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The Control of Structure and Neotectonic Activity on the Fluvial Morphology of the Banas Basin, Rajasthan

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Abstract

The Banas River Basin is known for its diversity of landforms with many striking contracts of landforms, tectonic and morphological characteristics. It has been regarded as the important open system in terms of input and output of energy in sub-tropical climate. The Banas Basin is one of the major contributory network to the Chambal drainage system. It is a part of the Pre-Cambrian metamorphic terrain of ancient Indian shield. The present landforms of the basin are characterized by great inequalities having hills, plateaus and vast rolling peneplain dotted with inselbergs and monadnocks. These landforms have been produced by the continual interplay between tectonic activities on the one hand and exogenic processes on the other. The complex entity of landforms peculiarities have been produced through long continued erosion on the Archaean basement and rocks undergone sequential changes throughout geological past. The paper is based on analysis of IRS LISS II FCC and detailed field verification. The study brings out that the Banas drainage basin is characterized by palaeo channels, antecedent river course, river capture and control of neotectonic activity on drainage network.

Introduction

The Banas Basin is representative of a variegated multi cyclic landscape being evolved primarily under fluvial cycles of erosion. The present polycyclic landscape has been produced by the interactions between the structural control including the tectonics and the fluvial geomorphic processes relating to the semi arid and sub humid environment of the south central part of Rajasthan. The Banas Basin is marked by the diversified landscape patterns being influenced by the structure and tectonics of the Aravallis and production of Great Boundary Fault of Rajasthan on the one hand and active fluvial erosional processes on other. The effects of structure and tectonics are found to be much prominent in the elevated and dissected south western part in Udaipur, Chittorgarh region and Sawai Madhopur region with strong relief and steeper hillside slopes. The northern and north eastern portion exhibits the effects of fluvial erosional processes which have fashioned the landscape with subdued relief and moderate range of dissection in the development of varied surface configuration.

The Study Region

The Banas drainage basin in central Rajasthan is asymmetric in nature with respect to the 6th order Hortonian Banas river channel (S.Sinha-Roy, 2001). It is bounded by the Aravalli Range in the west, the Shekhawati, Banganga and Gambhir Basin in the north, the Chambal basin in the south-east and the Mahi ,Sabarmati Basins in the south-west(Fig1). The total catchment of the basin is about 47,052 sq.km according

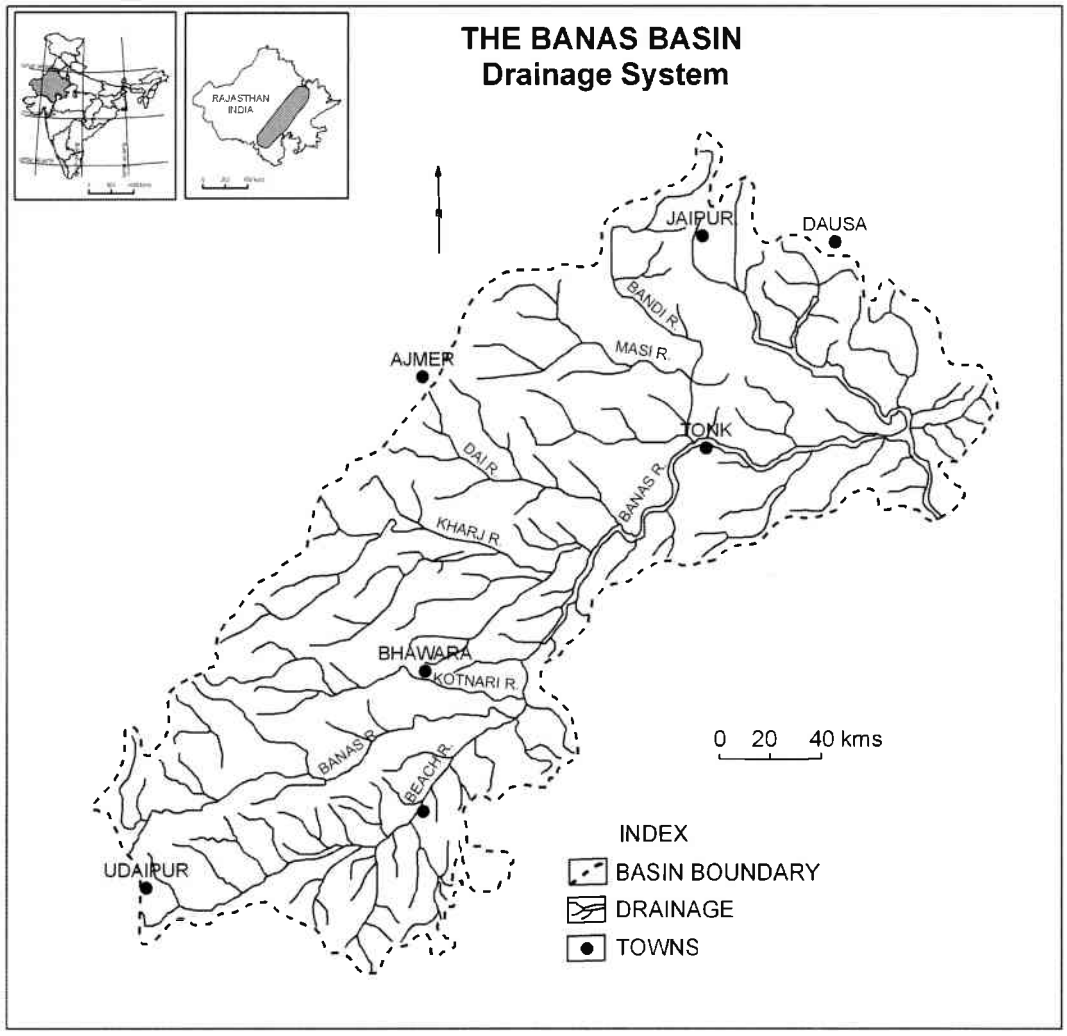

Fig. 1 Location Map Banas River Basin

to the catchment boundaries delineated by the Tahal Consultants (1996) on 1:250,000 scale topographical maps published by the Survey of India.

Objective of the Study

The main objectives of the paper are:

1. to study the relationship between tectonic structure and fluvial morphology of the Banas drainage system, and
2. to analyse the control of neo-tectonic activity in the changes of fluvial network.

Data Base and Methodology

The paper is based on collection of ancillary information from the Records and Memories of the Geological Survey of India. The study of IRS-LISS II FCC have also been made to indentify lineaments, palaeo drainage

and changes in river network. The results of LISS II data have further been verified in the field. The analysis of topographical maps on 1:50,000 have also been made to prepare long profiles of the Chambal, Banas and their tributaries using two variables i.e. length and altitude.

Asymmetric Nature of the Basin

The Banas Basin is very peculiar in the sense that it is characterized mainly by left bank tributaries right from its origin. All left bank tributaries like Chandrabhaga, Kothari, Khari, Dai, Mashi and Morel characteristicaly join the Banas river at a right angle. The only right bank tributary of the Banas is the river Berach which has a network of Gambhir and Menal rivers. Down stream the junction of the Berach with Banas there is no major right bank tributary up to the conflunce of Banas with the Chambal.

The Banas catchment is highly asymmetric in nature in the sense that the main channel does not bisect the watershed. In its middle reaches, the average width of the basin on the left bank is 100 km, while that on the right bank is 30 km. Notably, between Kachola and Devli the minimum width of the catchment is 7 km near Jahazpur (Fig. 1). The adjacent drainage basin is that of the Mej river which is a part of the Chambal drainage basin. This feature of basinal asymmetry needs an explanation. It is proposed to demonstrate here that this feature is caused by divide migration, drainage network adjustments and catchment capture due to neotectonism (Sinha-Roy,2001). The detailed explanation of this feature is given in later part of the paper.

The Banas River

The Banas river originates in the Khamnor hills of the Aravalli range (about 5km from Kumbhalgarh) and flows its .entire length through Rajasthan. The Banas river is a major tributary of the Chambal river. These two rivers meet near Rameshwaram in Khandar tehsil of Sawai Madhopur District. The total length of the Banas river is about 512 km being ephemeral and usually dries up during the summer.

The Banas from its origin flows eastward up to Rashmi and then it takes north eastern turn upto the conflunce of Berach with the Banas. From this junction the river takes northern direction and the trend continuous upto Tonk. The course of Banas within this limit is very significant in the sense that the river cuts across various ridges at Kachola, Rajmahal and Tonk. The sinuosity of river increases in this area. From Tonk downstream the river takes easterly direction and takes right angled turn near Malarna Dungar and joins the Chambal near Rameshwaram.

The course of the Banas throughout its long profile is meandering. It appears that the river once might have been flowing on the peneplain and then the peneplain has been uplifted and the river has established it course on the same meandering course as a result of upliftment (Sharma, H.S. 1987).

Antecedent Drainage Development

Antecdent drainge relates to one type of inconsequent with valleys transverse to geological structures. Infact such antecedent valley antidates the structure acrosss which it is cut and if the river initiated on a gentle erosion surface is warped up due to crustral

ANTECEDENT COURSE AT RAJMAHAL

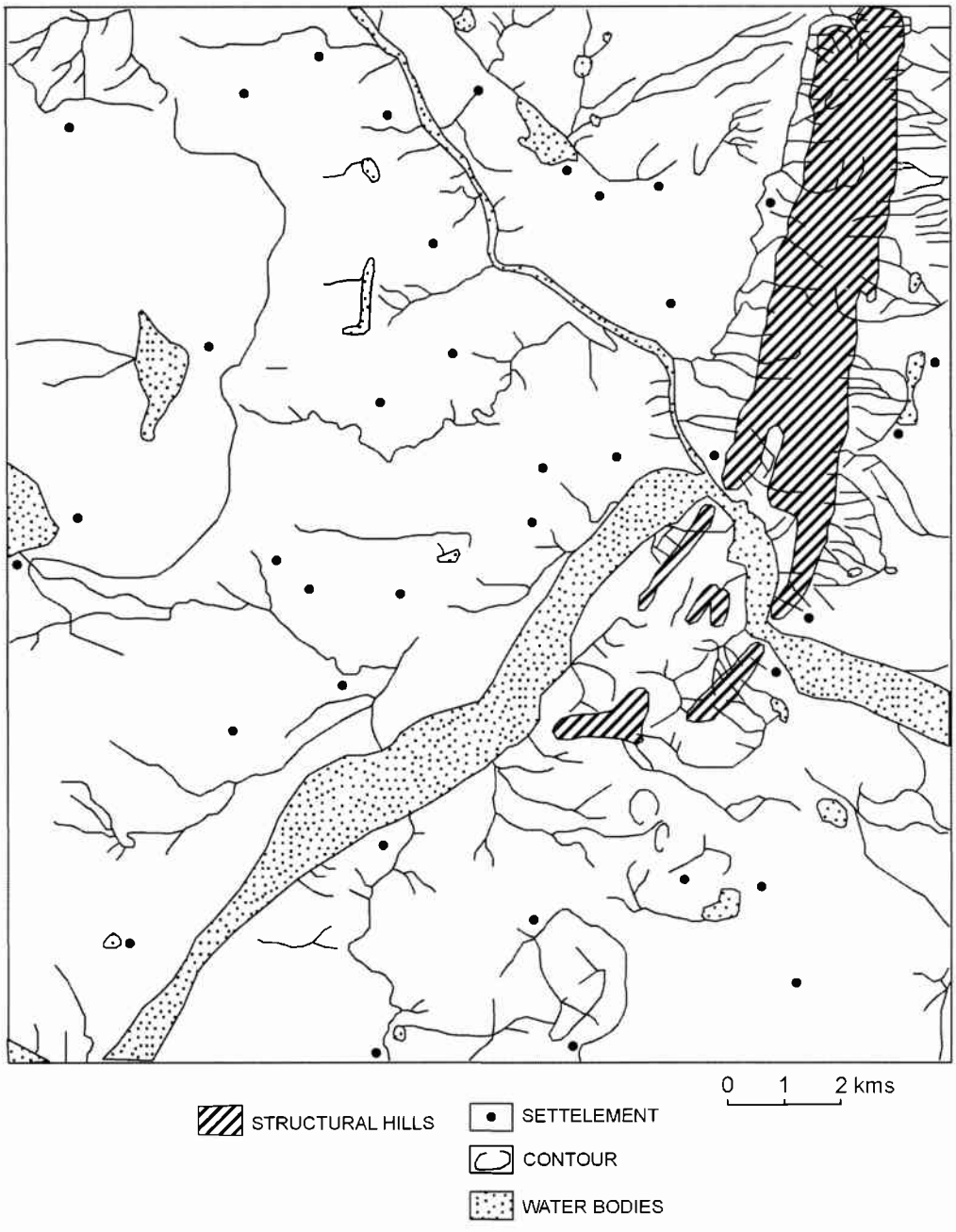

Fig. 2

disturbance, they are termed as antecedent river(Schumm, 1977, Bloom,1979).

The present author has considered the middle Banas basin relating to the development of the inconequent drainage of the Banas. The course of Bãnas at Sorli and Rajmahal is unrelated to the structure of the country rock.The section of the Banas near the Rajmahal area is very interesting and significant from geomorphological point of view (Fig. 2). Here the Banas at Rajmahal wandering through the extensive and wide alluvial plain, breaches two great isolated flat ridges of the Delhi quartizites in a gorge. The height of these ridges is about 300 metres from the river bed. One can infer that in the case of the Banas, its course across the ridges was in existance before the Aravalli peneplain was warped in the Cretaceous period and cut down vertically as the plain arched (Heron, A.M., 1938). The course of Banas here is a good example of antecedent river action. The Banas has its valley over the extensive peneplain and was flowing freely over this peneplain. Later on the peneplain was uplifted and the river continued its development as the peneplain arched. Chatterji and Bagchi (1957) are also of the same opinion that the Banas is a good example of antecedent river action. The course of Banas here is meandering and steep slopes and cut banks are common significant fluvial features of this section.

Analysis of Long Profiles

The analysis of long profiles of the Chambal and Banas and their tributaries like Berach, Menali and Dhund has proved to be a very useful for the study of morphology, identification of planer surfaces and development of valley forms and the other characteristics of the valley from the longitudinal point of view. The long profiles of the Banas and its tributaries have been

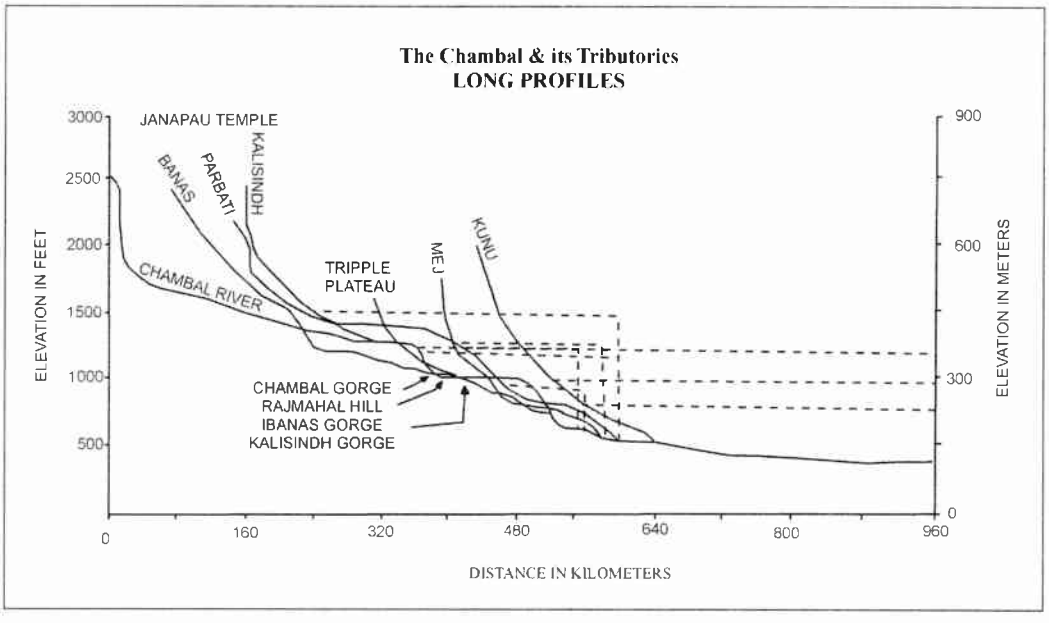

Fig. 3

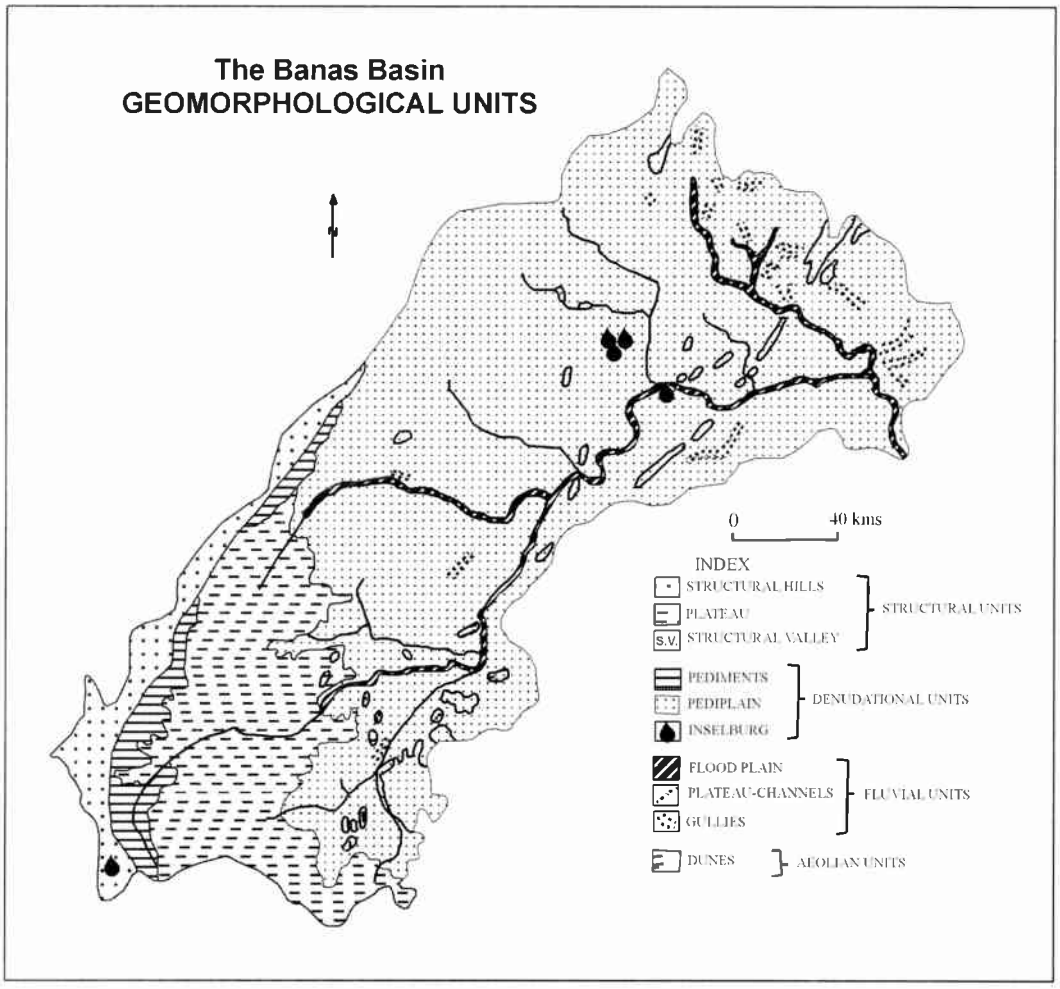

Fig. 4

drawn using mainly two variables (length and altitudes) from topographical sheets (Fig. 3). The profiles indicate characteristics knick points or break and varied slopes. The long profile of Banas indicates two breaks in the slope at an altitudes of 400 meters and 300 meters. Similarly the long profile of the Berach also indicates two breaks in the long profile at the height of 700 metres where the river in the form of river Ahar passes through a deep channel for about a distance 3.5 kms (Dhinwa ,1981). The river here does not make any waterfall but there is certainly a break in the continuity of the profile. There is another break at a height of 400 metres near Chittourgarh. This break indicates the existence of river terraces. The most important fact which emerges from the study of thalweg profile of Menali. The existence of two waterfalls at the height of 500 meters are not due to any structural control but they are knick points indicating the interrupted courses of the Menal river.

Migration of the Banas

The case of the migration of the Banas has been studied on landset imageries and in the field between Rashmi in Chittorgarh District and Hamirgarh in Bhilwara district. Between these sites the Banas had migrated leaving boulders and pebbles of 20 cm to 25 cm diameter on the right bank. The existence of a gravel ridge at Uncha and of a narrow terrace between the present course of the Banas and the gravel ridge indicate that river had rejuvenated simultaneously with its migration. The terrace surface is characterized by deep black soil. From the existence of big boulders on the paleao floodplain of the Banas, it can be inferred that fluvial conditions then were very strong as compared to the present, indicating a shift in climatic conditions from humid to less humid(Sharma, 1987).

An excellent instance of the migration of the Banas and the control of lineaments can be studied in the lower reaches south of Malarna Dungar near the confluence of the Morel River. Figure 4 depicts paleao-channels of the Banas river which have migrated southward as inferred from the channel scar terraces (Fig. 4). The figure also shows other fluvial features such as natural old lavees, gullies, palaeo-flood plain and channel bars. A field investigations in this part of Rajasthan reveal that the area is a region of high soil moisture possibly represent old inter lavee area with finer heavy sediments. It further indicating probably the greater flow regime in the Banas during recent geological periods. It has been pointed out earlier by Sharma (1973 and 1976) that that the Banas was formerly an independent river flowing across the karauali plateau towards the north-east. But as a consequence of the Great Boundary Fault movement the river got diverted towards the south taking an abrupt right-angled turn and joined the Chambal.The above two examples of the migration of the Banas lead us to conclude that tectonic events have played a major role in the migration of the Banas river course.

Structural Control On Streams

Many authors have described neotectonic features from Rajasthan (Sinha Roy, 1986;Sen et al, 1983;Dassarma, 1988). Post-Vindhyan (Jurassic?) regional uplift of the Aravalli range and formation of various erosion surfaces have been postulated (Heron, 1938; Sharma, 1987). The exact ages of the two prominent dislocation zones in the Banas Basin, namely Banas Dislocation Zone (BDZ) and Great Boundary Fault (GBF), are uncertain. However, several geomorphic features suggest that these dislocation zones are neotectonically active (Sinha Roy, 2001).

The study of lineaments and drainage of the Banas Basin indicate close relationship. The lineaments of Banas Basin have been identified using IRS LISS II data. The lineaments of this region have been classified into three types namely major, Intermediate and miner.(Fig. 5)

The major neotectonic features recognized in the Banas Basin are : 1. Strike slip fault 2. Normal faults 3. Graben structure and 4. Thrusts (Fig. 6). However first order topography , linear truncations of hill fronts with faceted scraps and hanging valleys, faulted gossons and silcretes grabens are also important neotectionic features in the Banas Basin (Fig.6).

Fig.6 Fault systems and neotectonic features of the study area. Note the horst-

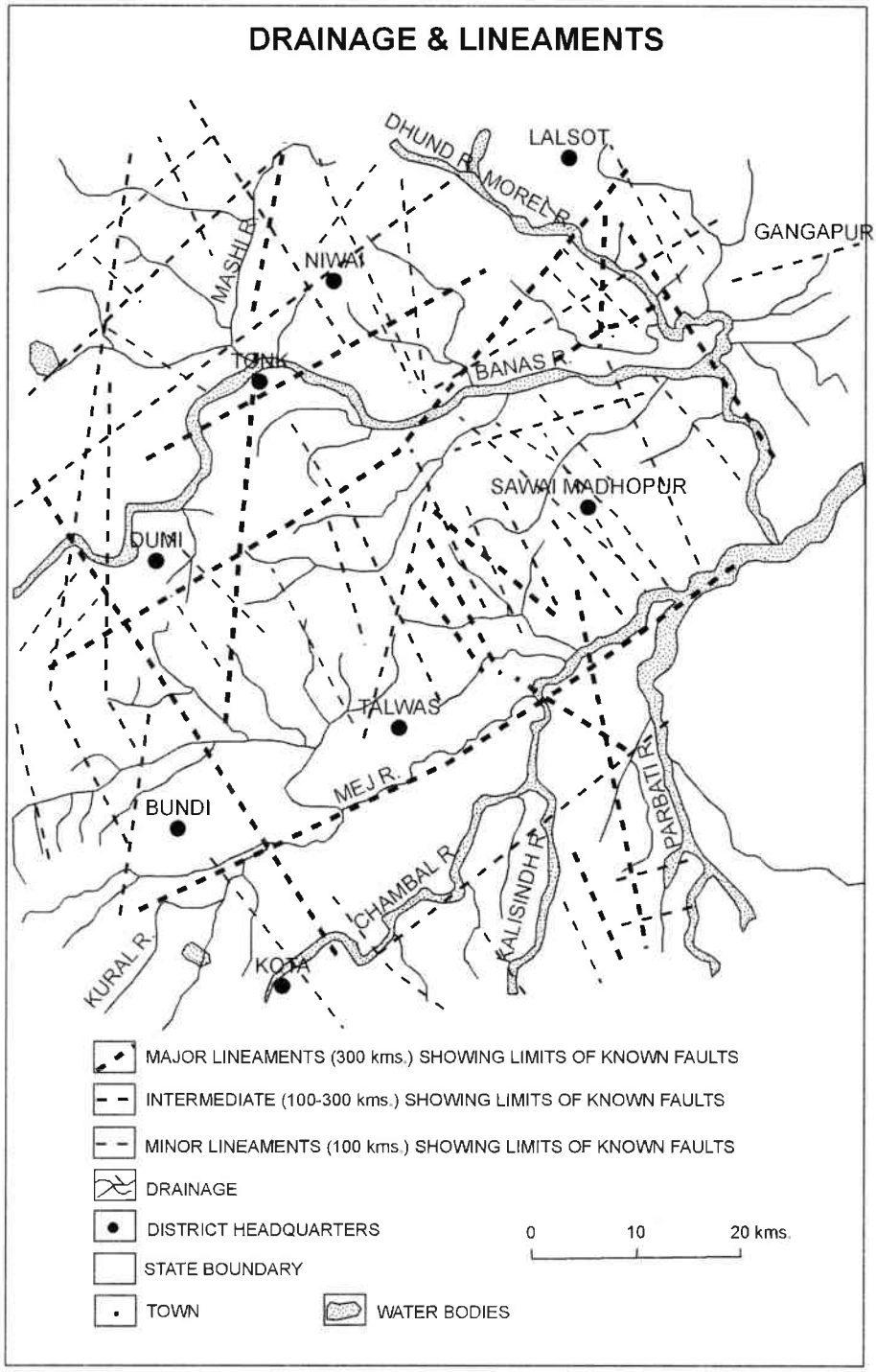
DRAINAGE & LINEAMENTS
DHUND R.
MOREL R.
LALSOT
GANGAPUR
MASHI R.
NIWAI
TONK
BANAS R.
SAWAI MADHOPUR
DUMI
TALWAS
MEJ R.
BUNDI
PARBATI R.
CHAMBAL R.
KALISINDH R.
KURAL R.
KOTA
MAJOR LINEAMENTS (300 kms.) SHOWING LIMITS OF KNOWN FAULTS
INTERMEDIATE (100-300 kms.) SHOWING LIMITS OF KNOWN FAULTS
MINOR LINEAMENTS (100 kms.) SHOWING LIMITS OF KNOWN FAULTS
DRAINAGE
DISTRICT HEADQUARTERS
STATE BOUNDARY
TOWN
WATER BODIES
0
10
20 kms.

Fig. 5

graben structures caused by longitudinal and transverse faults, and the fault-controlled course of the Mej river (After Sinha Roy S., 2001) .

The major lineaments identified in the region show limit of known fault. The major lineament is trending north east to south west. The another intermidiate lineament is trending from north east to south west is known as Tonk - Bhilwara lineament. There are several lineaments from north west to south east intersects major lineaments. It is interesting to note the major tributaries of the Banas like Berach, Kothari etc follow the course of intermediate lineaments. The right angle turn of the Banas from downstream the confluence of the Morel indicates the tectonic control on the diversion of the Banas. The Banas River draining the south eastern part of Rajasthan flows north west to south east and just before joining the Chambal it takes an abrupt turn nearly at a right angle towards south. This direction of flow is neither the general slope nor the strike of the rocks. It seems this diversion of the Banas indicates that once the Banas might have been flowing independently parallel to Sawai Madhopur Karauli line of hills (Fig. 5). The diversion of the river seems that it has resulted either by the tectonic movement along the boundary of the Gwaliars and the Vindhyans or by progressive stream piracy. The former seems to be the major cause of diversion of the Banas (Sharma, 1979).

This is interesting to observe that most of the drainage lines dissecting the Banas peneplain are tectonically controlled. Knick points on profiles of the Banas and its tributaries like Berach and Menal, are remnants of old valleys abundant flood plains and multitier terraces in the piedmont zones and Banas river, are indicative of the control of neotectonic features. In the Bhilwara gneissic complex rolling plain of the basin and braided straight courses of the major rivers are superposed on older meandering drainage pattern suggesting the control by neotectonic features.

Evidence of River Capture

Sinha-Roy(2001) has brought out new facts about neo-tectonically controlled river capture in the Banas and Chambal Basins. In the geomorphic and tectonic background, Sinha-Roy (2001) has proposed a model of catchment capture (Fig. 7). The different stages of this feature could not be dated as no Quaternary age-dates of relevant material in the study area are available. It has been proposed by Sinha-Roy that "in the initial stage, the SE segment of the Banas drainage basin extended up to the Vindhyan hills which formed the watershed between the Banas and the Chambal basins (Fig. 7 a). In the next stage (Fig. 7 b) neotectonic movements produced the antithetic longitudinal faults in response to reactivation of the Great Boundary Fault (GBF). These and the cross-faults divided the area into structural blocks, which show evidence for differential vertical movement. Among these blocks, the most active was the Shakargarh block where longitudinal faulting created grabens and half-grabens. The Banas watershed migrated toward NW to occupy the present day position at the graben shoulder. The residual hill trail gives an approximate location of the intermediate position of the divide, before leaping to the present position. The new Mej river course came into existence at the graben floor. Its drainage network, superposed on that of the Banas, developed due to headward erosion in the left bank whose inward slope was

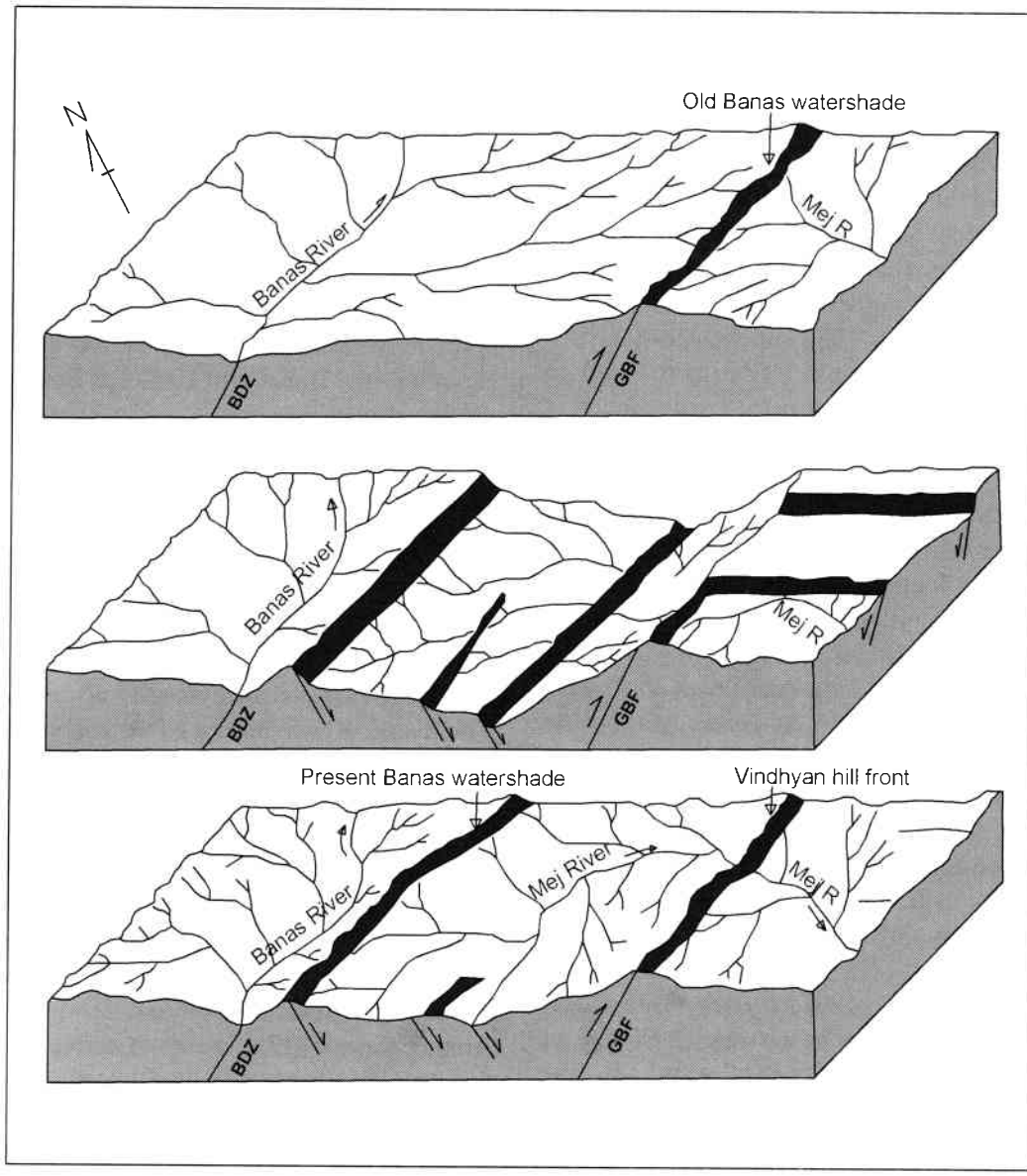

Fig. 7 Model showing the stages of capture of a part of the Banas catchment by the Mej drainagesystem. ***a***, Stage A – Initial disposition of the Banas and the Mej drainage systems, the Banas watershed being located at the Vindhyan plateau edge, marked by the GBF; ***b***, Stage B – Neotectonic movement formed half-graben structure in a part of the Banas right catchment, which was captured by antecedent Mej system and the Banas drainage divide migrated NW; ***c***, Stage C – Present-day disposition of the Banas and the Mej drainage systems (After Sinha-Roy, 2001).

controlled by the tilting of the downthrown block. The main tributaries ofthe Banas river were captured by the Mej. The slope of the right bank segment of the Mej river basin was controlled by the rotational movement of the block whose bounding faults were the normal longitudinal fault in the NW andthe reactivated reverse GBF in the SE. Eventually, the Mej river cut through the Vindhyan hills at a location where a transverse fault crossed the GBF to form a part of the Chambal drainage system. Thus, a part of the Banas catchment was lost to the Chambal basin (Fig. 7 c). Judging from the active headward erosion of the present Banas watershed by the Mej river and its tributaries, it is postulated that with only 7 km extension of these channels across the watershed near Jahazpur, the Banas main channel is likely to be captured by the Mej river in the future. The Banas river will then stand beheaded."

Conclusion

The study showed that the Banas Basin is representative of a variegated multi cyclic landscape being evolved primarily under fluvial cycle of erosion. It has a diversity of landforms with many striking contrasts of landforms, tectonic and morphological characteristics. The study reveals that neotectonic activities have played an important role in drainage adjustment. The Banas river course follows the Banas Dislocation Zone for a long distance showing low amplitude sinuousity, being controlled by Banas Dislocation Zone splays. In the Banas Basin a set of two E-W trending longitudinal faults control the course of the Banas and its tributaries. Antecedant course of the Banas at Rajmahal-Bisalpur is also

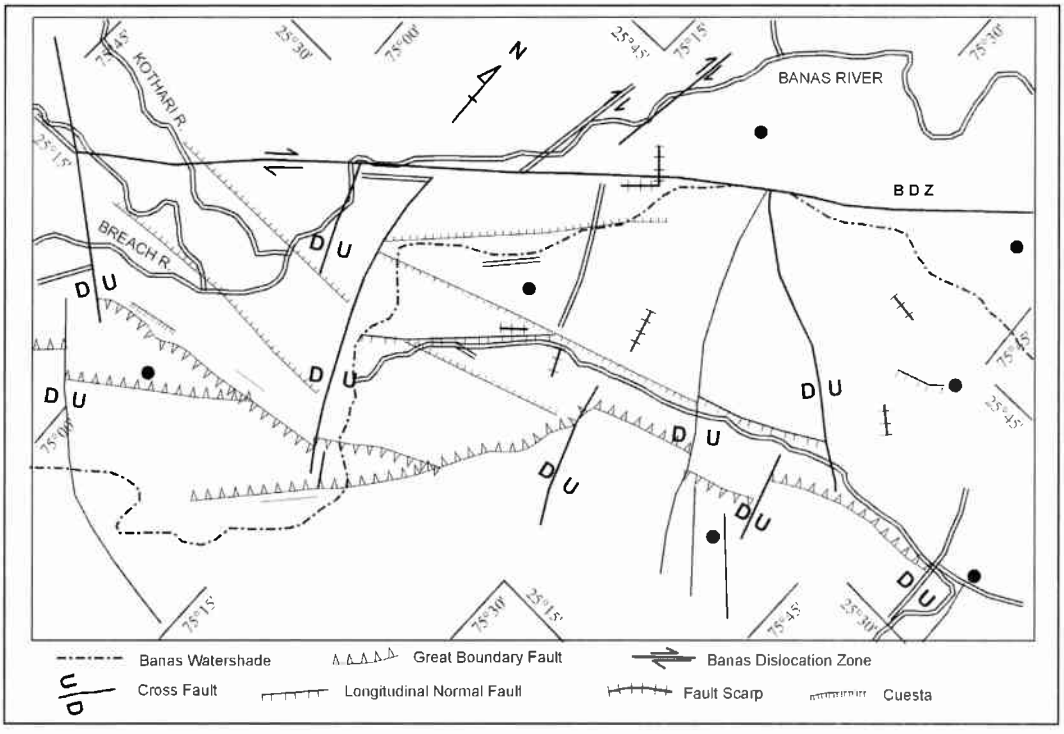

Fig. 6

a noteworthy fluvial feature in the study area. Capuring of right bank tributaries of the Banas near Jahazpur by the Mej river as propounded by Sinha-Roy(2001) appears convincing.

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