DISCUSSION ON HUNDRU FALL AS A KNICK POINT, JHARKHAND, INDIA

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Abstract
Subarnarekha River lies in the vicinity of the Ranchi mega lineament zone of Jharkhand State. This river links the Tamar Porapahar shear zone and the North Singhbhum shear zone. The Hundru falls is the sudden and abrupt drop of elevation (longitudinal profile) of river Subarnarekha. The basic aim of this paper is to assess the Hundru fall as a perfect citation of an upstream knick point in the Indian context. The paper covers the knick point formation of upstream of the Subarnarekha river. Upper catchment of Subarnarekha covers with diversified metamorphosed and igneous rocks. This zone has crossed a long path with several lithospheric adjustments with epirogenic upliftment. The physical attributes of Hundru fall explains through the various diagrams. Hundru fall is the evidence of zonal (regional) upliftment and here the fault line and scarp occurred simultaneously. The existences of scarp along the river line and the sharp V-shaped canyons with bedrock floor are the common phenomenon of Hundru fall. The most common rock types of Hundru fall zone is granite, gneiss, pegmatite, aplite and, the Archean conglomerate of Chandil. Here, the river Subarnarekha is flowing over the Precambrian crystalline basement of felsic strata. The stratigraphic succession of the Subarnarekha river (along with the Hundru waterfall) shows evidence of slip-dip fault and that gives half-graben like appearances.

Keywords: Subarnarekha River, Knick point, Hundru fall

1. Introduction

The river Subarnarekha (Fig.1) is one of the dominant rivers of the Chhotonagpur plateau and it's a perennial rainfed river. It originates near Nagri village, Ranchi, and connects three states; Jharkhand, West Bengal, and Orissa and meets the Bay of Bengal at Kirtania port ($21^0$33' 18'' N and $87^0$23'31'' E) in Orissa. Subarnarekha is a rejuvenated and antecedent river. The joint and fracture in the river bed is the most common phenomena. The Subranarekha cuts the Dalma range and related tectonic adjustment gives the impression of an antecedent channel flow. Subarnarekha is the dominant carrier of ferruginous sediments to Bengal delta (Bally, et al. 1980). Subarnarekha has crossed the series of geological formations (Dunn & Dey 1942) (Fig.2), and formed a numerous waterfalls and Hundru fall is the dominant one. The Subarnarekha river lies in the vicinity to the Ranchi mega lineament (Crawford 1974) zone in Jharkhand State and it connects Tamar Porapahar shear zone (Kumar, Srivastava & Srivastava 1994), Dalma volcanic range (Guha & Patel 2017) and north Singhbhum shear zone (Fig.2). The Subarnarekha basin is the combination of the Pre Cambrian basement, Tertiary Lateritic formation, and Holocene alluvium formation. The Hundru falls is the sudden and abrupt drop of elevation (in the longitudinal profile) of river Subarnarekha (Fig.3). The selected (Hundru fall zone) part of this river is discordant (Fig. 3) and as well as superimposed in nature. Here the successive drop of base level is common phenomena and that stimulated intermittent upliftment of flow of the channel. The longitudinal profile of the Subarnarekha river represents a perturbation of propagating upstream. The rate of sediment influx from a rejuvenated river channel is determined by the knickpoint behaviour. The landscape is the direct response to a base-level changes (due to knick formation) of the river channel. The large-scale landscape evolution also governs trough the knick point formation. Here an effort has been made to assess the Hundru fall as a perfect citation of an upstream knick point in the Indian context. The paper covers the knick point formation of upstream of the Subarnarekha river. Upper catchment of Subarnarekha covers with diversified metamorphosed and igneous rocks. This zone has crossed a long path with several lithospheric adjustments with epirogenic upliftment. The physical attributes of Hundru fall explains through the various diagrams. Hundru fall is the evidence of zonal (regional) upliftment and here the fault line and scarp occurred simultaneously. The association of Gold with Copper and Lead in Quartz veins, pyrites, and Iron Sulfide ore are common in the upper catchment of the Subarnarekha basin and that gives the watercourse of Subarnalekha a yellowish and shinning appearance and that justified the name Subarnarekha (golden line or the shinning curve line of gold).

2. Objective

The goal of this study is to show the nature of Hundru fall as a knick point on the upper catchment of river Subarnarekha.

3. Study Area

The study area (Fig. 1) covers extreme upper catchment river Subarnarekha (Fig. 2) and it covers the Hundru fall (23° 27'N and 85° 39'E) and its adjacent area. The height of that part of the basin is 456 m from the mean sea level and the height of the waterfall is 98 m (Fig.3). The Subarnarekha is the longest east-flowing inter Stare (connects three states) river (Comission, 2017) and it originates at the height of 600m (above the mean sea level). This river comprises with six principal tributaries; the left bank tributaries are the Kanchi (76 km), Karkani (110km), Kharkai (136 km), Raro or Daro (52 km),

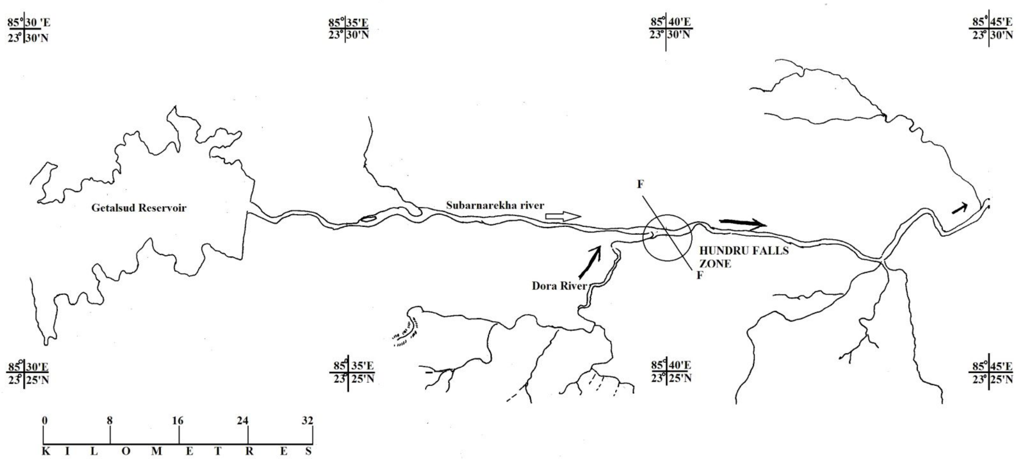

Fig. 1. Upper catchment of Subarnarekha basin

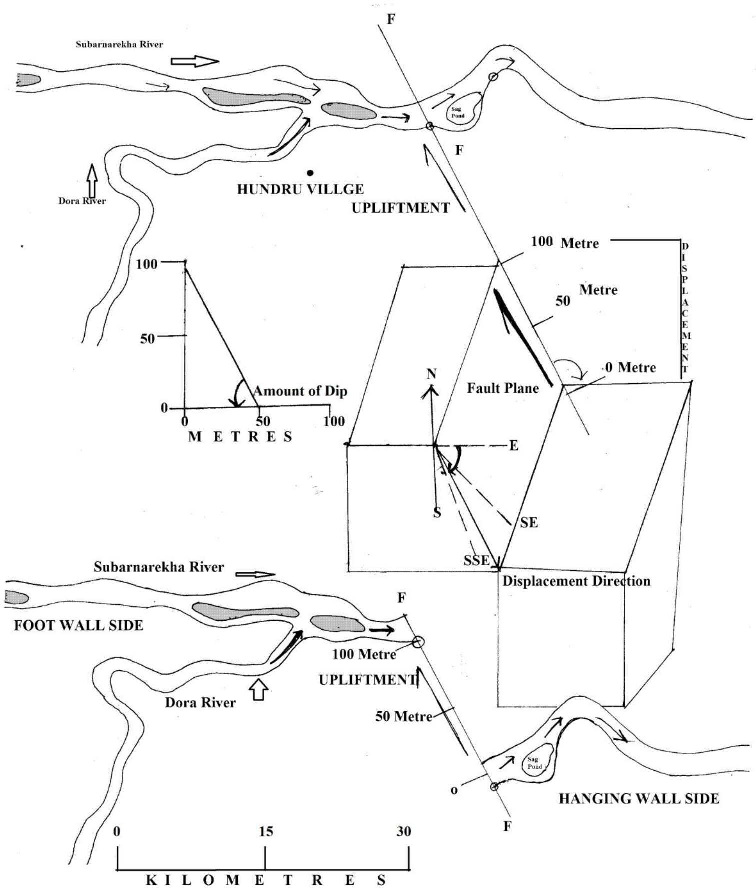

Fig. 2. Geological set up of Subarnarekha basin

Garro (58km), Sankha (30km) and Jumer (37km) and Dulang (84km) is the right-handed tributary. The Subarnarekha shows an asymmetry in its catchment; right bank tributaries comprise three fourths and left bank tributaries draining one-fourth of the basin area. The study area covers the meeting point of river Raro or Daro and Subarnarekha. It is bounded on the North-West by the Indian Shield (Chhotnagpur Plateau), in the South-West by Brahmani basin, in the South by Burhabalang basin and in the South-East by the Bay of Bengal (Comission, 2017). This river empties an enormous volume of sediment and formed a cuspate arrangement of chenier ridges and ultimately that chenier ridge converted to active delta near the Kanthi coastal plain of West Bengal.

4. Methodology

The study has divided into three segments; the premier segment covers the observation of lithological characteristic of the upper catchment of Subarnarekha, second segment covers the diagrammatic representation of the physical appearance of Hundru fall and the last one is to find out various geological history related to the area concern. Though the various model-study (related to the identification) of knick point is widely accepted but here the Hundru fall as the result of active faulting and the knick point formation has studied through the diagrammatic representation of the physical appearances.

The first segment of the study is to show the types of rock strata of the adjacent zone of Hundru fall. The rock strata survey has confined within its geographical appearances (surficial attributes) such as the pattern of rock texture, colour, gesture, grain size, and association. The rock details have identified with the help of a mineral microscope and the mineral types have been identified simply by the observation. The chemical or laboratory analysis is not included here. The vertical profile line (height) Hundru fall has been measured by the auto level and leaser distance measurer. The second segment covers the diagrammatic representation of the vertical and horizontal distance of Hundru fall. The geological setup of the lineament zone of Hundru fall has also been plotted on a map. The physical appearances of Hundru fall depicts the fault line scarp with a half-graben like structure and that structural appearance has been presented in diagrams. The last segments include the relevant information about topography collected from (surface elevation have collected from the Survey of India, Topographical Sheet no. 73I/15, 73I/16, and 73 M/3, R.F. 1:50,000 and through GPS survey by the Germin Trex) maps and through the GPS survey. Overall a brief and comprehensive literature survey on the geological history of the Ranchi plateau and as well as the upper catchment of river Subarnarekha have been covered. The geological succession of the study area has taken from literature.

5. Result

Here scarp meets with the transverse valley of river Dora (Fig.3). The sag pond, (Fig.1) wedge-shaped hill, and warped terrace (Fig. 6) are the evidences of rift features and this evidences clearly show the scarp produced by an active fault. Therefore, Hundru waterfall is the fault scarp (Fig.3). Here, the spurs are not fully interlocked and most of the lateral spurs have the facets. These faceted spurs formed due to active

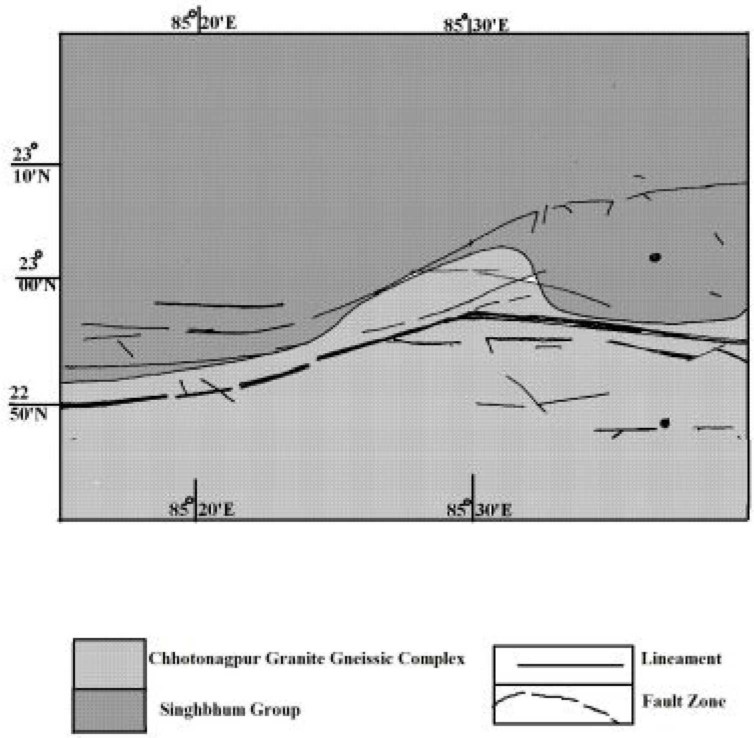

Fig. 3. Hundru fault zone

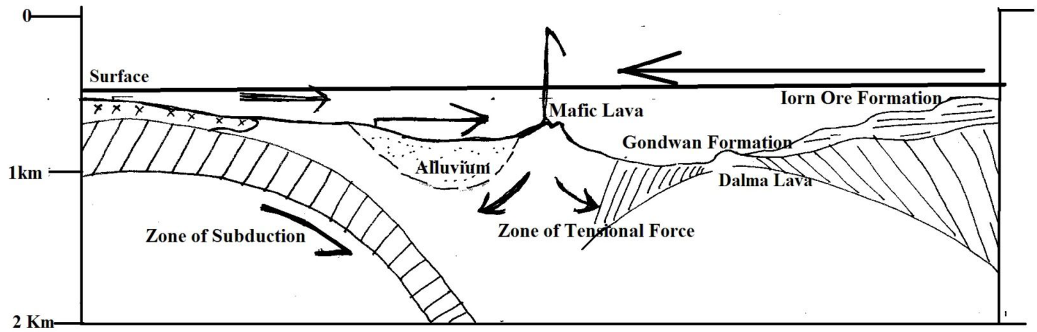

Fig. 4. Hundru fall and geological set up

faulting and it produced triangular facets on the edge of the rift system (Thornbury 2002). Here the lateral facets of the truncated spurs are the living evidence of fault scarp (Bally, et al. 1980). Here the Subarnarekha and Daro river meets along an oblique linear fault line (Fig.1,3) and along the meeting junction, a transverse fault line scarp (dip-slip fault scarp) has formed (Fig.3). Here the strata of the upward side of the scarp is more resistant in comparison to its downthrown side. This is the most dominant evidence of active faulting (Thornbury 2002). The rift features such as sag pond, small wedge shape hill with un-pair river terrace; all are showing the effect of past faulting. The river Subarnarekha's upstream intersects with the Dora river (right-hand tributary of river Subarnarekha) and it forms a lake in its base (Fig.1). This is the clearest evidence of fault scarp. Here the valley is abruptly cut off at the edge of the scarp and it produced the fault scarp. The knick point of the Subarnarekha river (Hundru fall) lies in the Precambrian basement. This Hundru fall is the result of successive upliftment and slip fault of the Miocene era (Kumar P 1981) but ultimately it is modified during the Quaternary era. Therefore, Hundru is a comparatively young fall zone. The gneiss banding and mylonites depict that the upper catchment is more complex and ancient one. This zone has crossed a long path of lithospheric adjustment with epirogenic upliftment.

6. Discussion

The Subarnarekha river is 395 km long and it covers 20610km^2 of basin area. The upper catchment is very ancient and most of it partly covers with the Dharwar formation (Dunn & Dey 1942), lower part covers with the tidal

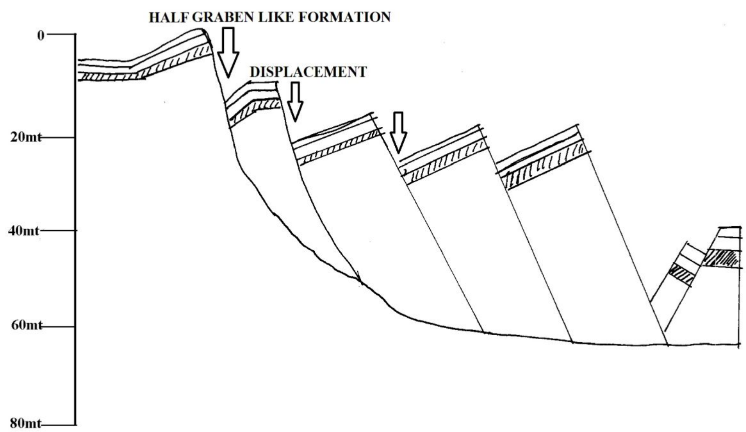

Fig. 5. Earth surface and Hundru falls

activities with active delta formation as well as alluvial deposition and intermittent part of Subarnarekha covers with hard Laterite and Sandstone zones which covers the Bengal peneplain (Guha & Patel 2017).

Geological Set-up of Upper Catchment of Subarnarekha

The river Subarnarekha lies on the edge of the Ranchi plateau, which is pre-Cambrian origin (Meert & Pandit 2014). This river is the carrying ferruginous sediment (Verma & Shukla 2015). This river bed has an early Cretaceous to Holocene sedimentary succession (Ghosh & Guchhait 2015). The Subarnarekha lies in the interplate basin boundary zone and it is flowing through the ductile (Mandal & Ray2009) to brittle shear (Fig.4) of Tamar Porapahar Shear Zone (Bally, et al. 1980). The upper catchment of Subarnarekha is (Verma & Shukla 2015) (the upper catchment of Subarnarekha) full of diversities and it is the (Ranchi plateau) convergent point (Fig.5) of trio microplate boundary; such as the Satpura mobile belt (orogeny), Chhotonagpur Gneiss Complex and north Singhbhum mobile craton (Fig.2) (Bally, et al. 1980). This triple junction microplate converges (Kaila, et al. 1996) in a linear boundary (Fig.2). This narrow convergence zone is elongated in shape and it lies in an east-west direction and that develops a micro suture zone (Kumar 2015) and Subarnarekha is following (upper catchment up to Chandil) through this ductile

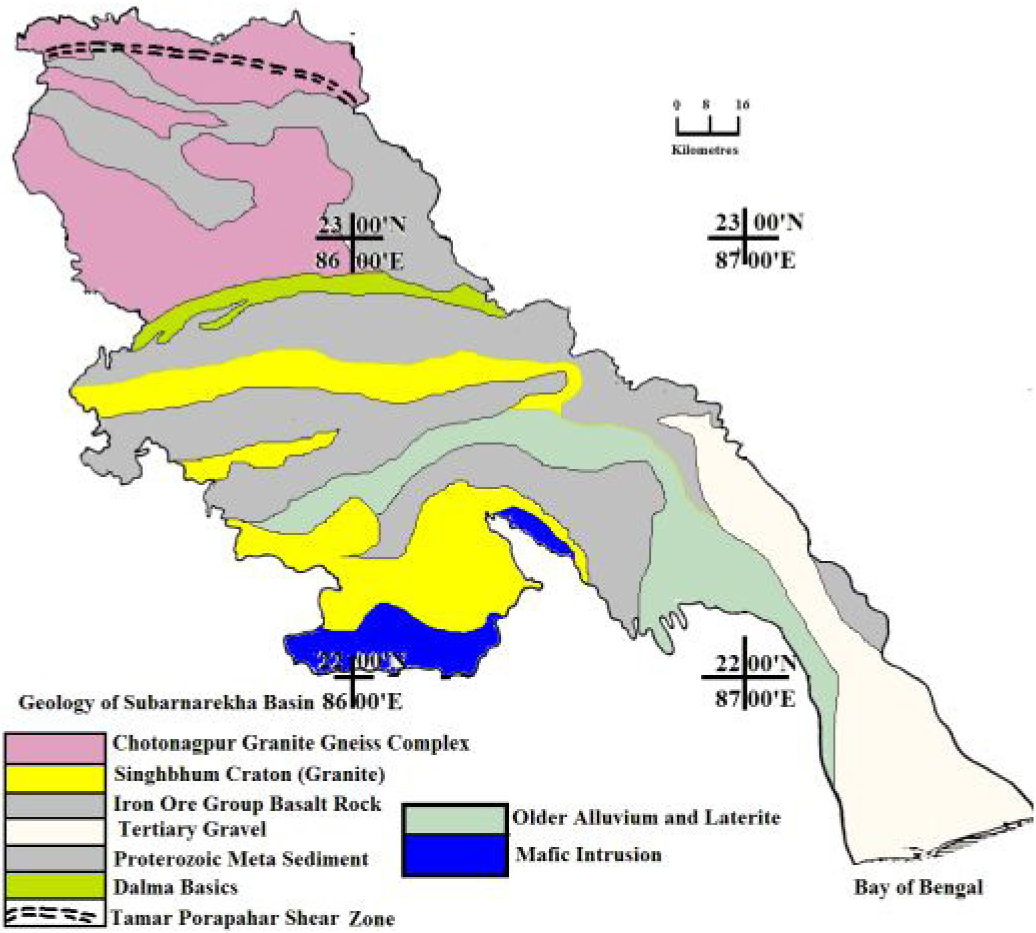

Fig. 6. Half graben like displacement in Hundru fall zone

to brittle micro suture zone (Fig.2).

According to Dunn (1941), the upliftment of the upper catchment of Subarnarekha (part of Ranchi plateau) is the result of out poring of the Deccan trap (Mishra & Kumar 2013) and its western part (part of Chhotonagpur plateau) has uplifted up to 1000 feet during the Cretaceous to Oligocene (Dunn 1941). During the Cenozoic, the soda granite of Dalma plutons modified the upper catchment of Subarnarekha (Mazumder 2005). The slope pattern of the Ranchi plateau indicates the facts of epirogenic upliftments (Kumar & Ahmad 2007) during Cretaceous to Oligocene (Dunn 1941). The basalt formation (similar to Kolhan series) is common in the upper part of Hundru fall and rock strata of the remaining part is similar to Dharawar (Sharma 1981) formation. These two types of rock strata (Basalt and Dharawar) are the evidence two distinct phases of upliftment (Sharma 1981). Subarnarekha's upper catchment has distorted by the localized upliftment during the Miocene (Cenozoic) and that was the consequence of Pliocene orogeny (Kumar P 1981). The Subarnarekha's basement (upper catchment) composes with the metamorphosed igneous rock of both acidic and basic (Kaila, et al. 1996). The river Subarnarekha is flowing up to 93 km along with the Tamar Porapahar Shear Zone (Bankura Purulia ductile Shear zone) (Fig.2) and it bends southwards (Fig.2) and enters in the Dalma volcanic zone (Khan, Bhukta & Tarafder 2016)(Chandil to Jamshedpur).

Hundru fall and Knick Point

The knick point is the evidence of palaeo tectonic movement. According to the Penckian concept, knick point is the point of interruption of the longitudinal profile of the graded river and it generally occurs in the second phase of the cycle of erosion (Harris 2015). Penck (Harris 2015) denoted, that abrupt changes in the river's longitudinal profile are due to change in base level (Harris 2015). Here knick point indicates the change in base level (Fig 3) of river Subarnarekha (Mishra & Kumar 2013) but without any evidence of changes in sea level. Therefore; the base level changes of Subarnarekha is the result of the regional palaeo-epirogenic movement (Sharma 1981) and the related earthquakes. The Doro river meets the river Subarnarekha along with an oblique linear fault line (Fig.1). Daro is the tiny subsequent (2nd order) stream (Fig.1). The cross-section of Hundru fall shows the displacement direction and it is E to SSE (Fig.3) and the amount of dip is around 78^0 (Fig.3) and the fault plane is very smooth (like slikenslide). The half-graben like step formation (in scarp zone) is observed here (Fig.6). There is symmetry between the fault line and the small lineaments (Fig. 4). Here the iron ore series and Dalma range are responsible for ferruginous sediments (Fig.5). The metamorphosed soda granite, volcanic-sedimentary (Bond & Grasly 2017), and the ferruginous sediments in the hanging wall side of Hundru fall is the evidence of Cenozoic upliftment (Fig 3). Here gneiss banding with a quartzite and the mylonite (Mandal & Ray 2009) are the evidences of shearing of Hundru fall zone. The Hundru waterfall is the mark point of earlier upliftment (Kumar R 2015). Here Hundru falls is the linear boundary between the old and new base level and thus it is marked by a knick point (Kumar P 1981).

The erosion (presence of cap rock basalt) is very common on the hanging wall side (Kumar P 1981) of Hundrufall (Fig3). The upper catchment of the river Subarnarekha is full of mesa and buttes. The Baghmundi plateau is nothing but a mega mesa and the Hundru waterfall and its surroundings are full of mesa and buttes with different shapes and sizes which are the result of differential erosion and weathering. Here the downward displacement of dip-slip fault form the half-graben (Fig.6) (Bally, et al. 1980) geometry with step-like pattern and its orientation is the west to east (Fig.3,6).

Hundru Fault Scarp

Here the knick point recession (Mukhopadhyay 1980) is very common, but numerical measurement of recession is not included here. The upper catchment of Subarnarekha has crossed the long path of several tectonic adjustments (Ghosh 2014) and it was interrupted by the Singhbhum cycle during the late Cretaceous. The late Oligocene and Miocene warps responsible for scarp formation which is known as the Hundru fall cycle (Mukhopadhyay 1980). Here the fault line and scarp formation occurred simultaneously (Bally, et al. 1980). The existences of scarp along the river line (Fig.3) and the sharp V-shaped canyons with bedrock floor are the very common phenomenon of Hundru fall. The most common rock types of Hundru fall zone is granite, gneiss, pegmatite, aplite and, the Archean conglomerate of Chandil area. Here, the river Subarnarekha is flowing over the Precambrian crystalline basement which is felsic and ferruginous (Mishra & Kumar 2013). The stratigraphic succession of the Subarnarekha river (along with the Hundru waterfall) shows evidence of slip dip fault (Bally, et al. 1980), and that gives half-graben like appearances (Fig. 3, 6).

7. Conclusion

The upstream of Subarnarekha is an ancient one and crossed the phases of several tectonic adjustments. Hundru fall appears as the half-graben like structure since the Miocene era and ultimately converted to dip-slip fault during the Quaternary. Hundru fall is the result of active faulting and it is the consequence of regional tectonic upliftment during Miocene. Here, the river Subarnarekha is flowing over the Precambrian crystalline basement of felsic strata. The stratigraphic succession of the Subarnarekha river (along with the Hundru waterfall) shows evidence of slip-dip fault and that gives half-graben like appearances.

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