GEOMORPHIC PROCESSES AROUND SHELLA, EAST KHASI HILLS DISTRICT, MEGHALAYA

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Abstract:

The area selected for the present study is a unique geomorphic unit individual in its character. The present geomorphic study poses varied and complex problems associated with landforms and landscapes and their explanations requires careful considerations of structural, historical, process and form approaches of geomorphological studies. The area under investigation records a complicated geological history. The cretaceous-tertiary sediments have had their influence during the later stage of evolution of the area. Endorsed with geomorphological problems where facts are made complicated by phases of long continued erosion, deposition and upliftment. The correct interpretation of which was made by a close study of the landscape and the existing morphology. Emphasis is given on studying the physiography, geology, structure, hydrology, drainage, climate, soil, vegetation and land use pattern of that area. As this area is located in the southern slopes of the Meghalaya plateau and very close to the Bangladesh border, no geomorphic study has so far been carried out particularly in this area. The main objective of the study is the identification of geomorphic processes of the area. Some of the important geomorphic processes operating in the area are weathering, fluvial erosion and mass wasting which have modeled the landscape. The present relief features are no doubt primarily the product of running water, but weathering and mass wasting have also contributed significantly to the development of landforms. So keeping in mind these facts the present research has been carried out. For the present paper, literatures of the area were studied and secondary data on climate, geology was collected. Through field work Primary data on the weathering characteristics were also collected During this phase, micro relief features, landslides zones, drainage patterns was identified for documentation and photographs were taken to support the paper. The methods used have also helped in identifying various erosional surfaces. These features together provide sufficient clues to visualize and reconstruct the history of the region.

Keywords: geomorphic processes, weathering, run-off, landforms.

1. Introduction:

Geomorphology is the study of origin and evolution of topographic features by physical and chemical processes operating at or near the earth's surface. The study of geomorphology in areas around Shella, can be related to a particular geomorphic process that all landforms developed and evolve with time, and will continue to do so in future. It tells about the shapes of hills and valleys, the degree and frequency of slopes, the development of drainage patterns and the nature of materials exposed in all available sections. The areas around Shella selected for the present study is an interesting area with an evolutionary history, uniqueness and individuality of its own. It lies between 25° 12'N to 25° 8'N latitudes and 91° 38'E to 91° 42'E longitude. An area located in the southernmost part of the Meghalaya Plateau covering an area of 129 sq. kms, bordering on the Sylhet plains of Bangladesh and towards the north a narrow footpath goes to Cherrapunjee. The area is drained by rivers Umiew and Sonai and their tributaries later on flowing south and meeting to Surma in Bangladesh. The area has dissected plateaus, scarp zones extending in east-west direction with numerous waterfalls and floodplains. one of the most important geomorphic units of the extension of Deccan Plateau. Limitation of researcher is obvious, particularly when one attempts to investigate a land like Shella with very difficult terrain where there is no previous information on the geomorphology of the area. Naturally, the present work may be considered to be pioneers venture not only in assessment but also in evaluation of geomorphic processes coupled with the underlying structure. Thus, geomorphology can now be visualized as a landform process science and the main thrust of this micro- regional study is to elucidate this theme in the context of geomorphic studies around Shella, East Khasi Hills District of Meghalaya.

2. Physiography:

Although a part of the Deccan plateau, the Meghalaya group of Plateaus is topographically different from the former in that they present a more hilly character with hills, ranges, deep valleys and gorges. Firstly, the hot and humid tropical climate of the region as stated above, favours vigorous chemical weathering and has given rise to rivers and streams.

Secondly, the Plateau is surrounded by Barak-Surma plain to the south. Thus the local base level of erosion being very low the rivers and streams of the plateau run turbulently, with vigorous down cutting and forming deep valleys and gorges along their courses and leaving the harder parts standing as high hills with steep slopes. Thirdly, being located on a tectonically sensitive zone (at the front of the Indian plate) and near the seismically unstable eastern Himalayan zone, the Karbi–Meghalaya Plateau partly or in toto experiences uplift and subsidence. These factors have contributed to the present hilly physiography of the plateau.

The topography of the region is marked by rugged hilly terrain in the north at 700m a.s.l. and low altitudes plains to the south up to 60m a.s.l. To the north, the land rises abruptly to the higher altitudes of the plateau whilst to the south, the land slopes gently to the plains of Bangladesh. To the east, the land slopes gently forming a gorge through which the river umiam flows. To the west, the land rolls with hills of different elevations. There is an extensive belt of limestone. The area also presents karst topography with the presence of solution joints and cracks which permit the surface water to percolate downwards and after circulating through underground, the water finally re-appears as hillside spring at favourable outlets.

Geology:

Geologically, the rocks of the area form a part of the cretaceous–tertiary sedimentary sequence that occupies the southern fringe of the Meghalaya plateau. The calcareous and calcarenaceous formations of the region belong to the Jaintia group of rocks of Eocene period, which are considered equivalents of Sylhet limestone formation of the Bengal basin. The Jaintia group is essentially a calcareous facies representing shelf sediments and has been divided into three formations: viz. the Langpar formation, the Shella formation and the Kopili formation. The Langpar formation, the basal member of Jaintia group, consisting of calcareous shale, calcareous sandstones and impure limestone rests over a thick group of conglomeratic beds that overlies non-conformably the Sylhet traps on the margin of the plateau. The Shella formation, of which the lithological units of the area form a part, consists of three sandstones and three limestone members beginning with sandstone over the Langpar formation. These lithological units have been designated successively as Therria sandstone, Lakadong limestone, Lakadong sandstone, Umlatdoh limestone, Narpuh sandstone and Prang limestone, which together account for a total thickness of about 540m.

By the end of Jurassic time, the southern margin of the Khasi hills experienced eruption of the plateau basalts – the Sylhet traps, through East-West fissures along which the southern block subsided and the northern block upheaval. The resultant marine invasion led to the deposition of the upper Cretaceous sediments. The rate of subsidence gradually slowed down towards Paleocene-Eocene times when the area attained a stable shelf condition and the Calcareous formations of the Jaintia group were deposited containing high-grade dedrital limestone with abundant foraminifers and algae. The strata thus deposited form a monocline dipping into the Bengal plains. In the southern fringe of Khasi hills, the monocline of Tertiary formation is split along East-west running fault system, the down thrown side thereof dipping steeply into the plains of Bangladesh.

Stratigraphic Sequence: The limestone formation occurring over the area of investigation belongs to prang limestone unit, being the topmost member of Shella formation exposed in the area. At the present exposed level, the thickness of the topmost limestone member varies from 100 meters to more than 200meters according to variation in the ground relief. Further north it is seen to rest comfortably over a narrow sandstone member, about 20 meters to 25 meters thick designated as Narpuh sandstone in local stratigraphic sequence. The Narpuh sandstone in turn conformably overlies a lower limestone member designated as Umlatdoh limestone, which is exposed over the southern slope hills lying further north of the study area. At the southern end, the Prang limestone beds an overlain of the shales and silt stones of Kopilli formation, the boundary between the two units being structurally disturbed and marked by an east –west trending fault.

Lithological Units:

Umlatdoh Limestone:

The limestone unit occurring at the bottom of the sequence is exposed along the steep hill slopes on the north. These limestone units are light pink to pinkish-grey in colour, hard, densely consolidated and richly fossiliferous with large foraminifera. The limestone is interbedded with thin bands of soft, fine grained calcareous and arcosic sandstone. In the upper part the limestone is well-bedded and light grey to grayish white in colour showing a gradational contact with overlying Narpuh sandstone. Ferruginous and calcareous siltstones and mudstones occur as thin intercalations.

Narpuh Limestone:

This sandstone bed conformably overlying the Umlatdoh limestone with thickness varying from 18 meters to 22 meters is exposed over a depression along a nala, further away from the northern boundary of the study area. The sandstone is medium to coarse grained, pinkish to brownish white in Colour and friable in nature. The bed dips flatly towards south at about 10º to 15º. Because of the distinct morpho-lithological features, the sandstone bed serves as a basal marker horizon for the overlying productive Prang limestone.

Prang Limestone: The Prang limestone bed, constituting the main productive horizon, occupy almost the entire study area being exposed over a north- south outcrop at an altitude of about 1200-1300 m. The area is practically devoid of any over burden except local soil packets in cavities and sinkholes. The limestone outcrops on the hill slope show a typical 'Karst topography' being cavernous in pockets over a thickness varying from 10 m to 45 m from the surface. The ground features are characterised by sharp edge outcrops intersected by numerous fissures, solution cavities and some large sinkholes. Wide channels formed by solutions along fractures and vertical bedding joints are common features in the outcrop of the Prang limestone. The surface is also characterised by boulders and blocky outcrops formed by partial collapse and slumping of limestone blocks. The boundary between Prang limestone and Kopilli shales is marked by a prominent east-west fault as evidenced by the structural discordance of the beds on both sides of the faulted contact. The Shale bed to the south of the fault, show a general east-west strike with steep southerly dips.

Kopili Shale: Weathered outcrops of dark grey and brown shales and calcareous siltstones representing the younger Kopilli formation occupy the area immediately to the south of the east-west running border road at the southern end of the study area. The contact between the Prang limestone and Kopilli shale is a discordant one representing a major fault in the vicinity of which a shale bed show a steep dip towards south.

Structure

Geologically, the Shella area forms a part of the southernmost part of the Meghalaya plateau. The geological, geomorphological and biotic evidences strongly support the assumption that the Meghalaya plateau is a continuation of the Chotanagpur plateau of the Indian peninsular shield. In the southern parts of the area around Shella, the rocks are concealed beneath cretaceous-tertiary deposits. The Sylhet traps are found in a narrow belt of about 4 km, width running in east-west direction in the southern part of the plateau. These rocks differ in their lithological and structural characteristics. Numerous faults and folds are present in the rocks, which are followed by cretaceous-tertiary sedimentation into the relative down thrown portions along the faults. These faults run in east–west direction in the south Khasi hills. The Dawki fault in the southern fringe of the Khasi hills is a prominent lineament, which comprises of at least four east –west running faults.

Cretaceous-Tertiary sediments:

The cretaceous tertiary sedimentary rocks occupying the southern part of the Meghalaya plateau are quite thick and extensive in nature. These rocks may be grouped under semi –consolidated formations. These formations consists of clay, siltstone, fine to medium grained sandstone, conglomerates and limestone and are found to attain a thickness of more than 300m with a tendency of thinning out towards north and north-westerly direction. The porosity is more in these rock formations and thus percolation of rainwater is moderately good and there by the ground water prospects are better in certain aquifers.

Sylhet traps:

The Sylhet traps are of the nature of plateau basalts, exposed in a narrow east west strip of about 80 km long and about 4 km wide along the southern border of the Shillong series .The Sylhet traps are predominantly basalts. These rocks are unfavorable for groundwater potential.

The sedimentaries of the south:

Further south occur the sedimentary rocks of cretaceous and tertiary age. These rocks have an almost horizontal structure with gentle inclination to the south. The inclination gradually increases towards the south and near the southern margin of the plateau the rocks form a flexure bend and plunge down the alluvium of the Surma valley of Bangladesh. These sedimentaries include mainly a few patches of cretaceous rocks and the tertiary formed of sandstones, limestone and shales. The Shella formation is again subdivided into Sylhet sandstone and Sylhet limestone. The Sylhet limestone beds with average thickness ranging from 120m to 400m consists of thick foraminifera limestone with alternate shale and marl beds, usually exposed along the rivers, nallas and its valley side slopes.

Tectonics:

The basin has been subjected to both diastrophic and volcanic activities in its process of evolution in the geological past. The present configuration of the basin is the result of several geotectonic events of upliftment and subsidence of different blocks of the basin. The traces of influence of endogenic forces on landmass causing major disruptions in the rock structure, which are depicted in the form of faulting, broad, folding, fracturing in the tertiary formation of the area. It is commonly believed that periods of orogenesis are episodic in occurrence, widely spaced in geologic times and worldwide in extent. It is also believed that between the orogenic movements there were long periods during which the earth's crust was relatively stable with only slow epirogenic upliftment or subsidence.

The orogenic movements in the basin are confined to the tertiary sedimentary deposits and towards the edge of the plateau showing traces of gentle broad open fold and fracture in the rocks. Some of these rocks are intrically folded showing high degree of flowage indicating high mobility of rocks. The general foliation trend of rocks seems to be north-east-south-west in the Shillong plateau. The general horizontal and gently dipping rock structure with NE-SW strike denotes the absence of major orogenic disturbances in the plateau structure of the area. Very little is known about the orogenesis of the area for want of detailed survey and investigation. The orogenic movement in the area resulted in upliftment and folding and thrusting of tertiary sediments during the Eocene period All these orogenic and epirogenic forces working in the geological past had left the imprints on the area and moderately influenced the development of the present landscape.

Climate:

The climate of the study area is sub-tropical type where seasons can be classified as:
Summer (March-April)
Pre-Monsoon (May-Mid June)
Monsoon (Mid June-October)
Post-Monsoon (October-November)
Winter (December-February)
The area receives an average rainfall of 1150cm most of which occurs during monsoon season. Cherrapunji is the nearest Indian Meteorological Center situated in the northeastern direction at the distance of about 56 km from Shella. The predominant wind direction is from north and northeast directions. The monsoon wind enters from the south from the Bay of Bengal. The Bay of Bengal current being obstructed by the Arakan Yoma hills moves north wards and then causes rainfall in some states of North East India and then it strikes against the southern face of the Meghalaya plateau rising up and causing orographic rainfall at the southern part of the plateau. That is why this part of the region (Cherrapunji-Mawsynram) receives the highest average annual rainfall in the world.

It should be noted that the occurrence of storms is also common in the study area. Most of these storms have their origin in the tropical cyclones of the Bay of Bengal. Being not very far from the tip of the Bay, the hills experience cyclonic storms that reach them after blowing over the Bangladesh plain.

All the climatic features discussed above reveal one important aspect that the area under study is under sub-tropical climate where dry and hot season are followed by a wet and rainy season. It is the relative humidity of a place that affects the amount and processes of precipitation of that place. The amount and incidence of atmospheric precipitation determines the mode of weathering and even the character of rocks decomposition. In the limestone areas, humidity plays most important role by giving a helping hand for chemical decomposition on the exposed rock masses. Relative humidity is highestin the months of June to August with more than 90%, while in the lowest months of January to February it is 60-70% only.

Generally the amount of rainfall received increases from the southern foothills tracts towards the mountainous areas according to relief. The amount of rainfall decreases on further north due to the effect of rain shadow. The rainfall starts by the third week of April and continues up to the end of September after which it gradually diminishes. The maximum rainfall occurred is 1150 cm. It is clear from the above discussion that there is marked variation in temperature between the north and south of the study area.

The mean maximum temperature is about 24º C to 44º C in dead summers during may to July and the average minimum temperature during December to January ranges from 3.5º C to 15º C respectively.

Hydrogeology:

The hydrogeology of the area is governed by the drainage pattern in the region that represents the most spectacular features revealing extraordinary courses of the river and streams evidently along the joints and faults.

Joints and fractured bedrocks combined with extensive solution channels provide favorable conditions for circulation of ground water. The surface runoff percolates down through these surface openings and re-appears as hillside springs where suitable outlets are encountered. Due to the hilly terrain of the area there is no ground water available within the study area. Further, due to the rocky strata, the drilling of dug well or a bore well is difficult.

Drainage:

The principal river Umiew or Bagra flows in the north-south direction. This river rises from the southern slope of Smit area at an elevation of 1804m enters the study area by cutting deep valleys through the Cretaceous (chalky) sandstone and limestone. In many places older rocks like Gneisses and Schist's have been exposed along its bed. The basin of Umiew or Bagra River has separated the Cherrapunji platform from Mawsynram region and finally reach the Bangladesh plain near Shella. It joins river Surma in Chattak Bangladesh. The feeders of Umiew form a drainage network in relation to sedimentary joints. The important tributaries are Phlangkaruh which originates from the foot hills of Nongtrai-Dewsaw coming down from the north maintains its identity in the Indian territory and further joins Umiew downstream in Bangladesh. On the other hand the river Sonai originates from the foothills of Cherrapunji flowing over the scarp line of Thangkharang Park and the Khohramhah rock at 720m and above on the east of Shella. It is another important river that enters the area by cutting deep valleys through the cretaceous sedimentary rocks. It has a number of tributaries and Ishamati is one of the tributary flowing in Tyllab. This river also finds its way to Bangladesh making deposition as its important activity.

The study area has several perennial water sources. However these water bodies are the only perennial water source which controls the occurrence of surface water and phreatic water bodies in the local pits, ponds, artificial reservoir and sink holes as well as they influence the course and quantitative occurrence, formation as well as the loss of water sources. Some other streams that flow around the study area are Nalaha, Nur-ruksan and Nur-khapmohi near Jatap, Um Tyllab near Ishamati, Maula River and Pryringithull in Phlangkaruh. One of the sources of water for the Phlangkaruh river is the water springs coming out near that area.

Soil: The soil in this area is a product of continuing process of evolution that takes place in a parent material through physical and chemical weathering processes and influences of organic decayed materials. The soil forming processes of the area is also influenced by the characteristics of the terrain, certain biological factors and drainage conditions.

The regolith, comprising the broken and weathered igneous and sedimentary rock fragments overlying the rock in situ is the parent material from and in which soil develops. The most important regolith of the study area is composed of mainly alluvial sediments on flood plains, the sands gravels of rocks fragments, disintegrated sedimentary and igneous rocks. The physical and chemical constitutions of the parent material also contribute substantially in the formation of different types of soil of the area. The study revealed that the areas around Shella are made up of different types of soil. Towards the north the land comprised mostly of sand while to the south the area comprised of alluvium and clay.

The entire plateau is devoid of soil, while the slopes although, have some soil cover but does not show the soil profile. High rainfall, hilly geography and nature of substrata are responsible for the loss of soil layer in the entire area. The soil of the study area is found in the gullies and crevices and cracks, which characterized the area. At places dense growth of grasses and shrubs, wild banana, and undergrowth have helped in retaining the soil whose thickness rarely exceeds 50 cm.

As per the earlier studies three soil types are found, in crevices, from hill slopes and from foothills soil is characterised as sandy clay loam in texture in the crevices and sandy loam in the foothills. The soil reaction is near neutral to alkaline in all three types with pH ranging from 6.93 to 7.86. The soil in crevices is reported rich in organic carbon, total nitrogen and available phosphorous. Soil in some areas is observed to be generally loamy texture containing high humus and with nature varying from slightly alkaline to alkaline. The nitrogen level fall and potassium level fall under the category of low. Whereas, the level of phosphorous fall under the category average to sufficient. The level of organic matter in the soil falls under the category of sufficient. The flood plains are significantly rich in soil due to alluvial deposits. However, in the plateau and hill slopes the soil depth is very low and large tracts of land are uncultivable. In and around the limestone block the soil is alkaline and does not support any healthy plant growth. The hill slopes are extensively used for plantation of betel nuts, which require running water and very little soil depth for growth. Also to prevent land sliding and soil erosion the hill slopes, the bamboo vegetation and the plantation trees play an important role. The growth of the bamboo does not allow washing away of the little topsoil above the rock structures and in the fissures and gullies of the hill slopes. The flood plains and the valley soil are primarily sandy alluvial deposits where paddy is grown.

Vegetation:

surrounded by a chain of hills and with narrow roads waving their way through them, the area has no dearth of vegetation. However, before the hosts of plant species of the area are described, it is worth mentioning that the area also shelters numerous small villages. Almost all the village houses have pieces of land of various sizes attached to them. These homelands are used to grow fruits and herbs along with ornamental plants. The vegetation of the study area is mostly comprised of evergreen and semi-evergreen vegetal cover including grasslands riparian and swamp vegetation. There are heaps of fractured rocks scattered all over the place. The terrain undulation, the karst topography and rocky structure do not allow normal plant growth. The greenery mainly lies on the east –west of the area and down south covered with shale deposits. High rainfall, karst topography results in trapping of very little ferralitic soil in the fissures and cavities, which support relatively thinner plant growth in the area. Present status of flora at the study area is only due to clay present in the cavities and fissures. The area does not support anchorage space for their big tree roots. The flora of the area provides a list of threatened and rare species.

In some areas to the west, *SARPGANDHA*, a medicinal plant is found growing in patches. In the adjoining areas comprising of fragmented components of shale, larger tree species are observed. Infact, the general area seems to be better endowed with vegetation.

Landuse pattern:

Land use Pattern reflects the topography, soil characteristics and proximity to the river, which dictates water availability for irrigation. In Meghalaya state, the land belongs to the people and not to the state. Some parts of the study area are located on predominantly undulating to rolling country to the west of the Umiam River, with a small portion of the eastern boundary extending into the flood plains of the south. A large portion of the study area though covered with dense growth of vegetation, however has not been considered or classified as reserved or protected forest land by the Department of Forest, Government of Meghalaya. The surrounding land has some of the area as consecrated forest or sacred forests (Lawkyntang in Khasi), set apart purposely for the religious performances of the village. The core zone is practically devoid of any soil cover. This area is not arable and hence does not support agriculture. The land is mostly rocky and the rock is wholly limestone. The adjoining areas surrounding the core zone have almost similar structural features. The total geographical area of Shella-Bholaganj Block is 578 Square Kilometers. Agriculture/Plantation is the main occupation in the region. Most of the lands are natural rain fed while in some areas irrigation through canals and bamboo connection have been provided. The entire land use of the study area around Shella as per satellite imagery IRS-1B, data is given in the figure below.

Reportedly there is no study done on the land use pattern at the village level for the Shella Block and there are no records available on the land use pattern as well. In the District of East Khasi Hills most of the land belong to the people and not to the state, the land tenure system are of different category. “Rikynti” or the private land is the land which belongs exclusively to a person or persons (irrespective of how he and they got exclusively under his or their possession) and which has as its boundaries permanent stones, or boundary stones or stones marking the division of land or of trees, bamboos or rivers or of streams or of plants of definite marks. “Raid land” is the land belonging to the community of the people of the Raid. Raid in the Khasi District is the Administration of the Village Dorbar by the person known as Bakhraw or Basan or the Elders or Headman appointed within the state, which fall under their administration.

“Whereas all life forms require water, a primary natural resource for sustenance;” quoted from The Meghalaya Water, Act 2012.Water sources in private and community land is protected in accordance with the Meghalaya Protection of Catchment Areas Act, 1990 and the Meghalaya Forest Regulation Act, 1973.

Findings:

Geomorphic processes

The geomorphic processes are all those physical and chemical changes, which effect a modification of the earth’s surficial form. A geomorphic agent or agency is any natural medium, that is capable of securing, and transporting earth’s materials. Thus, running water, groundwater, glaciers, wind and movements within bodies of standing waters including waves, currents, tides and tsunami are the great geomorphic agents. They may further be designated as mobile agents because they remove materials from one part of the earth’s crust and transport and deposit them elsewhere. Most of the geomorphic agencies originate within the earth’s surface and are directed by the force of gravity. Gravity is not a geomorphic agent, because it cannot secure and carry away materials. It is better thought of as a directional force. The geomorphic processes and their actions operating at present are to produce an end product, resulting in a typical landscape.

Although the genesis of landforms is very complex, there are certain laws under which the geomorphic processes operate. While individual geomorphic processes operating in a region do produce some distinctive landforms, it is difficult to distinguish the processes in the field. Some of the important geomorphic processes operating in the region under study are weathering, fluvial erosion and mass wasting which have modeled the landscape. The present relief features are no doubt primarily the product of running water, but weathering and mass wasting have also contributed significantly to the development of landforms. Three different geomorphic processes therefore, are to be studied separately.

Weathering:

Weathering may be defined as the disintegration or decomposition of rocks in situ at or near the ground surface. It is primarily concerned with reduction of a rock mass to a form and size susceptible to erosion, which is accompanied by such agencies as mass movement, running water etc. Arthur Holmes (1952) has presented more elaborate definition of weathering which also includes the processes of weathering. According to him 'weathering is the total effect of all the various sub-aerial processes that co-operate in bringing about the decay and disintegration of rocks, provided that no large scale transport of the loosen product is involved'.

The climate of this area falls under sub-Tropical monsoon climate. The area receives the heaviest rainfall and due to the plateau nature of the area, it is conducive to chemical weathering. Due to the climate and altitude, the area is covered by fairly dense mixed vegetation. The litter of the vegetation present turns the soil acidic that in turn increases chemical weathering.

The high variation in temperature increases mechanical disintegration of rocks. The area experiences high rainfall. The rainfall over the acidic soils yields large amount of acidic waters, which increases removal of huge quantities of chemical from the soil. Similarly, higher rainfall in the Study area increases run-off along slopes. Consequently, large quantities of material are constantly removed down slope. As a result, new bedrock is frequently exposed to physical and chemical weathering. Humidity is related to rainfall and temperature. Because of higher rainfall in the area, the humidity normally remains moderate to high in Table 3. As a result evaporation is slow. This indirectly helps in retaining the soil moisture for prolonged period leading to chemical weathering.

Since weathering involves disintegration and decomposition of rocks, hence, mineral composition, joint patterns, layering system, faulting, folding, etc. largely affect the nature and intensity of weathering. For example, in the study area, the presence of calcium carbonate having more soluble minerals is easily affected by chemical weathering. Well-jointed sedimentary rocks are more subjected to mechanical disintegration. Generally, weathering processes are conveniently divided into physical, chemical and biological weathering.

1. Physical Weathering:

The physical or mechanical weathering leads to fragmentation and break down of rock masses into big blocks and boulders, cobbles and pebbles, sands and silts. Physical weathering may be defined as the disintegration of rocks due to temperature variations. Though temperature variation is a key factor in physical weathering, run-off and gravity also play major role. The scarp features of Kynrem has bare sandstone rock out crop covered by scanty vegetation and is affected by physical weathering particularly along the waterfalls and banks of rivulets. The presence of well-marked joints and cracks in the upper Kynrem sandstone accelerates the physical weathering. At the foot of the scarps, the weathered and eroded materials supplied from the crest of the scarps, is deposited in the form of a debris slope.

2. Chemical Weathering:

Decomposition and disintegration of rocks due to chemical reactions is called chemical weathering wherein, the minerals of the rocks weather away. Water vapour and water are the medium, which activates several types of chemical reactions within the rocks. Chemical weathering is the reaction that takes place when water comes in contact with soluble rocks. Since the area around Shella is comprised mostly of limestone, Due to long continuation of this process, rock masses becomes weak, the joints and cracks enlarge in size. Due to weathering and erosion, in the study area large number of caves and sinkholes in the body of the limestone are formed in the study area.

3. Biological Weathering:

Biological weathering in the study area is not so significant as the other two processes of weathering. Man through his various activities such as mining of limestone, quarrying of sandstone, deforestation, etc. is an important agent of biological weathering. However, the effect of roots of trees in penetrating along the joints of the rocks cannot be neglected. This type of weathering is mostly noticed in highly jointed rock, especially in the southern parts of the study area.

Mass wasting:

The intensive action of weathering in the areas under study produces large amount of material, which move down the slope. This bulk transfer of rock debris down slope under the direct influence of gravity results in mass wasting. Sculpturing the land and reducing the surface to a new topography to karst landform.

The amount of mass wasting differs from one part of the area to the other. Rockslide seems to be a common feature in this area. Some of the big rock masses may be seen in the Kynrem, Umwai area. It appears that due to the action of mechanical and biological weathering along joints, the compactness of the rock mass is lost and the boulders fall down the slope due to the force of gravity. Due to the presence of regolith materials landslides are more common along the steep slopes on the escarpments of Umwai village. Seepage from the hillsides produces mud creep or slump along the road cuttings. Earth fall or sliding may occur because of undercutting by a stream whose predominant forces are directed laterally rather vertically by rivers of low gradient in flood plain channels. Such types of mass movement are common in Kynrem, Umwai and Ishamati areas.

But in some areas these rock materials are so large that the running water can hardly wash them away along the slopes. The above discussion reveals that mass movement in the study area is predominant due to heavy rainfall, presence regolith materials, steep slopes and areas dominated by joints, bedding planes fault, etc. The wasting products cause road blockades during rainy season making it difficult to communicate. In order to prevent such type of environmental hazard, it is necessary to understand the nature of slope instability and resultant mass movement and to access the problem through an interdisciplinary study.

Fluvial Processes:

Fluvial processes are very much important to understand the evolution of landscape. Fluvial processes cause progressive dissection and degradation of the higher lands. Runoff is the most dominant geomorphic agent in sculpturing the landscape of an area. Run off in the area consist of all surface water flow, both over the land slopes and in streams. Run off in the area is derived directly from excessive precipitation which cannot infiltrate the soil or it may originate as the out flow of ground water along the line where the water table intersects the earth's surface.

As regards to the character of rocks and slopes of the surface, the area is a region of physical inequalities. The plateau consists mainly of limestone and shale in the inner strata and sandstone in outer strata. Most of the study area is covered with thin veneer of soil, which support fairly dense vegetation. The study area gets quick and voluminous run off during the rainy season. As the distance, from the water parting increases, so also the volume and erosive power of water flowing in the hills also increases. On the slopes of the study area, run off flows down the surface of the land in more or less broadly distributed rills and sheets that may be designated as overland flow. In the lower and moderately sloping areas of Shella itself, the overland flow gradually takes the place of stream flow, in which the water occupies a distinct narrow deep gorge confined by steep wall bank. During the rainy season the water level rises up and the rate of stream inflow increases.

The run off of Shella and its adjoining areas are divided into two: They are,

1. Immediate run off
2. Delayed run off.

1. Immediate run off:

After heavy rainfall in the slopes of the study area, the surface water makes its own path to flow from the higher reaches to the lower reaches. All these are helped due to the presence of big rivers such as Umiam and Sonai while the rest are the works of the streams and tributaries like Phalangkaruh, Ishamati, and Maula that flows over the study area.

2. **Delayed run off**:

It includes the springs and underground water of Shella and its adjoining areas. Springs spot the hydrological character of the study area. The percolation and sinkage of water during rains through the soils has maintained storage in the underlying impervious bed. Where the sandstone has been eroded and the shale surfaces have been exposed, the formations of contact springs have come into existence, attributing a peculiar hydrological feature over the surface of the area. Such springs are locally called as "um pohleu" from where water flows regularly throughout the monsoon season and gets dried up during winters. But some springs particularly on the northwestern parts of the study area, where water flows all throughout the year and they are meant for the utilization of human beings. The imprint of underground water is seen in narrow glens which are locally called as *"nurs"* or *"noors"* These are collapsed narrow caverns valley but even after the rains has stopped in these nurs, the perennial streams flow shows the character of subterranean drainage. Examples are *"nur ruksan"* and *"nur khapmohi"* located in the east of the study area. Many underground streams that originate due to percolation of water through porous rocks like limestone, sandstones and shales are seen inside the limestone caves present in the study area.

Conclusions:

Studies in geomorphology is not only an academic exercise, but it also involves an in-depth investigation on the subject. The study clearly reveals complete geological - geomorphological evolutionary history of the areas around Shella. The study of landforms and drainage revealed that their development is directly related to lithology and structure of the underlying rocks. The climate played an important role in the formation of landform through various geomorphic processes. The other processes like vegetation, weathering, mass wasting and run-off are quite active in shaping the landform. Thus, summarizing all these we may say that, even though the area has a very complicated origin, it has reserves of fascinating landscape and it is a museum of karst landforms.

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Table-1: Litho-Stratrgraphic Succession in the Thangkharang-Shella Area.

Age	Group	Formation	Thickness	Rock Type
1. Oligocene to upper Eocene	Garo group	Baghmara formation	530m Approx.	Feldspathic sandstone, pebbles diamictite, clay, silty clay.
2. Upper Eocene to lower Eocene	Jaintia group	Kopili formation	450m	Shale, sandstone, marl, nummulitic.
		Prang formation	+-200m	
		Narpuh formation	20-25m	Calcareous sandstone.
		Umlatdoh formation	122m	Foraminiferal limestone.
3. Upper Eocene to lower Paleocene.		Shella formation	600m	Sandstone and limestone
		Lakadong sandstone	192m	Sandstone with seams and lenses of coal.
		Lakadong limestone		Fossiliferrous limestone
		Therria sandstone		Grayish-white and brown sandstone.
		Langpar formation	120m	Calcareous shale sandstone and limestone.
4. Upper cretaceous	Khasi group	Mahadek formation	350m	Glauconitic sandstones and conglomerates

Source: NEHU.

Table-2: Areas Covered Under Particular geology.

Sl. No.	Geology	Areas Covered
1	Sylhet	Tyllab, Byrong, Phali, Mawryngkhong, Lubia, Disang, Mustoh, Laitkynsew, Nongwar, Shella Bazar, Therria.
2	Baghmara	Shella Bazar, Sohbar, Jatap, Umdon-Mawpot, Kalatek.
3	Khasi Group	Ishamati, Mawlong, Rangamati.
4	Granites	Dewsaw.
5	Shillong Group	Mawlong, Mawshamok, Nongkroh.
6	Fault line	Stretching from Kynrem-Tyrna.

Source: The researcher.

Table-4: Soil Quality.

Shella-Phalangkaruh	Soil	Category	Texture
Nitrogen	14.6-25 KG/HAC.	Very less	Silty Clay and slightly alkaline.
Potassium	93.2-96.4 KG/HAC.	Very less	
Phosphorus	18.8-19.5 KG/HAC.	Less	
Organic Matter	0.48 %	Sufficient	

Table-5: Soil Quality.

Shella Bazar	Soil	Category	Texture
Nitrogen	65.5 KG/HAC.	Less to very less	Loamy soil and acidic.
Potassium	100.6-106 KG/HAC.	Low	
Phosphorus	19.9-22.1 KG/HAC.	Average less	
Organic Matter	0.91 %	Sufficient	

Alkalinity of the Sample is 0.412Meq/100gm.

Table-6: Soil Quality.

Phalangkaruh River Bed	Soil	Category	Texture
Nitrogen	14.7 KG/HAC.	Very less	Sandy clay and slightly acidic.
Potassium	104.6 KG/HAC.	Low	
Phosphorus	20.8 KG/HAC.	Medium	
Organic Matter	0.5 %	Medium	

The soil has a high moisture retention capacity.

Table-7:Soil Quality.

Nongwar-Mawryngkhong-Pyrkan	Soil	Category	Texture
Nitrogen	10.2 KG/HAC.	Very less	Loamy and acidic.
Potassium	100.6-108.1 KG/HAC.	Very less	
Phosphorus	18.9-21.4 KG/HAC.	Less	
Organic Matter	0.44 %	Sufficient	

Alkalinity of the soil is in the range of 0.4212-0.618 meq/100gm.
The moisture retention capacity ranges from 32.8-40%.

Table-8: Soil Characteristics.

Area	Texture	pH Value
Phalangkaruh	Silty clay	Slightly alkaline
Shella	Loamy soil	Acidic
Phalangkaruh River bed	Sandy clay	Slightly Acidic
Nongwar	Loamy	Acidic
Mawryngkhong	Loamy	Acidic
Pyrkan	Loamy	Acidic
Khamlai	Silty clay loam	Acidic
Ishamati	Silty clay loam	Acidic
Jatap	Silty clay loam	Acidic
Dhorum	Sandy clay loam	Acidic
Kalibari	Sandy clay loam	Acidic
Lubia	Sandy clay loam	Acidic
Rangamati	Silty clay loam	Acidic

Source : Soil quality and characteristics; Courtesy Lafarge Cements limited.

Plate-1: Physical weathering.

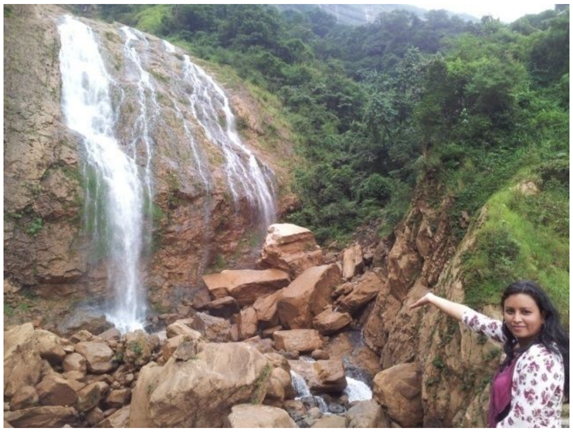


Plate-2: Chemical weathering

Plate-3: quarrying

Plate-4: Biological weathering

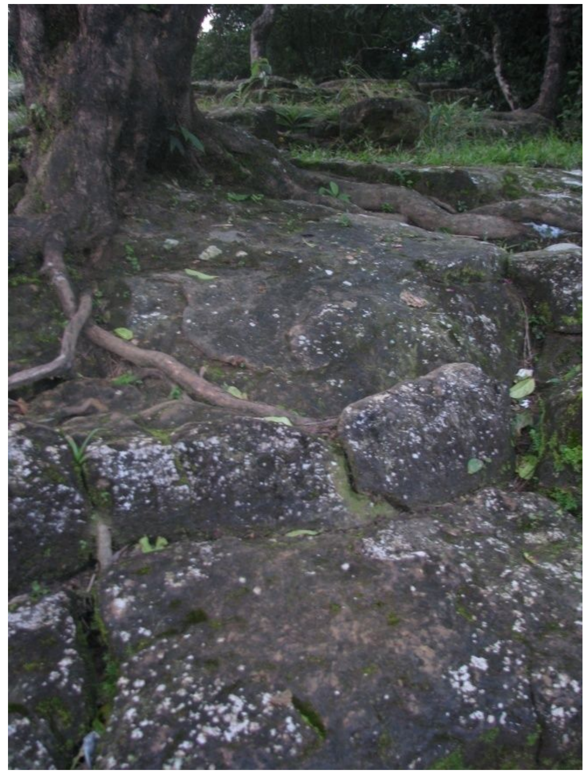


Plate-5: Landslide

Plate-6: Rockslide

Plate-7: Gushing water

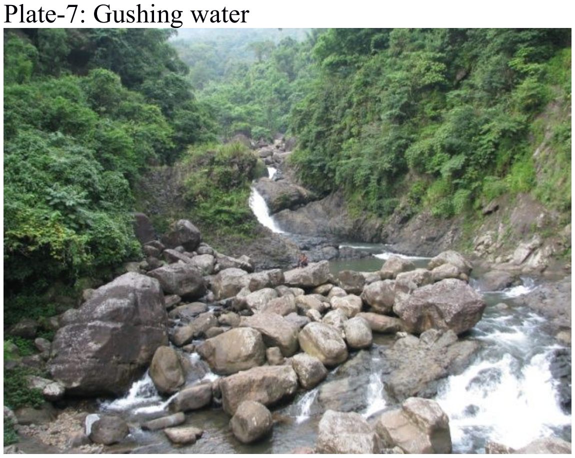


Plate-8: Springs

Plate-9: Gullies

Plate-10: Shella river

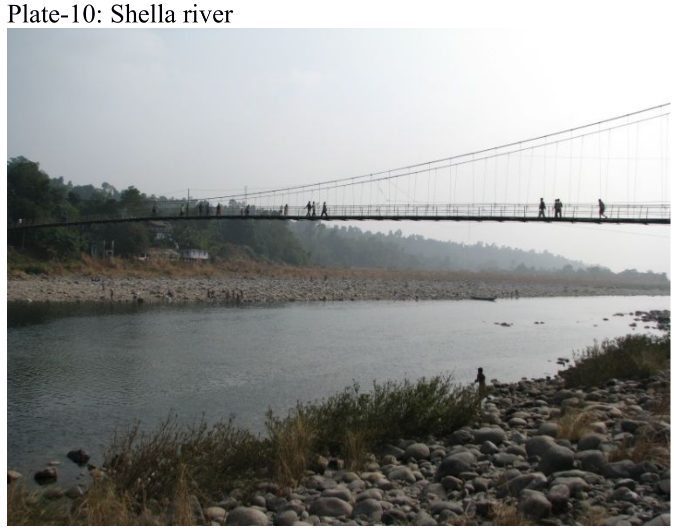
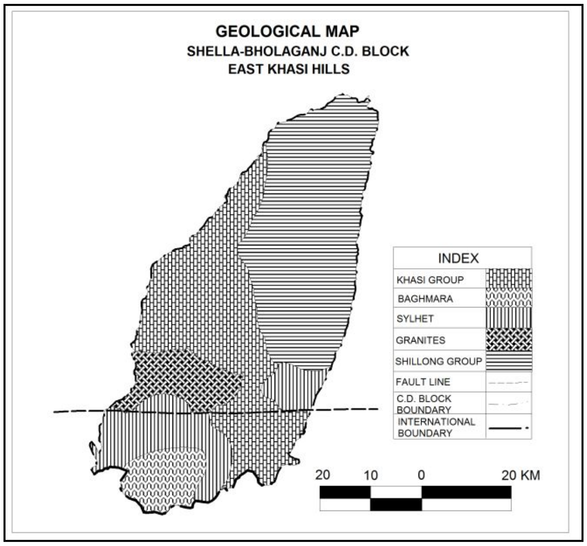


Fig-1: Geology

Fig-2: Drainage



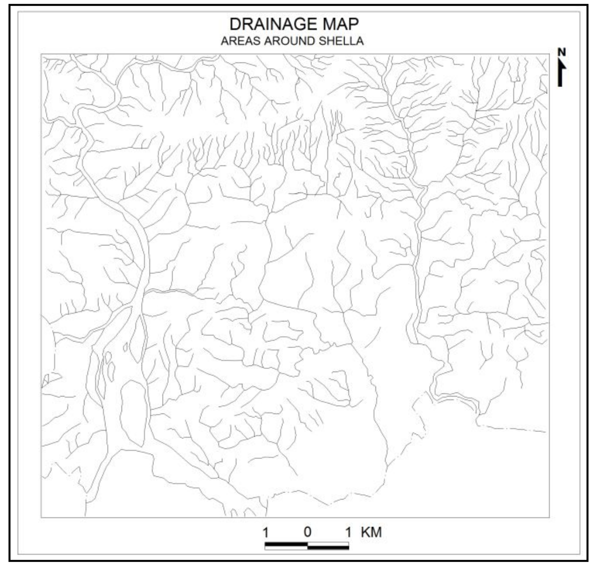


Fig-3: Rainfall and Temperature Graph