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# Channel Patterns, Depositional Behavior and Sediment Composition of a Tropical River, Northeast India: A Study from Source to Sink

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**Channel patterns:** The present paper deals with the channel patterns, depositional behavior, hydrodynamic regime ,textural and mineralogical properties of the Ajay , (N24°35'; E86°15'-N23°35'; E88°10**')** a perennial, tropical meandering river that flows for a length of 290km covering a catchment area of 6760 sq km in the northeastern part of India .With an overall flow trend from northwest to southeast, the river originates from the pre-Cambrian Archean Gneissic complex of Chotonagpur Plateau at Sarwan and drains for about 50% of its course through the hilly terrains and some outliers of Gondwana sedimentaries of the Permo-Carboniferous age. Finally, the river traverses through the Older Pleistocene and Recent alluvium to meet the River Bhagirathi (the Ganga) at Katwa. The Ajay has a meandering channel with degree of sinuosity varying from 5.1 up to a distance of 8km from the source, 3.7 at and around Bolpur, 220-225 km downstream, and 1.7 at and around Katwa near its confluence with the Bhagirathi. The meander wavelength generally ranges from0.8-2.6km and the radius of curvature of meanders from 0.6-1.5km. The wavelength and radius of curvature of meanders maintain a positive linear correlation. The channel width ranges from 30-150m from its upper to the lower stretch. The river is fed by 10 major tributaries at different reaches from the north and the south. The average gradient is low with a few knick points arising from differential erosion of hard and soft rocks. The elevation of the river bed near its source is 303m and at its confluence is15m.Lateral shifting of the river with abandoned old channels and cut offs , particularly at its middle and lower stretches is evidenced from the aerial photographs.

The climate is tropical. The river maintains a high discharge of 15000-20000 cusecs during August and September (freshets) of every year**.** Monsoon rain causes spasmodic flood flow when the discharge becomes torrential to the tune of 36000cusecs for a day or two. Secondary freshets also occur during the months of July and October. Very low discharge prevails during December to April, the dry season of the year when the discharge values range from 200-1000cusecs and the river level runs close to the thalweg level. The river level rises 3.2-5.0m above the thalweg during periods of high discharge when the river overflows its bank totally submerging the megaripples that occupy the higher relief areas of point bars. Unusual heavy precipitation (33- 38cm in 2/3 days) during freshets cause havoc annual floods in the Ajay (24 major floods in the last 100 yrs) with abnormal rise of river levels. Such flash floods of Ajay discharge huge sediments to the Bhagirathi and lead to spasmodic bedload movements of the Bhagirathi near Katwa, the downstream migration of such sediments even affects the navigation channel of the Hugli River (lower stretch of the Bhagirathi) beyond the Calcutta Port.

**Depositional behavior:** Point bar deposits, mostly asymmetrically crescentic in plan, characterize the inner concave banks of meander bends and are formed by lateral accretion of sediments as registered by crude accretion marks of alternate scroll ridges and swales. At Kesia near Katwa, a crescentic point bar is however, located on the outer convex bank of meander and stands as a ground evidence of shifting course of the river. The bars attain maximum widths at the points of inflection of meander whereas; the two tapering ends along the upstream and downstream directions terminate against the riffles or crossings. The elevation of the point bars during dry seasons ranges from 0.9 to 1.8m. above the water level and from the water margin to the bank this elevated relief is attained either gradually or in two to three steps.

The first order undulations produced by accretion marks on the point bar surface often get obscured by the occurrence of various bedforms like the megaripples, ripples of many different kinds (Table1) and flat surfaces which have definite time and space relations as regarding their formations on the point bar surface. Small linguoid ripples, made of medium to fine sand, are the dominant bedforms; their lee directions parallel the point bar margins. They form under normal time flow conditions of the river. Megaripples, made of coarse to fine sand, are always localized marginal to the banks on higher relief areas of point bars; their lee directions are oblique to main flow direction and are produced during flood time flow. The flat surfaces, made of pebble to fine sand, occur sporadically in between the ripples and megaripples .During normal flow, the channel floors are occupied by small linguoid ripples with lee directions pointing to the direction of flow. Inter-megaripple troughs are often covered by thin veneer of mud drapes deposited during the high water sand still .The waning flood water produces various kinds of small scale ripples of different orientation depending on flow diversifications .Pools are located at the distant bank off from the river channel and are occupied by thick mud deposits which exhibit mud cracks on desiccation. Thin mud drapes over ripples on point bars are torn into curled mud cracks on desiccation and create non-tidal fluvial flaser beddings. Ripple drift laminations in-phase to ripple-drift laminations (Type2) and parallel laminations occur as top stratum deposits of the natural levees. The surface bedforms in L-shaped vertical trench surfaces cut parallel and perpendicular to the flow directions reveal various kinds of stratifications (Table1) which are useful for determining the current directions in a unidirectional fluvial system. It is revealed that small scale linguoid ripples and the small scale trough cross stratifications are the best indicators of current directions in unidirectional flow (Table2). The megaripples, in sections cut parallel to flow, have revealed one or two 'reactivation surfaces' within large-scale planar cross-stratifications and are formed due to superimposition of successive flood phases during the formation and migration of megaripples. As interpreted from primary sedimentary structures the Ajay belongs to the lower part of lower flow regime to the lower part of the upper flow regime. Texturally, the river shows a gradual reduction of grain sizes from very coarse gravelly sand to silt sizes A gradual increase of log normality of particle sizes downstream suggests "multiple stage abrasion process" for the formation of sand sized particles, whereas, silt sizes were formed by splitting (chipping) off larger grains and not by progressive size reduction.

**Mineralogically,** 80- 85% of quartz, 15-20% feldspars of both alkalic and plagioclase varieties and heavy minerals 3-5% constitute the composition of the Ajay sediments. The heavy minerals in the decreasing order of abundance are as follows: amphibole > tourmaline > opaques> epidote >zircon > garnet. The mineral composition of Ajay shows a close relation with bed rock and catchment rock mineral composition.

**Table1. Interrelationships of surface structures and internal stratifications**

| Surface structures | Internal structures |
|---|---|
| Crescentic ripples (both linguoid and lunate types, and also small scours | Small trough cross stratification |
| Elongate hollows, small channels and rill marks of point bars, and inter dune troughs | Large trough cross stratification |
| Megaripples | Large planar tabular cross stratification |
| Dome- shaped dunes | Wedge cross stratification |
| Straight or wavy marks | Small planar tabular cross stratification |
| Flat beds | Horizontal stratification |
| Planes of erosion | Lines of separation between structural units. |

**Table2. Variability of cross beds and their applicability in determining the current directions**

| Types | Small Trough x- beds | Large trough x-beds | Large planar tabular x beds | Small planar tabular x- beds | Wedge x-beds |
|---|---|---|---|---|---|
| Variability (in deg) | 0-15° (lim±15°) | 0-90° (lim±90°) | 0-60° (lim±60°) | 0-135° (lim±135) | 0-180° (lim±180°) |
| Application | Excellent | Not good | Moderate | Bad | Bad |