Research Paper Geography

Geometric Forms of Gully Basin Micro-Features and Their Significances: A Study on Lateritic Area of Medinipur, India

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ABSTRACT

This paper assesses the significance of geometric forms of microstructure and microgeomorphology of the gully morphology in lateritic area of Medinipur, India.

KEYWORDS

INTRODUCTION:

Geometric dimension of landform is one of the main elements for any geomorphic explanation (King, 1966). Thus for the assessment of its development and present status geometric forms like height, length and width are very important along with the other elementary factors like process efficiency and time in a large area as well as the smallest unit (Dey, 2005*a*). Microgeomorphic features or micro-features are normally small sculptures and designs on the surface, which are formed by geomorphic agents and occupy only a few centimetres to a few metres as the smallest unit of landform (Dey, 2005*b*). So, the spatial scale of microgeomorphology varies from a few centimetres to a few metres. Besides that the micro-features also can be explained in temporal scale. Selby (1985) and Bloom (2002) accorded that generally smaller features of landform can be created and destroyed more rapidly than larger ones with fluctuation of processes. It depends on the variability and efficiency of processes under specific environmental conditions. Though little has been discussed in the scientific literatures, these small features or micro-features are integral parts of landforms and cannot be ignored in the discipline of Geomorphology since influences of environmental changes on geomorphic processes first reflected by the small sculptures and designs. Thus the micro-features can explain even a very minor change in environment. For example, sea level fluctuation can be detected by observing the rip channels and wave ripples (Dey, 2002; Dey 2003). Like the coastal areas other geomorphic agents also form so many micro-features under different environmental conditions. The tropical lateritic landform also consists of several micro-features, which can explain the environmental significances in temporal and spatial scale. Considering the significance of the micro-features, we decided to perform a study on the geometric forms of the micro-features of the gully basins in lateritic areas of Medinipur District, West Bengal, India, which is a part of south-eastern fringe area of Chottanagpur plateau. (O'Malley, 1911) and falls under a tropical monsoon type with sub-humid in nature (Adak and Pal, 2004). The main objectives of this paper are (i) to analyse the geometric shape of the small designs and sculptures and (ii) their environmental significance from the geometric forms of the micro-features. The main focus of the present study is on the morphology of the gullies of this area because the gullies are not only consists of several micro-features but also expose many geological evidences by erosion which are preserved beneath the surface for long time.

METHODOLOGY

Prior to visiting the field area, the present authors surveyed the existing literature such as recent research papers published in different journals and presented in different seminars, congresses, district gazetteer etc.

Detailed data generation has been done through field work by the authors to understand the forms of microstructure and microgeomorphology of the study area. Instrumental survey works (using Dumpy Level, ranging rods, staff. clinometers and measuring tape) have been done to generate hard data. Profiles across and along the gullies have been taken by the present authors to measure the micro-level variation of slopes and elevation for understanding the characteristics of general morphology at micro level of this slope. Different micro-features were identified systematically for over all explanation of the microgeomorphology of the selected slope. Coverage of the depositional materials is measured in the field.

Data collected from the field were analysed for assessment. High-resolution photographs microgeomorphic features are taken during field and photographs of the collected samples of different types of depositional materials are taken in the laboratory. All the photographs were processed and edited by computer in the laboratory for analysing the microstructure and microgeomorphology of the present study area.

RESULTS AND DISCUSSIONS

Influence of micro-relief and its impact on landform geometry:

According to Zonn (1986, p-195) variation of elevation within 0.2 m to 1 m is called micro-relief. Height or elevation influence surface slope angles. The present authors have measured the micro-relief conditions of gullies to understand the influence of elevation change upon surface slope. It has been observed that the change of elevation within a very small area results the change of surface slopes, which create rugged condition of landform at micro level. These micro level changes of slopes also influence whole shape of the studied cross profiles. In the present paper these authors presented only three selected profiles as examples, two of them are across the wide gully channels and one along the gully channel since the whole study area is marked by thousands of gully channels and it is not possible to show all of them in a limited space.

In the selected profiles some micro level angles on the surface of the profiles are recorded more than 90°, which create small overhang slopes. During the field study it has been observed that overhangs cause gravity sliding and removal of upper layer sediments. Finally it changes micro level shape. The present authors view that these are very important geometric forms as development of many micro-overhang may cause a large of removal of upper layer sediments and modify the original shape of the profile.

Microgeomorphology created by denudation and erosion:
Hairline weathering mark: Micro level cracks by the weathering are developed on the both horizontal and vertical faces of the softer sediment layers. The weathered parts look like the scales of the animals. The roots of small grasses are also play important role for the development of the cracks. These are the indication of hot and humid alteration of climatic condition in this area. Hardness also plays important for the shape of the hairline weathering marks. It has been observed that on the hard surface these marks are straighter than the softer layers.

Alligator's nose: This is typical micro-feature, which indicates the meeting of two very small and narrow rills. It shows the micro-level slope variation on the undulating surface of the lateritic gully basin. Due to both side erosion, a nick is created on the junction of the two rills and that looks like the nose of an alligator.

Caves along the hard and soft layer margin: These are comparatively larger features than the other erosional micro-features discussed earlier, but considering its morphological significance the present authors decided to include these features in the contents of this paper. By the water the soft layer beneath the hard top layer is eroded which creates the deeps caves. These are rapid growing features and related to increase of geomorphic processes in monsoon seasons. After every monsoon the caves are found increased in size and depth.

Rills: Rills are formed by according to the slope and water flow. On the steep walls they are found straight and narrow. On the flat floor these rills are wider and create small meanders. These are responsible for sediment transport and modification of slopes at micro level. Price-Williams's et al (1982), Partridge and Maud (1987), and Partridge (1988) successfully advocated that climatic conditions are also very important factor for run-off development. In the tropical area seasonal variation play a vital role for the changing of water supply and geomorphic process (Sen et al, 2004), which influences the development of run-off channels in various size and shape like the present study area. During the monsoon increase of rainfall creates maximum water energy which causes maximum modification of landform.

General microstructure of depositional features and their significances:
Horizontal sediment layers: Study on microstructure is a very rare interest of the geo-scientists in India. The only known work has been done recently by Mamtani et al (2007) for explaining the banded iron formation (BIF). Here the present authors attempted to analyse the microstructure of the hard lateritic layer in present study area for understanding the significance of the previous depositions. Very thin sediment layers are normally found on the topsoil part of the steep gully walls. These layers are the evidences of the early geological development of this area. It has been detected that sediment depositions took place in this area during the Tertiary-Quaternary period and modified this place which result the southward shifting of shoreline from this place and modified the environment (Pal, 2002; Hazra et al, 2002; Dey et al 2002). It is quite evident that under hot, humid and monsoon climatic condition very hard conglomeratic sediment layers are formed (Wadia, 1919). In the present study area typical conglomerate layers consists of various sizes of deposited materials, mainly sandstones, clay, shale, gary micaceous schist's, phylite quartzite, epidiorite etc are also observed. These sediment layers are formed horizontal to the present surface and having 0.2 cm to 8 cm thickness. The thicknesses of these layers are the indication of energy and duration of work of the previous geomorphic agent, which is related to climatic fluctuations. It proves that the early climatic condition was not in stable condition that affects the efficiency of the geomorphic agents at micro level. The increase of size of the gravels in the upper layers also proves that the energy of the geomorphic agents increased gradually during the ancient period. The laterisation process took place on these sediment layers during recent geological period. According the size of the rock depositions they can be classified into four groups, which are as follows:

Table-2: General features of conglomerate layers

Radius of the deposited material	Average Surface Coverage (number in 36 cm^2)	Geomorphic indications
> 2cm	2	High intensity of processes
1-2 cm	12	High intensity of processes
<1cm	45	Low to medium intensity of processes.
Sands	Coarse to fine sands are deposited and consolidified between the gravels or pebbles.	Low intensity of processes.

(Source: Field data generation)

Holes: Some holes in the sediment layers are formed by the removal of gravels by denudation from the layers. The size and shape of the holes depend upon the gravel removal of which it is formed. Normally round, triangular etc are the common shape of the holes. Sometimes organic matters also create this type of holes on the sediment layers.

Recent depositions: Various sizes of gravels and sands are deposited on the gully bed during the monsoon season. Due to weathering by temperature variation denudation occur in the dry season and high speed water flow eroded during the monsoon season. These are mostly round to semi-round in shape and not carried from the any far away. The origin of these particles are on the higher parts of the present gully basin. Two types of depositions are found in the gully beds of this area(Table-1). They are:

a) **Arranged depositions:** Gravels from 6cm to 0.2cm radius to very fine sands are found in this type of deposition. In this type gravels are comparatively arranged as the different size ranges are deposited separately. Sands are mixed with the every group. Comparatively greater sized gravels are deposited far away from the place of their origin than the smaller sized gravels. It is a evidence of gradual increase and decrease of the energy of geomorphic agent by seasonal influence.

b) **Mixed depositions:** Various sized and shaped materials are deposited together without any arrangement. This type is marked by fine to medium size sands and small gravels. Some larger particles with >6cm to 4cm radiuses are found in this deposition which indicates the fluctuations of climatic condition in monsoon season. It causes fluctuation of energy geomorphic agent and as a result of that some greater particles are carried by water from the upper part with small particles.

c) **Flash deposition**: This type of landform is created by flashing of water flow due to heavy rain during the early monsoon season. Small to medium size gravels with coarse sand are deposited in few meters of areas on the flat bed of the gully in a scattered form. Some flat faces are observed on the materials of this deposition which evidences that they are carried by high energetic agent (flash water) and from greater distance than the above depositions.

Table-1: General features of recent depositions

Type of deposition	**Shape of the materials**	**Average surface coverage of graves and pebbles (numbers / 100 cm^2)**	
		3cm to 6 cm Radius	<3 to 0.5cm Radius
Arranged deposits	Round, oval, half round etc. The surface is very uneven and rugged.	6	29

Mixed deposits	Round, semi-round, half round, conical etc. The surface is very uneven and rugged.	3	64
Flash deposits	Conical, tetragonal, pentagonal, spherical, half spherical, oval etc. Some flat faces are observed and the surface is comparatively less uneven and rugged.	2	13

(Source: Field data generation

Rock micro-morphology and microstructure:
Apart from the general microgeomorphology and microstructure study, a study was conducted by the present authors on the individual morphological structure of the depositional features like gravels and pebbles of different size, keeping it in mind that each rock has some specific micro-morphology / microstructure which are related to their place of origin. This study was totally done in the laboratory on the collected rock samples during the fieldwork.

A clear morphological and microstructural difference between the conglomerate gravels of older depositions in the sediment layers and recently deposited gravels has been observed. In the older sedimentary beds gravels of various size and shape are found. They are conical, tetragonal, pentagonal etc in shape. Sharp marginal angles are observed in most of these rocks. Some spherical shaped small pebbles are also observed in this deposition. The morphology of these gravels is comparatively smooth than the recent depositions. This type of surface may be created by corretion for long time when they are carried by the water. It may prove that they are carried from the far distances and deposited here by energy discharge in the geological past.

In the small gravels the marks of very straight and thin parallel sediment layers (0.01 to 1cm thick), formed by very fine sediment, are also observed which does not match with the local sediment characters. It has been tested that the local sediment of this study area is coarser than those fine grains. Some of them are metamorphosed but the micro-layers are still visible by high-resolution lance. Among the recent depositions, flash deposition materials have some same types of characters since they are eroded from the older sediment layers. This also supports the view that these sandstones are transported by the geomorphic agents in geological past.

On the other hand the recent depositional materials have very rugged micro-morphology, which proves that they are originated in this place and carried by the run-off water. Each and every gravels and pebbles have high micro-relief condition with microscopic holes. No arranged sediment layers are found in these materials. These are highly lateritic and sometimes silica, mica etc are very prominent on the surface micro-photographs.

CONCLUSION
Though the micro-features are used as only passing references in the literature of landform sciences, they can explain many things about the development and existing condition of geomorphology of any place. Sometimes the study of micro-features is more expressive than the general approach since the individual micro-features, as the smallest unit of landform, silently preserve the history of its origin and recent status in the environment. Present study on geometric forms of micro-features in the lateritic gully basins of Medinipur district shoes a difference between the older depositional features and recent depositional features, which is a significant evidence of environmental change. Existence of hard and parallel sediment layers clearly proves that discharge of the materials and then laterisation occur under pluvial environmental condition in this place during the early geological period. The geometric forms and microstructures of the deposited materials also prove that all these materials not originated in this area and they are carried by the geomorphic processes. So, this also strongly supports the sediment discharge during the geological past. The recent features are also very significant to assess the existing environmental condition. The micro level landform geometry shoes that this place is more rugged than what it looks by naked eye. The micro level elevation influences the micro level slopes, which ultimately control the general morphology of the gully basin. From this study it can be said without knowing micro level geometry, the description of land from is really incomplete as many characters of landform may be omitted. The small depositions, which cover only a few metres or a micro area is able to explain the origin and process intensity within a small area which is very much influenced by local factors. In the study area the seasonal fluctuations is understood by the deposited materials of various sizes and shapes. Hence microgeomorphic and microstructural study can be a very handful tool for the geo-scientists for in-depth analyse the geomorphic development and form.

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