Journal of Indian Geomorphology
Volume 1, 2012 • ISSN 2320-0731
Indian Institute of Geomorphologists (IGI)

acb publications
Kolkata, India
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Geomorphology and Palaeoenvironmental Characteristics of Quaternary Sediments of Purna River Basin, Maharashtra

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Abstract: *The lithology and faunal assemblage of the alluvium of Purna valley, Maharashtra, suggest that the older Quaternary alluvial deposits are of Late Pleistocene age. The sediments of colluvial slopes in the upper reaches and the alluvial fills along the main stream reflect the monsoon environmental fluctuation between arid and semi arid period in the late Pleistocene. The black soil was formed under humid condition in early Holocene. The depositional environment of coarse gravel sediment in upper reaches of Purna valley indicates that the streams are of relatively high energy with prevalent bed load transport, whereas fine clay and silt formations in the lower reaches connote that the streams are of low gradient and of high sinuosity.*

Introduction

Geologically, the Purna valley area of Maharashtra, India, is covered by Deccan basalt formations comprising of near-horizontal lava flows. These basalt flows indicate fissure type of lava eruption during late Cretaceous to early Eocene period. In the Deccan Peninsula India, Quaternary deposits are primarily fluvial. They are confined to very narrow belts along rivers showing little variety in landscape features (Dikshit, 1970). The rivers flow in an erosional landscape, with bedrock being Deccan basalt. The extent of the alluvium is a few kilometres at the most and its thickness rarely exceeds 20 m. In spite of the limited extent and volume of the alluvium, some localities have preserved Early Pleistocene sequences and even remnants of Pre-Quaternary sediments have been identified (Mishra *et al.* 2003).

Fluvial forms and processes are closely associated with the morphogenetic regions (Stoddart, 1969). Semi arid regions of lower latitudes have strong imprints of humid tropical climate of the Neogene (Rajaguru *et al.*, 1993). The fluvial systems in the semi arid areas are subject to wide fluctuation in discharge. Although river channels can be classified as meandering or non-meandering or bedload or washload dominant (Schumm, 1977), the nature of the semi arid rivers is complex because they are subject to marked fluctuation in water and sediment discharge (Baker and Kochel, 1988, Rajaguru *et al.*, 1993 and Kale *et al.*, 1994). Mishra *et al.* (2003), for example, in a case study from upland western India found evidences of fluvial responses to the late Quaternary climatic change.

The general predominance of coarse fractions in semi arid rivers is responsible for less stability and more mobility of sediments (Rajaguru and Kale, 1985 and Rajaguru *et al.*, 1993). Such streams are therefore, unstable and dynamic and are characterised by constant channel migration. Further, the semi arid rivers quickly respond to the changes in the hydraulic regime because of their higher average rate of motion of coarse sediments.

Geomorphic setting

Purna river, a tributary to the Godavari originates in Ajanta ranges and flows in a general southeasterly direction till it meets the latter near Kantheshwar in Purna *tahsil* (block) of Parbhani district, Maharashtra (Fig. 1). The study area is bounded by latitudes 19°06'N and 20°43'N and longitudes 75°27'E and 77°05'E and it covers an area of 4,435.42 km^2 in Parbhani and Hingoli districts. The average channel slope of the Purna is 3.8 in 1,000, which is sufficiently steep for the movement of gravels in its upper riches. From the source up to 15 km, the river flows through the high relief of Ajanta ranges at the height of about 700 m above sea level. In this zone, the tributary streams form colluvial or pediment slopes. The Purna valley in the rest of its course flows on a large, gently undulating erosional surface and the tributary streams transport very little coarse material. It is only the Dudhana, which joins the Purna at Sangameshwar in Parbhani district, which supplies some coarser material to the main river. Here the main stream is incised 10 to 12 m into its former floodplain on which fertile black soils have developed. The area is intensely cultivated at present.

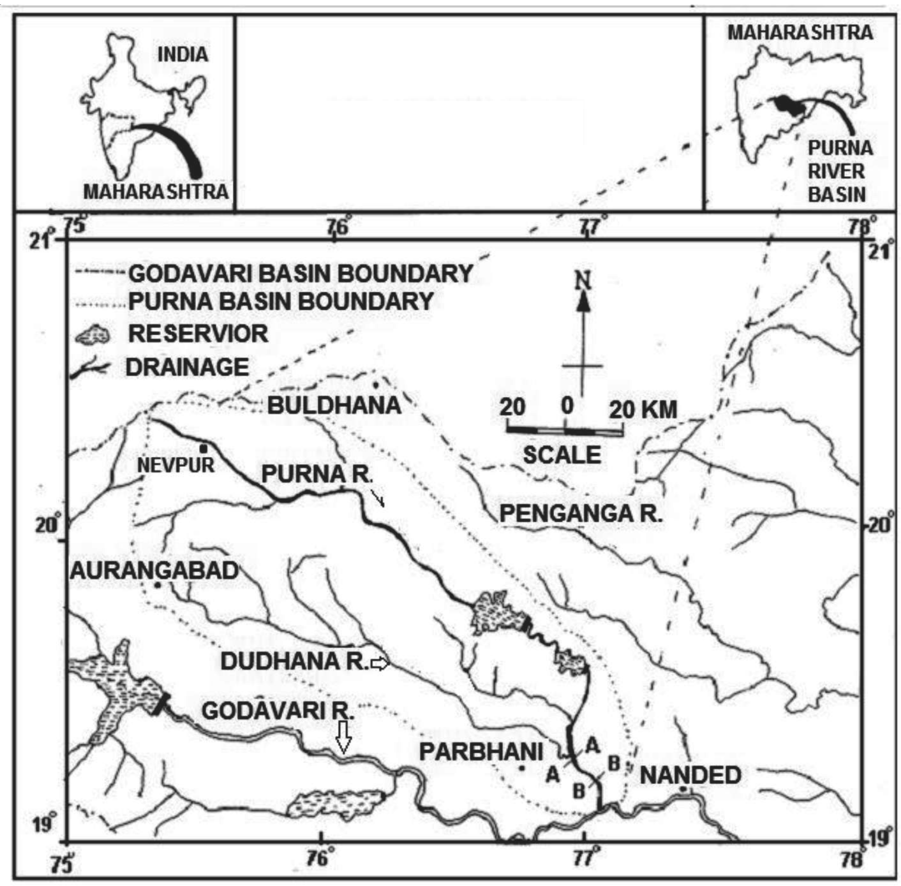

Figure 1. Location map of the study area

Table 1. Stratigraphic Succession of the Study Area (modified after Tiwari, 1999)

Era	Period	Formation
Quaternary	Holocene	T0 – Present Floodplain
	Late Pleistocene	T1 – Older Floodplain
	Early Pleistocene	T2 – Pediplain
Tertiary and Mesozoic	Early Eocene to Late Cretaceous	Deccan Trap Basalt

Stratigraphic description of study area

General stratigraphic succession of the area is given in Table 1.

Quaternary sediments are found along the slopes of the residual hills, towards the divides in the upper riches of the Purna basin, and along the main river channel. The first category of Quaternary deposits is colluvial in nature, while the second is alluvial. These are described below.

Quaternary colluvial sediments

The colluvial sediments of the Purna river basin in the source region has shallow mantle of 2 to 7 m thickness, while further downstream at Nevpur (Aurangabad district, Maharashtra) the thickness of colluvial sediment is 10 to 15 m. The surface is covered with an immature brown soil. In these areas just below the steep slope of the residual hills of basalt, distinct pediment slopes without the veneer of sediments are seen. The colluvial sediments in the area lie on the base of weathered basalt. In a well section of colluvial sediments at Nevpur in the upstream region of the Purna river, an exposure of a massive (~15 m thick) sediment with valley floor consisting of hardpan type calcrete underlying the entire Quaternary colluvial sequence is observed (Fig. 2). It overlies the weathered basaltic bedrock. The gravel bed overlying this massive calcrete contains a few patinated basalt flakes, which indicate an earlier Pleistocene age for the basalt deposits (Bopardikar, 1970; Mishra, 1982). Boulders of this massive calcrete are noticed in basal gravels of the entire source area.

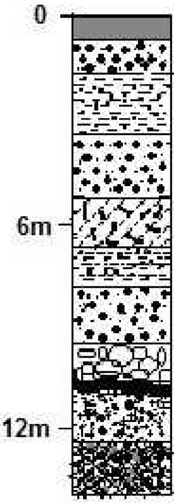

Figure 2. Quaternary colluvial sequence at Nevpur in the upstream region of the Purna River basin (see Fig. 1 for location).

Quaternary alluvial sediments

Alluvial plain of the Purna river shows three terraces namely, T0, T1 and T2 in increasing order of elevations (Table 2). These terraces are described as suggested by Tiwari and Bhai (1997) and Babar, (2008) with reference to the soil types and soil characteristics.

Table 2. Lithostratigraphy and morphostratigraphy of Purna alluvium (after Tiwari and Bhai, 1997 and Babar, 2008)

Terrace	Origin	Lithostratigraphy	Lithology	Soil characteristics and type
T0	Depositional— Present floodplain	Purna Formation: 8 to 10 m thick	Uncalcified silty sand and gray silty clay	Gray, fine silty clay (Entisol)
T1	Depositional / erosional— older floodplain	Nandgaon Formation: 10 to 18 m thick	Light grey silty and brown to grey brown calcareous silty clay	Dark brown clay (Vertisol)
T2	Depositional— pediplain	Katneshwar Formation: 12 to 20 m thick	Brown to dark brown calcareous clay	Dark brown clay (Vertisol)

Terrace T2: The oldest terrace T2 is the most widespread in the pediplains of the basin and has an elevation range of 500 m in north to 380 m in south indicating a drop of 120 m over a distance of 180 km. In general it comprises of grey sand and silt along with grey brown to dark brown calcareous clay. This formation has been designated as Katneshwar formation of early Pleistocene age (Babar, 2008).

Terrace T1: This terrace has a general westerly slope with elevation of 400 m in the north to 376 m in south, showing a drop of 24 m in elevation over a distance of 130 km. This terrace is mainly formed of grey sand and brown calcareous silt. At the confluence of Dudhana and Purna river the terrace material comprises of light to dark grey inter-layered sequence of silt and sand with incipient calcification, coarse to medium sand and consolidated gravel layer at the base. This formation has been designated as Nandgaon formation of late Pleistocene age (Babar, 2008).

Terrace T0: It comprises of sands of lower point bar, channel bars and grey sand and silt of the present floodplain. The sediments are unoxidised and non-calcified. Unconsolidated cobble and gravels are predominant in the channels. This formation has been designated as Purna formation of Holocene age (Babar, 2008).

In the study area, three lithostratigraphic formations have been identified on the basis of order of superposition, nature of sediments, sedimentary structures and pedogenic characters (Babar, 2008). Characteristics of these formations are given in Table 2. The general slope of Purna alluvial plain is towards south. It is to be noted that the break in slope in the transverse profile of the alluvial plain is prominent and quite common between terrace T1 and the present floodplain T0 (Babar and Kaplay, 1999).

Environmental characteristics of quaternary sediments

In the present study the depositional environment has been deduced on the basis of the sedimentological character of the fluvial deposits. The deposits in the upper reaches of the Purna comprise of rounded to sub-rounded pebbles and cobbles of basalt, chalcedony, agate, chert and quartz set in a matrix of granular sand and silt (Fig. 3). The presence of sand and silty materials between coarser sediments may have been derived from sheet floods and the overbank deposits of small ephemeral channels. These features suggest that the colluvial slopes in this area were formed under a fairly arid climate. During periods of aridity as seen in the presence of angular calcrete pebbles, calcretised root, sand, wood, etc. have also formed in the sediments.

Figure 3. Quaternary sediments along the left bank of Purna river at Mathkarla showing gravel bed at base (hammer is 30 cm long).

During the early Pleistocene the deposition of sediments, both gravels and silts, interrupted by small scale deepening occurred in sedimentary basin along the river (Babar 2000). Pleistocene gravel deposits also provide evidence for the weathering of basalt. Older gravels are often found to be sparse in basalt pebbles compared to modern river gravels. In the Godavari basin, because of basin deepening the high level gravels are found to occur about 20 m above the present river level at a number of places (Mishra 1982). Near Paithan, basalt pebbles larger than 50 mm in diameter are completely absent from such high level gravel, which is dominated by chert. In the Purna river also such small scale deepening occurred in the source region of the river and caused the reduction in size of basalt gravels. The conspicuous fluctuation in the climate between aridity and semi-aridity is well reflected in the early Pleistocene deposits (T2). The presence of calcretes in the Quaternary sediments and presence of vertebrate fossils *Stegodon insignis*, *Bos nomadicus*, *Elephas hysudricus* and *Elephas sp.* from the Purna river at Yeldari dam pit (Rajaguru, 1969) suggests that alluvium (T1) is older than the sediments of the present floodplain and is possibly of late Pleistocene period. Badam (1979) also reported similar fossils from construction trench at Jayakwadi project at Paithan on Godavari river and at Majalgaon dam site on Sindphana river in the adjoining parts of the study area. The Holocene terrace (T0) has been correlated to the mid-Holocene period of global aridity (Sadakata *et al.*, 1995). As the Holocene started, the southwest monsoon was rapidly strengthened. Under the fairly heavy rainfall conditions the Pleistocene alluvium was weathered into black soil. Contemporaneously, the floodplain along the main stream was deeply entrenched. The development of gullies is one of the main landform changes in this region during Holocene (Babar, 2000). The climatic control is quite evident in the basin, which is reflected in the early Pleistocene deposition of sediments, both gravels and silts, interrupted by small scale deepening in sedimentary basin along the river. The phases of erosion can be linked to warm and wet periods while the episodes of deposition are associated with cold and dry phases (Babar 2000 and Mishra 1982).

The presence of gravel at the base of the sediment layer in different localities indicates different periods of Pleistocene aridity. In the lower reaches of Purna basin the sediments are medium to fine grained sandy silt and silty

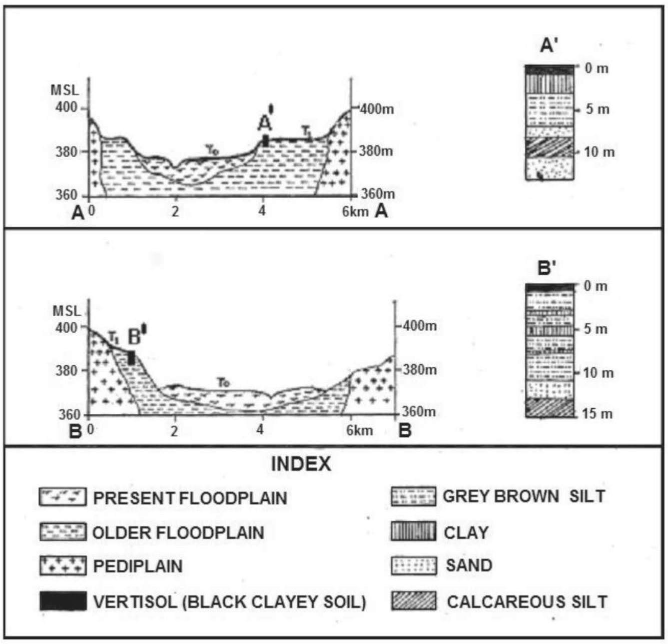

Figure 4. Cross sections along A-A and B-B (Locations given in Fig. 1) and stratigraphic sections in downstream region of Purna river at A' (Nandgaon village) and B' (Purna town).

clay (Fig. 4). The deposits are complex in nature and might have resulted from vertical stacking and amalgamation of a number of low sinuosity channels.

Conclusion

The colluvial deposits are distributed in the upper reaches of the Purna river. In its upstream region, colluvial deposits consist of hardpan type calcrete underlying the entire Quaternary colluvial sequence. A comparison of the present channel deposits with older alluvium of late Pleistocene reveals that the latter are of sandy pebbly in nature and thus are coarser than the present ones. This indicates that the rivers during the closing phase of Pleistocene had relatively low competence. The Quaternary alluvial deposits along the river course were deposited during periods of aridity as seen in the presence of angular calcrete pebbles, calcretised root, sand, wood, etc. The alluvial soils formed during humid episodes. The fill terraces in the entrenched valley along the main stream were formed not only during the arid episode, but also during the late Holocene. The climatic control is quite evident in the basin where phases of erosion are linked to warm and wet periods and episodes of deposition are associated with cold and dry phases.

Acknowledgement

The author gratefully acknowledges the guidance and suggestions of Dr. R.D. Kaplay, School of Earth Sciences, Swami Ramanand Teerth Marathwada University, Nanded (M.S.).

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Paper presented in the 22nd IGI Conference, held at Allahabad University during 29–31 October, 2009.
Date received: 27 January 2010
Date accepted after revision: 10 October 2012