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Terraces And Springs In A Portion Of Rajmahal Highlands: Geomorphic Evolution Of Ghutkandar River Basin

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ABSTRACT: A River Basin is considered as an important unit to understand the geomorphic and geologic history of an area. The Rajmahal Traps have an interesting history of their origin and evolution. The adjacent areas of Rajmahal Traps have been subjected to face a number of events since the Upper Carboniferous to ongoing Quaternary. Lithologically the area is characterized by basalt, glacial boulder deposits, gravel bed, laterite and alluvium *etc.* It has unique and complicated geological succession. Geomorphic features like straight channel with sharp bend, river terraces, antecedent channel, springs *etc.* are commonly visible in the study area. In a tectonically influenced area, terraces and springs not only play an important role to understand the geomorphic evolution but also has geohydrological importance. Springs are formed where ground water table is influenced due to land subsidence, faulting, removal of surface soil cover *etc.* River terraces, generally considered as erosional feature are imprints of tectonic upheavals or rejuvenation. The Ghutkandar basin is characterised by a number of springs. Therefore, this work is a humble attempt to analyse the geologic and geomorphic evolution of the Ghutkandar basin, a portion of Rajmahal Highlands and to find out the geohydrological potentiality and importance.

Keywords: Rajmahal Highlands, Rajmahal Traps, Alluvium Upland, Intertrappean bed, Spring line

Ghutkandar Basin: A Brief profile

Location: Ghutkandar River Basin is located in the eastern portion of the Rajmahal Highlands. The river basin consists of some portions of two states of Jharkhand (Dumka district) and West Bengal (Birbhum district). The river basin is extended from 24° 05′ 45"N and 24°12′30"N latitudes and 87°31′30"E and 87°45′20"E longitudes (Fig.1). The total area and perimeter of the basin are almost127.8 sq.km. and 66.59 kilometres respectively. This elongated basin has maximum east-west and north-south extensions are 20 km. and 8 km. almost. Ghutkandar is a tributary of the river of Dwarka, a tributary of Mayurakshi which finally meets the river of Ganga in east. Ghutkandar flowing from north-west to south-east in such a way that it divides the basin area into two unequal parts along north-south direction. Two-third basin area exists on the north and rest of in south. This may be an outcome of tectonic events and geological structure. Relief: Surface features like relief, slope *etc.* give clue to the development of land-forms under the purview of fluvial geomorphic cycle of erosion (Prasad, 1985, p. 206). The topography of the area is quite undulating to steeply sloping with the elevation ranging from 300m to 70m above M.S.L. In the eastern and central portion of the basin a number of isolated flat-topped hills are found. Besides these, scarps, cliffs, structural hills, residuals hills are found. Spatial variations were caused by Himalayan orogenic movements and Chotanagpur epeirogenic movements. Malik has mentioned the impact of epeirogenetic uplift on the spatial relief variations (Malik, 2014, p.49). Actually these residual hills make the relief more pronounced. Tectonically it is assumed that the area is uplifted along with whole of the Chotanagpur plateau during the Himalayan orogeny. As a consequence its erosional capacity is increased. The whole area has been dissected by a number of streams. Maximum ruggedness and relative relief are observed in the western part of the basin where first order streams cut their valley deep accompanied with headward erosion. General slope of the basin is from north-west to south-east.

Climate: The area comes under the Eastern Fringe area is characterized by humid tropical monsoon (Bay of Bengal branch) climatic phenomena (Pandey, 1958, pp. 46-47). The Wet July receives maximum rainfall (almost 371mm) and the driest month is December (2.2 mm). Maximum temperature reaches in the month of April (38ºC) and the minimum in January (10.6ºC). Tropical disturbances like *Kalbaisakhi, Loo etc.* influence the diurnal temperature range. Climate influences the weathering and soil forming processes which indirectly control the agricultural practices. This wet-dry climate is favourable for chemical weathering as well as laterisation process.

Soil: The Rajmahal Uplands are characterized by lateritic soil. High-level and low-level both types of laterite are common (Pascoe, 1963, pp. 1960-1963). Gravelly High-level laterite is opposite to low-level laterite which is dark heavy loams and clay (Prasad. 1973, p.49). In the extreme west sand dominated soil is found. Gravel, pebbles and boulder mixed Laterite soil is observed on the Rajmahal basalt which covers the central area. Comparatively fine grained laterite and lateritic which is supposed to drift-soil from hill top seen in the eastern part of Rajmahal hills. Old fine grained Ganga alluvium soil is found along the pedimental zone towards eastern confluence zone. Water penetrates fast in the weathered zone of hills and its downward movement is restricted when it reaches fresh rock. Due to seepage the surrounding foothill alluvium soils become wet. Caliche nodule base hard alluvium covers the extreme eastern part of the basin. Active geomorphic processes are exfoliation, block disintegration, oxidation, hydration, fluvial processes, sheet wash, rill and gully erosion, laterisation, deposition *etc.* Deposition occurs mainly in the eastern pedimental zone and onwards part of the basin.

Vegetation: The Rahmahal Highlands are characterized by the moist deciduous (Prasad, 1973, p. 53). *Sal* (Shorea robusta) trees are found unanimously. Previously, before Santal Rebellion the flat topped hills were covered by *Sal* but at present due to huge unrestricted deforestation forests' density has been being reduced. Plantation on the hills is found near the tribal villages.

Objectives

The main objectives of the present study are as follows

- To understand the geomorphic evolution of the Ghutkandar basin
- To identify the basic properties of the study area
- To explore the geohydrological importance of the Basin

Evolutionary History

Rajmahal Highlands are described as the concrete base for the study of geology in Indian context. The study area has earliest Archaean to recent Quaternary rocks and sediments. One of the most important event in the study area is the volcanic eruption which makes Rajmahal Traps. Such a huge volume of basaltic magma on the continental crust has profound effect on crustal evolution (Singh, Kumar & Singh, 2004, p. 759). The huge pressure is supposed to produce depression of crust. The area has evolved through long time as started from Precambrian but major changes started from Cretaceous and ended with the 3rd phase Himalayan Orogeny, the last and most powerful movement of Middle Miocene in Pleistocene (Sinvhal, 2010, pp. 53-58, Misc. Pub., 2009, p. 36).

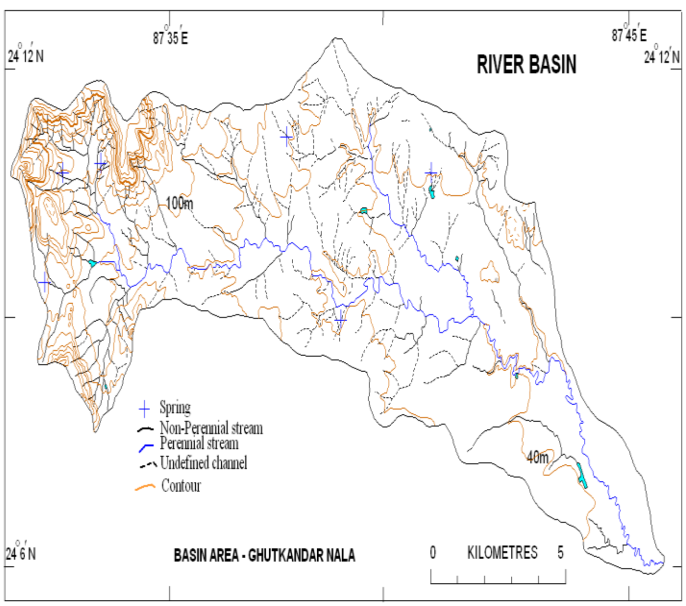

Fig.1

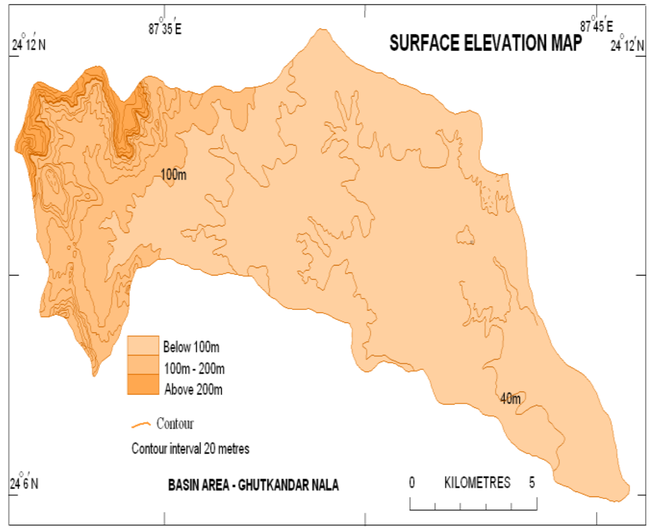

Fig. 2

History of evolution of the Ghutkandar river basin is briefly discussed as follows. Lithologial map shows the rocks coverage and the profile also exhibits the underlying structure (Figs. 4 & 5). Chotanagpur Gneissic Complex (CGC) constitutes the oldest lithounits of south western Bengal and exposed in the western part of the Birbhum. CGC is bordered in the north by Gangetic alluvium, in the south by Singhbhum Mobile Belt and on the north east by the Rajmahal Basalts and in the east CGC continues under the unconsolidated or semi-consolidated sediments of Bengal Basin (Misc. Pub., 2013, pp. 10-13). CGC is overlain by Gondwana formations and Rajmahal basalt. During Upper Carboniferous (Gondwana Super Group) the area was manifested by Gravity Block Faulting in Chotanagpur Granitic Gneiss terrain and glacial boulder bed deposition (Misc. Pub., 2008, p. 36). Rocks of Gondwana Supergroup characterized by huge coal deposits along with sandstone with shale beds exhibit their typical development in the faulted troughs found in the western margin of the ranges. The outcrops are scattered and discontinuous. This coal bearing Barakar is concealed coalfield occur below the cover of Upper Gondwana, Rajmahal Traps and Tertiary sediments (Misc. Pub., 2013, p. 30). Gondwana sediments are overlain by Rajmahal traps (Singh and Singh, 1969, p. 18). The Kerguelen large igneous province (LIP) includes Cretaceous Rajmahal basals on the eastern part of Chotanagpur plateau is characterized by ten flows separated by intertrappean beds(Kent, Pringle, Muller et al. 2002, pp. 1141-1142). Rajmahal Highlands consist of Rajmahal hills or Rajmahal Traps and Alluvial Upland (Prasad, 1973, pp. 28-30). The Ghutkandar River Basin is lying on the Rajmahal basalt. The Rajmahal traps form hill tracts with flat topped or terrace like topography. The Rajmahal trap consists of dark, very hard, amygdular, and fine-grained basalt and dolerite and andesites. (Misc. Pub., 2013, p.15, Singh and Singh, 1969, p.18)). Rajmahal hills consist of basaltic lava traps with interstratifications of shale and sandstone. The traps basalts are interbeded with sedimentary deposits of white and grey shale, carbonaceous shale, sandstone, grit *etc.* The sedimentary bands are deposited in intervals between two volcanic eruptions (Sydney & O'Malley,1925, p.5).The

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intertrappean beds vary in thickness occur between flows composed of silicified, grayish white quartzose, sandstone and shales are deposited over the eroded surfaces of traps and thickness vary along the strikes (Chakrabarti, 1985, p.142, Misc. Pub., 2013, p. 15). Intertrappean sandstone bed is visible near Jhikra village (24°09′42"N and 87°32′33"E). The Tertiary rocks overly Rajmahal basalts (Misc. Pub., 2013, p. 11). Tertiary rocks in the form of pebbly grit, red shale, rare mottled clays, gravel or conglomerate and gritty sandstone occur as small patches in Quaternary terrain in close association with glacial deposits, laterite and older alluvial formation. In Pleistocene the Rajmahal Hills was uplifted almost 700 to 1000 ft and got their present elevation (Ahmad, 1965, p. 25). Mainly during middle Miocene, due to stain produced by the collision, folding and faulting caused a rapid uplift of Himalayan ranges was the most powerful one (Sinvhal, 2010, pp. 55- 58). Himalayan mountain ranges elevated due to successive uplifts and as a consequence south of the Himalaya were converted into a depression (Ahmad, 1965, p. 17). Later this subsided portion (Indogangetic depression) was filled by the Ganga alluvium. Hussain also has accepted this view and concluded that, this stable older alluvium, Bhangar comes under the Lower Ganga Plain is formed by the downwarping of a part of the Penensular India between Rajmahal Hills and the Meghalaya Plateau and subsequent sedimentation by the Ganga and Brahmaputra rivers (Hussain, 2008, p. 36). The eastern part of the Rajmahal Highlands comes under Alluvial Upland formed due to coalescence of alluvial fan is less fertile than Ganga plain (Prasad, 1973, p. 30). This upland alluvium was deposited during middle Pleistocene Period lies above the flood limits and contains concretions and nodules of impure calcium carbonate or '*kankar*' (Hussain, 2008, p.33). In the basin area Laterites are common as duricrust over all types of rocks. The laterite is produced due to weathering of the volcanic rocks which cover the higher flat-topped hills (Prasad, 1965, p. 59). In India Monsoon climate has been established at the beginning of the Eocene epoch (Pascoe, 1963, pp. 1969-1972) is supposed to begin of laterisation also. High level laterite forms the capping of Rajmahal hills and low-level laterite forms isolated patches in the eastern part of Rajmahal hills adjacent to the Ganga alluvium (Prasad, 1973, p. 49). This happened during Late Tertiary when huge laterisation and alluvium filling were occurred. Thickness of laterite varies from 6m to 15m. Neotectonism causes local upliftment of the laterite (Misc. Pub., 2013, p. 16). A good number of laterite quarries are there. For road construction laterite is collected from these zones and until the unweathered basalt basement is reached it continues. Besides the laterite and alluvium deposits glacial deposits are also found at places. The Talcher Sseries (Orissa) of Gondwana System provides good number evidences of glaciations (Hussain, 2008, p.27., Singh, 1958, pp. 30-31). Glacial gravel beds overlay on Rajmahal basalt which is overlain by old alluvium (Fig. 3). 'Gondwana rocks contain a boulder bed at the base which is of glacial origin' (Misc. Pub., 2013, p. 14) but most probably these boulder beds are recent origin (Pleistocene glaciations). '

Fig. 3, *Source: near Auturia village*

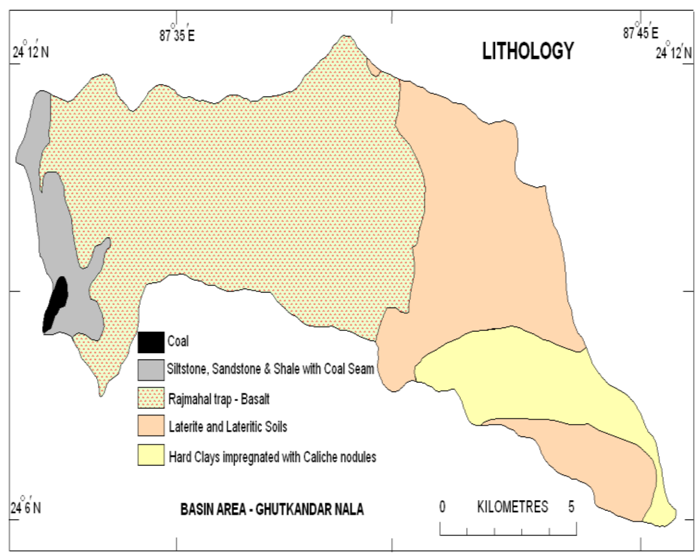

Fig. 4

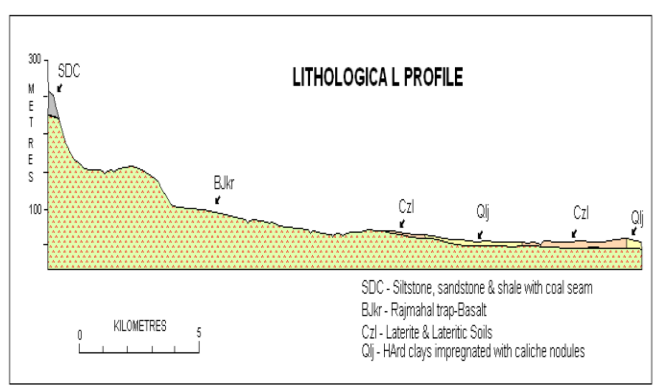

Fig.5

Evidences in Support of the Evolution of Ghutkandar River Basin

Ghutkandar is a fault guided spring recharged river. Diversion of the stream courses, spring lines, abrupt changes in the depth of water level *etc.* all indicates existence of fault (Misc. Pub., 2013, p. 8). Generally faults. Horizontal and vertical displacement of rocks are associated with upliftment. River terraces act as an evidence of upheaval. According to seasonality perennial, intermittent and ephemeral rivers are categorized as influent and effluent. Influent streams are those the stream feeds groundwater as opposite to effluent stream which gains water from groundwater. A stream may convert from effluent to influent depends on the length and geological formations. Perennial streams and ephemeral streams are basically effluent and influent respectively. Intermittent streams are those which receive water from spring or surface run-off and temporal (Gordon et al., 2013). Ghutkandar is perennial in nature but recharged by springs. Therefore, some evidences have been taken to analyse these facts.

(i) Springs

Springs are scattered on all over the basin area. According to topographical map total six springs are obtained. Besides these a number of discharge points have been found in the field. Actually where the overlain unconsolidated rocks in the form of small rounded hills intersect the impermeable basalts or unweatherd rocks water comes out on ground. It not always like spring but in low magnitude and makes the surface wet. On an average springs are located from 80 to 100 metres elevation (Fig.). A line can be drawn to join the springs *i.e.* spring line which denotes the weathering front. Weathering front denotes the junction between weathered and fresh rock (Mabbutt, 1961 cited byThornbury, 1969, p. 46., Ollier, 1975, p.121). Thickness of weathering zone also may be calculated form spring line. Springs also arise due to faulting. Quaternary upheaval of Himalayan mountain has left several structural deformation as stated earlier. Consequent faults make the stream perennial.

(ii) River valley

The basement of the river valley is formed by Rajmahal basalt which is visible upto middle course but in the lower reach alluvium is found on the valley floor as the thickness of alluvium increased. Actually the stream is superposed on the Rajmahal basalt. “A superposed river is one whose course was initially formed on the rock surface and is imposed on a different underlying rock and structure by downcutting through the cover” (Morisawa, 1985, p. 170). Here the stream cuts the alluvium bed and is lying on basalt. The basaltic basement resists the water to percolate and the coming spring water makes the river perennial. The river side residual weathered highlands are very susceptible to water. Whereas the weathering zone meets the un-weathered base rock the downward movement of water is ceased. Therefore, at times the river becomes aquifer. Shallow depth of the water level in wells ranges from 2.5 to 3.5 metres is found here.

(iii) Terraces

Rutimeyer accepted W. M. Davisis’s viewpoint and considered that a new phase of erosion is reinitiated by reuplift and consequently erosion terraces are to be seen as indicator intermittent uplift and rejuvenation (Pal, 1986, p-9, Bell, 2007, p. 103). Therefore, terrace is an important parameter for geotectonic and geomorphic study. Paired terraces reflect mature lateral planation with rapid incision. Unpaired terraces indicate slower and more continuous rejuvenation. The former is more cyclic and the later is non-cyclic and each terrace plain is a remnant of old valley floor but it always not in continuous form rather is traceable over a long distance (Morisawa, 1985, p. 124., Pal, 1986, pp-8-11). In the basin area discontinuous terraces with narrow low magnitude terrace scarf or benches are found.

(iv) Straight channel with sharp bend

As stated earlier, in Pleistocene a depression formed in the eastern portion of Rajmahal Highlands *i.e.* in Ganga plain (Rajmahal gap) which is filled by the Ganga alluvium later. The river Ghutkandar cuts it valley and at present is flowing on Rajmahal basalt. The river shows one side alluvium wall and another bank boulder deposits in several places. Ghutkandar takes sharp bend (almost 90º) at a number of places (Fig. 6). The channel becomes straight in small segments and behaves like a fault guided river. From the geological history and the valley feature it can be said that the river is fault guided river. The river may be as an antecedent river which is able to continue its flow after structural deformation as it shows terraces also.

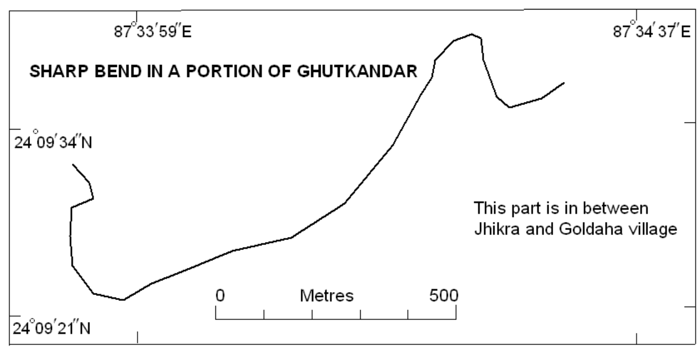

Fig. 6

(v) Laterite

Pascoe has classified laterites as High level or Primary laterite (above 2000ft) and Low level or Secondary laterite (below 2000ft) but exception is there. He also mentioned that presence of silica mainly in form of quartz is generally indicates ex-situ or detrital laterite (Pascoe, 1963, p.1962).Sometimes low lying laterite appears to be non-detrital and formed by the decomposition in-situ. High-level laterite is found on the hilly areas of the western part produced by in-situ deep weathering (Fig.7). Low-level detrital laterite also observed in the eastern zone where surface elevation is not more than 100m. Reddish Low-level laterite, loose and friable contains ferruginous concretion locally known as *morum* (Ghosh & Maji, 2011, p. 1737). Huge rill and gully erosion produce bad-land topography (Fig.8).

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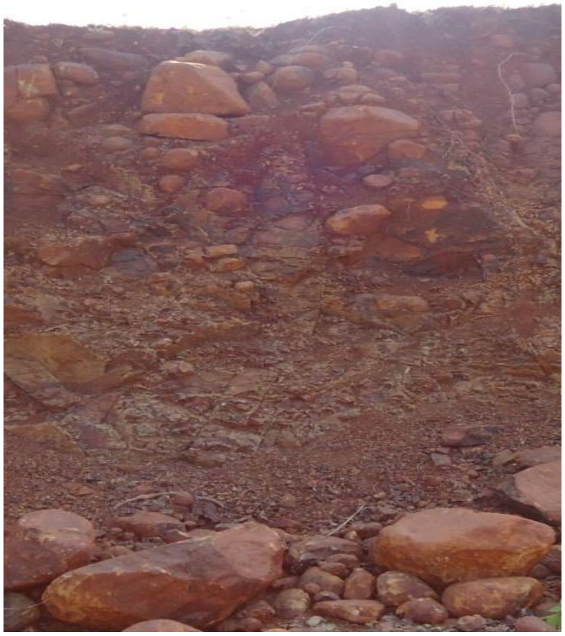

Fig. 7

Fig. 8

(vi) Drainage Basin shape

The Ghutkandar drainage basin area has been delineated where water divides follow the crest of the escarpment or spur. Due to headward erosion river basin gets elongated shape (Prasad, 1985, pp. 264-265). The Ghutkandar basin is elongated west-east. Headward erosion may cause the nearness of water divides to the first order streams in the western boundary. But in the northern and southern boundary expected stream channels are found which depicts less or insignificant headward erosion. In extensions in east-west and in north-south are almost 20 km and 7 km respectively. The left bank and right bank make the ration 2:1. Therefore, it can be said that the left bank is wider than right bank. The narrow right bank is characterised by terraces. As early stated that in Middle Miocene Himalayan ranges were elevated and Rajmahal hills also and depression formed which was filled by alluvium. The Ghutkandar stream is flowing along the junction of these two *i.e.* elevated Rajmahal basalt and older alluvium. The hard rocks of right bank restrict erosion and the stream shifts in left bank side. In the extreme west the stream is flowing on basalts (west of 87º32′E) but in the east of 87º32′E longitude the stream is showing superimposed nature. Therefore, more tributaries are found in the left bank than right bank. The longest tributary of Ghutkandar *i.e.* Chilla meets it in the left bank. Comparatively shorter stream courses are found in the right bank. Long profile determines the stream gradient and curvature of a stream has been drawn. Total length of the profiled stream is 15.5 km. The stream started its journey from 245m elevation and meets Dwarka at an elevation of 70m. there are three zones are visible here *i.e.* the steep western part, slight concave curve in middle and almost straight or little concave in eastern confluence zone (Fig. 9). In initial stage steep gradient, in middle course gentler gradient and in final stage very gentle gradient are common (Bunnett, 1965, pp. 75-76). The long profile of Ghutkandar has steep gradient at the source region due to dominant vertical and headward erosion by first order streams. In pediment zone streams dump their load due to sudden change in slope and forms alluvial fan. Coalescence of fans makes the surface slight convex. Valley becomes comparatively wide in middle reach and minor concavity is found limited down-cutting. Near the confluence the slope becomes gentle where the stream flows on the old alluvium.

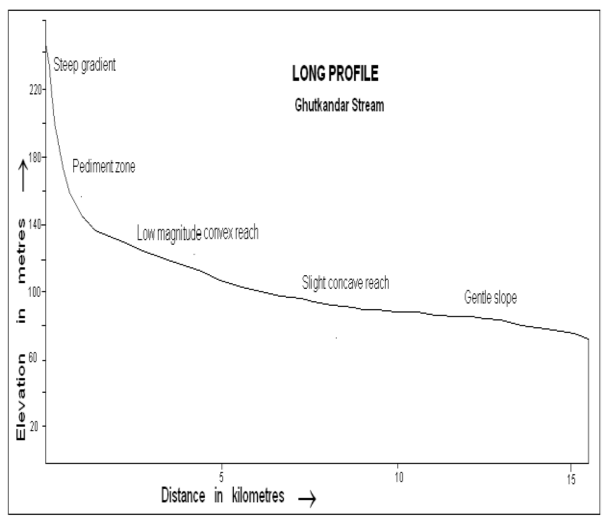

Fig.9

(vii) Depth of water table

A good variation of depth of water table is found in the river basin area. After the Late Pleistocene uplift the Rajmahal hills also get tilting surface towards east Ganga plain and rocks dip flatly below the alluvium (Ahmad, 1958. P. 18-21). Therefore, in this pedimental zone ground water is available only at 2 to 4 m from below the ground level (Geomorphology and Geohydrology, 2001). But in the eastern Upper mature deltaic plain the ground water depth varies from 4 to 6 m. This fact also depicts that the tilting of Rajmahal basalt towards east.

(viii) Valley-in-lier

Valley-in-lier is strong evidence in support of geological succession. The stream cuts it valley and underlying rock beds are exposed along the valley side. Old Ganga alluvium, gravel bed, Rajmahal basalt from top to bottom direction these sequence is quite visible along the channel (Fig. 10). Due to Late Tertiary upheaval Rajmahal hills get elevation and the stream abruptly fall down along the sliding plane of basalt. Therefore, the narrow terrace plains are found with steep scarps. The left bank which is alluvium filled depression is also steep but not hard.

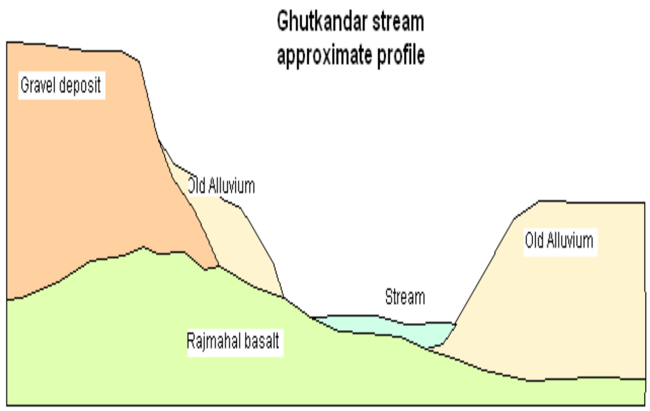

Fig.10

Geohydrological Potentiality and Importance

Geohydrological potentiality is controlled by number of factors like geology, lithology, drainage, geomorphic forms, slope, depth of weathered material, soil depth *etc.* (Giri & Prasad, 2007, pp. 187-188). Ghutkandar is spring recharged perennial stream. Springs are natural source of ground water and is also available here throughout the year. Therefore, this stream has a great geohydrological potentiality. This narrow stream is the only source of irrigation water for the surrounding uplands. Riverlift irrigation is commonly practiced. Few small size dams are constructed but due to unscientific human interferences the stream is suffering for natural flow. At places local people make small reservoir by boulder for fish cultivation. Due to these natural flow is restricted and the lower course of the stream becomes dry.

Conclusion

Geomorphologically the basin area is characterized by erosional and deposional features both. The Ghutkandar Nala is a spring recharged perennial stream. It is most probably not older than Middle Miocene. The stream may be concluded as a superposed river. Valley-in-lier is visible at places which depicts the history of evolution and geological succession of beds. The elongated drainage basin depicts active headward erosion. Un-paired terraces suggest that the basin is faced upheaval. Old Ganga alluvium covers the eastern half of the basin area. Therefore, proper irrigation plan may change the landuse pattern of the area as well as can improve the economy.

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