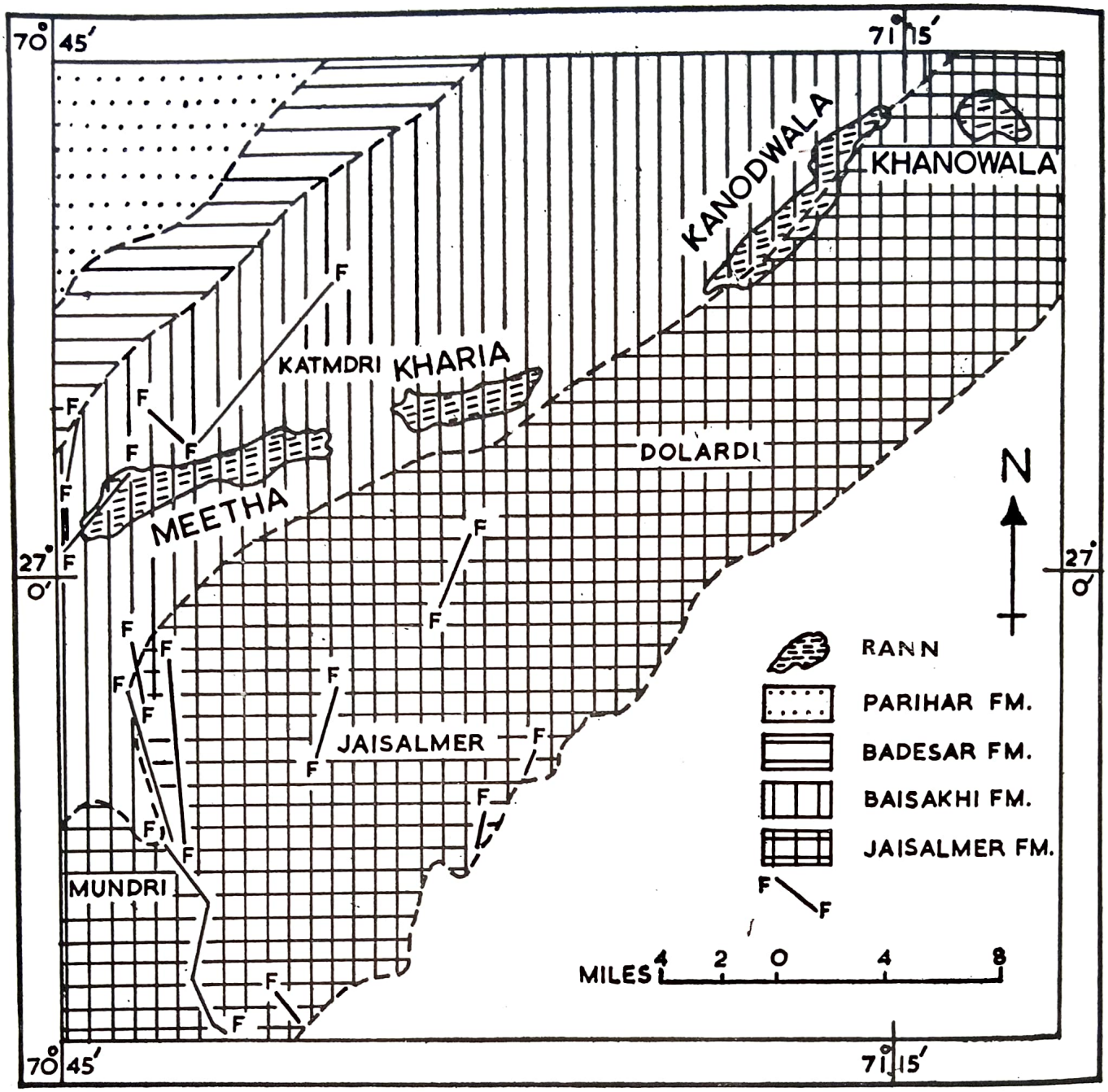
The nature and the geomorphic history of the landforms around Meetha, Kharia, Kanodwala and Khanowala ranns north of Jaisalmer have been discussed. It is suggested that a main NE-SW fault between Jaisalmer and Baisakhi formations affected by the cross faults at a few places resulted into the formation of these basins. It is also indicated that the area has been rejuvenated twice and peneplained before attaining the present shape. The importance of some palaeogeomorphic features has also been discussed.

INTRODUCTION

The Jaisalmer District of Rajasthan has four major salt water lakes which are located near Baisakhi, Baramsar, Kathori and Kanodwala villages in an area between 27° to 27°15′N lat. and 70°50′ to 71°20′ E long. (Map-1). The area is thinly populated and only small villages are located near these ranns. The Meetha and Kharia ranns are connected with Jaisalmer by a metalled road while Kanodwala and Khanowala ranns are approachable by fair weather tracks. The lakes remain dry for most part of the year and get filled only during the rainy season, if there is sufficient rainfall. The mean annual precipitation of the area is 164 mm. The subterranean water is charged with brine. At Kanodwala village the brine is being utilised for the manufacture of common salt. In April 1977 the water was at a depth of 2.8 m from the dry bed of the rann. The vegetation in the area is scarce and is typically desertic in nature.

The area south of the ranns is characterised by the mature topography of limestone country while towards north the highly ferruginous sandstones of Baisakhi Formation are exposed forming low ridges. The region is nearing peneplanation and only small patches of Jaisalmer limestone and Baisakhi sandstones are exposed at places. The larger part of the area has flat erosional surfaces mostly covered by the sand dunes and gravel wastes. On the fringes of these surfaces the country rock is cut deep enough to form linear depressions. The Meetha, Kharia, Kanodwala and Khanowala ranns are located in one of the prominent depressions trending Northeast-Southwest. The slopes are covered by the dune sands up to a considerable height from the base of the ridges and therefore, the actual nature of the slopes could not be observed.

The physiography and geology of Rajasthan have been described by various authors. Blanford (1876 and 1877) gave an account of the physical geography and geology of the great Indian desert, the Thar. La Touche (1902) described the general geology of the western Rajasthan and Heron (1938) presented the physiography of Rajasthan. Narayanan (1964) has published on the stratigraphy of the Rajasthan shelf. Rode (1964) has traced the evolution of the Rajasthan desert on the basis of his sheet hypothesis. Recently, Allchin *et al.* (1978) has discussed the prehistory and palaeogeography of the great Indian desert.



Map-1—Showing the location of Meetha, Kharia, Kanodwala and Khanowala ranns near Jaisalmer, Rajasthan (Modified from Pandey & Chatterji, 1970).

Pandey *et al.* (1964), Ghosh (1964, 1965) and Ghosh *et al.* (1966) have published notes on geomorphological aspects of the salt basins of the Central Luni Basin in western Rajasthan. Ghosh and Singh (1965) have discussed the importance of aerial photographs in geomorphological study of the Rajasthan desert. Pandey and Chatterjee (1970) described the genesis of the Meetha, Kharia and Kanodwala ranns in the great Indian desert and suggested the origin of these ranns due to faulting. The author visited the area during the field seasons 1977 and 1978 to study the geomorphology of the area in detail. In the present communication the results of the field work have been analysed to give a detailed geomorphological concept of the area and the lake basins with emphasis on the origin and evolution of the landforms in relation to the formation of Rajasthan desert.

GEOLOGICAL OBSERVATIONS

The rocks of Jaisalmer and Baisakhi formations are exposed in the area around the ranns, forming flat low ridges towards north and south, as the ranns are mainly developed along the contact of these formations. The nature of the contact seems to be faulted as about 1 m thick band of fault breccia has been observed between the rocks of these formations in a nala section near Baisakhi village. The evidences of faulting on the surface are not seen at other places, therefore it is possible that the rocks are less disturbed towards east and west of Baisakhi. The fault is trending NE-SW along the strike and forms the most important structural feature in the area. Near Kanod, Baisakhi and Baramsar villages the rocks are also seen displaced laterally towards north, possibly due to the complementary faulting across the main fault line. It seems that the highlands of basement rocks between the ranns were developed mainly due to this feature.

Lithologically, Jaisalmer Formation is mainly characterised by limestones, marls and shales and Baisakhi Formation is mainly composed of ferrugenous sandstones. These rocks are of Jurassic age.

GEOMORPHOLOGY

The four ranns are situated in a linear, depressed area almost in NE-SW direction between Jaisalmer and Baisakhi formations. The shape of the ranns is linear and they are separated from each other by the basement rocks or sand dunes. These ranns are fed by numerous small streams joining the lake from almost all the directions. A few larger streams also feed the lakes. The stream channels and the lakes usually remain dry. In general the area presents typical desertic landforms with dry stream channels, mud cracked flat surface of the dry lake beds and smooth peneplained erosional surfaces of the limestones and sandstones mostly covered with gravel wastes and active sand dunes.

The area presents erosional and depositional landforms which can be divided into following important geomorphic units.

(i) Drainage, (ii) Residual hillocks, (iii) Erosional surfaces, (iv) Sand dunes, (v) Saline depressions and (vi) Concealed streams.

(i) *Drainage*

The area is almost completely devoid of any river system. Few small streams are seen mainly falling in the saline depressions. These streams remain dry for most part of the year. Only when there is sufficient rainfall in the area the run-off takes place in the stream channels. The courses are usually broad and shallow. The narrow and deep channels are hardly seen in the area.

(ii) *Residual hillocks*

The area is represented by few ridges of limestones and sandstones around the lakes. In general, the rocks are highly weathered and seen only in patches forming small mounds.

(iii) *Erosional surfaces*

There are two erosional surfaces seen in the area. These surfaces are developed as gently sloping plains at the top and base of the ridges stretched over a considerable area mostly covered by the dune sands and gravel wastes. This unit is represented on the sides of the ranns and forms suitable place for the development of the sand dunes. The upper reaches of these plains are covered by the thick pile of aeolian sand. The lower part con-

sists of layers of rock fragments deposited mainly during torrential and heavy rains by the sheet flow of water. At places the gravel has been found to be coated with red iron oxide presenting desert varnish. These plains have also been found to be dissected by minor streams at number of places. The streams in general die out at the margins of the plains.

The surfaces are characteristically found almost at the same elevation, therefore, forming well marked erosional surfaces, which possibly represent the phases of severe erosion in the geomorphic history of the area.

(iv) *Sand dunes*

Various types of sand dunes have been observed in the area ; the common ones are barchan, longitudinal, transverse, etc. These are active dunes as the sand is loose and exposed to the sand drifting action of the wind and commonly occur on gently sloping plains. The dunes at some places have become almost stabilized. The dunes are also present along the base of the low ridges.

(v) *Saline depressions*

The important geomorphic feature in the area is the presence of four main (Meetha, Kharia, Kanodwala and Khanowala) saline depressions.

A. Meetha Rann

The Meetha Rann is located about 20 km NW of Jaisalmer City on Ramgarh road. It is the largest rann among all the four ranns of the Jaisalmer area. The rann is about 6 km long and 2 km wide forming a depressed area in the limestone country. The longer axis of the lake trends almost NE-SW and northern and southern flanks are characterized by the presence of gravel waste surface up to a considerable distance. The gravel wastes have been developed on the eroded surfaces of the limestones and sandstones, and have become considerably rich in the red iron oxide. At places the iron oxide is so rich that a distinct layer has developed. Near the lake margins a limonitic layer has also been observed. As this surface forms the higher ground it also marks the extent of the flat low lying lake area. Thick dune sands occupy the slopes between the gravel waste surface and the lake bed.

The rann is being fed by many small channels from different directions. Therefore, it also forms an ideal place for the cultivation of wheat as the salt concentration is low. A prominent 20 m wide channel opens in the rann from the north running almost along the road. Another main channel, almost of the same magnitude, meets the rann from south-west. It seems that due to these channels the concentration of salts could not increase significantly in the rann.

The sediments of the lake up to a depth of 3 metres are characterized by the mud coloured plastic clay (Fig. 1). This depth also forms the subsurface water level in the rann and hence, the sediments occurring below this level could not be studied. The important feature observed in the profile is the presence of Gypsum crystals right from the top 50 cm up to the 3 m level suggesting dry climate. At the ground water level the clay also contains a small amount of sand.

B. Kharia Rann

The Kharia Rann is situated between Kanod and Meetha ranns separated by the basement rocks towards east and west. The longer axis of this rann is also almost in NE-SW direction. Towards north and south of the rann basement rocks are exposed forming

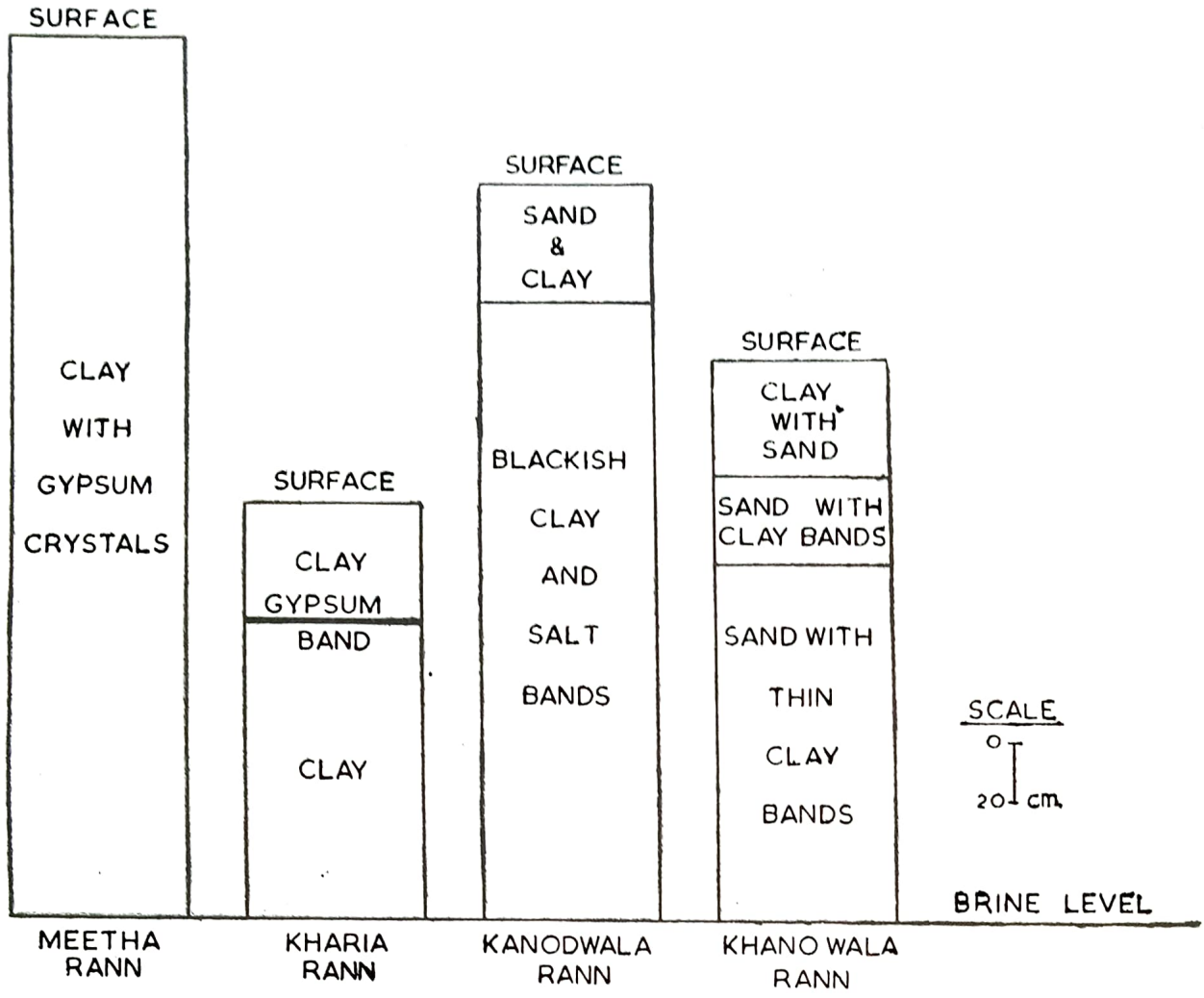


Fig. 1.—Profiles showing the nature of the sediments.

small low ridges with flat gravel waste surfaces. The sand dunes occur on the slopes of these ridges separating the rocks from the rann. The top layers of the rocks are highly weathered and have become hematitic in nature. At places the yellow limonitic bands have also been observed. Besides the hematitic bands, the gravel waste surfaces flanking the rann from north and south were seen up to a considerable distance from the lake. This gravel seems to be of local origin as the pebbles are sub-angular in shape and rich in ferruginous content.

The rann is fed by a number of minor channels from all the sides, but for a prominent 27 m wide channel which has been observed feeding the lake from the eastern margin across the sand dunes and basement rocks. The channel sands are coarser in nature and distinctly different from the fine aeolian sands forming the sand dunes. Further, the channel sand is mediumly sorted having pebbles up to 2 cm in size. In general appearance the sand seems to be something between grit and coarse sand. This channel is located about 400 m north of Pohora village, locally known as "Mandalaya".

Information reveals that during periods of high rainfall the Meetha and the Kharia ranns turn into one unit and the water flows from Kharia towards Meetha through the Mandalaya channel.

The lake sediments are characterised by the presence of mud to brown-grey coloured clay (Fig. 1). At 40 cm from the surface of the lake a 5 cm thick band of gypsum layer

has been observed. It is significant that the brine level (1.4 m) here is at a much shallower depth than at Meetha and Kanodwala ranns and is also not highly charged with salt.

C. Kanodwala Rann

The Kanodwala Rann is situated about 50 km NE of Jaisalmer City. It is about 5 km in length and 1 km in width forming a crescent like depression in the limestone country. In almost all the geomorphic characters this rann compares closely with the Meetha and Kharia ranns excepting that the ridges in the north have become quite prominent here. At places the sand dunes have become stabilized and the area has been brought under cultivation. This rann remains isolated from the Meetha and Kharia ranns even during the periods of high rainfall as it is almost completely separated by the ridges of the basement rocks. Beyond the sand dunes developed on the ridge slopes, the gravel waste surfaces flank the rann towards north and south up to long distances.

The sediments in the Kanodwala Rann are distinctly different than the rest of the two ranns, as the black clay which starts at about 40 cm depth from the surface continues up to 2.5 m laminated with the white salt layers (Fig.1). No idea of the sediments occurring below can be given as the brine starts coming at this depth. The brine is utilized for the manufacture of common salt.

D. Khanowala Rann

The Khanowala Rann is the smallest rann in the area located east of Kanodwala rann separated only by a sand dune area on the surface. It is subcircular in shape and flanked by the sand dunes from all the sides. The basement rocks are not seen near the rann. Number of small dry channels are seen joining the rann from all the sides. The density of the drainage channels is more towards the eastern margin of the rann.

The sediments of the rann are characterised by the clay and sand layers up to the depth of about 2 m (Fig. 1). This depth also forms the brine level and hence the nature of the sediments below this depth could not be studied.

(vi) *Concealed Channels*

At Moolsagar, Badabagh, Baisakhi, Amarsagar etc., seepages of fresh water from rock exposures are tapped for cultivation. They seem to be remnants of ancient concealed drainage of the limestone country. In addition to the above significant features, a few fossil valleys (?) have also been observed in the area which are mainly seen over the first erosional surface suggesting the rejuvenation of the area. These ancient landforms also represent the palaeogeomorphic features.

GEOMORPHIC HISTORY

The interplay of the geomorphic processes over the rocks of Jaisalmer and Baisakhi formations has produced the erosional and depositional landforms of various orders. The sequence of events can be traced mainly from the late Tertiary times. After the deposition of the Tertiary sediments the area was uplifted and peneplained forming the first and also the older erosional surface. Later on, the area was again uplifted and subjected to erosion by various agencies resulting into the formation of low flat topped ridges and gullies. At certain places the presence of fossil valleys (?) also indicates the influence of rapidly flowing streams fed by considerable amount of rainfall suggesting a humid climate in the geological past, which has also helped in the development of the initial topography. Later on, the water started flowing in sheets over the smooth rock surfaces and helped

in the development of extensive gravel waste areas. This process was repeated once again resulting into the development of the second and younger erosional surface, possibly during the Pleistocene times. These surfaces were developed mainly due to erosion, but the role of deposition by sheet flow of water is also significant. Therefore, the term planar surfaces seems to be more appropriate instead of erosional surfaces. However, for the ease in understanding the word erosional surfaces has been retained. These uplifts of the region seem to be related to the main Himalayan orogeny. The evidences of this fact have also been recorded from the main Aravalli region.

It seems that during one of the uplifts of the area the main NE-SW fault has developed. Later on, the complimentary faulting across this fault has helped in the development of the closed/inland basins, all along the fault zone. Since the fault and ranns are very prominent features in the area, it is possible that these were originated during the first uplift. The ranns are being filled by the small streams from all the directions. The prominent channels which feed the lakes are few, but their size indicates that these must have been carved by sufficient run-off in the past. Presently channels have become dry and less significant almost completely filled by aeolian sands, but their beds bear the testimony of the past history suggesting at least better rainfall earlier in the area than at present.

After the development of erosional landforms, the second and the younger phase, mainly of depositional features started in the area which seems to be the result of arid conditions. The excessive availability of sediments in desertic conditions and the water having started flowing subterraneously leaving the surface material to be transported mainly by wind, resulted in the development of sand dunes. In the process, the drainage channels, small landforms, etc. were almost completely burried under the sand. The concentration of salts also increased due to the excessive evaporation in the basins as these ranns had practically no outlet, resulting into the formation of brine. Thus, the fresh water lakes of the past were converted into the saline ranns of the present day.

The evidence of seepages presumably from a few concealed streams in the area, which might be the remnants of the ancient drainage of the Jaisalmer limestone country is of great significance. A wider detailed and careful study of the concealed drainage systems may help in solving the water problem in the area.

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