GEOMORPHIC STUDY OF TURA AND ADJOINING AREA WEST GARO HILLS DISTRICT, MEGHALAYA

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Dissertation

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This is to certify that the dissertation entitled, "Geomorphic Study of Tura and adjoining Area(), West Garo Hills District, Meghalaya" submitted by Shri Paul Soren in partial fulfilment of the degree of Master of Philosophy of the Department of Geography, School of Environmental Sciences, North Eastern Hill University, Meghalaya, is a bonafide study of the author carried out under my Supervision and Guidance and may be placed before the examiners for necessary evaluation.

Shillong
The 15/5 1992.

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PAUL SOREN

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CHAPTER I

INTRODUCTION, LOCATION OF STUDY AREA, OBJECTIVES, SALIENT FEATURES OF THE REGION, EARLIER INVESTIGATION, PLAN OF WORK

INTRODUCTION

Geomorphology is a study of landforms, "The Science of the Earth". It is an important branch of physical geography. It is concerned with the scientific study of the origin and evolution of the relief features of the earth surface. The literal meaning of geomorphology is a discourse on the form of the earth. The term geomorphology is derived from the Greek word, 'Geo' meaning 'earth', 'morpho' meaning 'form' and 'logos' meaning 'science', the science of landforms. Thus, geomorphology is a systematic and organised description and analysis of the landforms of the earth. The word 'landform' is understood in its widest connotation and includes not merely the minor features of the land but also the major relief features such as continent and ocean basins, mountains, plateaus and plains and an interpretation of their origin is equally relevant. This is possible only if we have knowledge of the structure of the earth, the nature of rocks, diastrophism, plate tectonics, continental drift as well as the processes of weathering and erosion, because it is all these factors that influence processes and change in the relief features of the earth. The study of landforms have a structural, erosional and depositional dimensions and both the aspects have been considered for a proper understanding of the evolution and distribution of landforms.

Worcester has used the terms geomorphology in this extended sense. According to Worcester, "Geomorphology is the interpretative description of the relief features of the earth, in other words, geomorphology is the science that describe the surface of the lithosphere, explains its origin and interprets its history[1].

Geomorphology is the science of landscape. It describes the landforms and attempts to explain their origin in terms of Geology, structure climate and processes. It is traditionally, the science of description, interpretation and evolution of landforms of the landscape, which provides the geomorphic knowledge for identification of an aereal landscape.

There has been phenomenal development in the field of geomorphological studies in the twentieth century, modern trend in geomorphology is towards the increasing importance of quantative methods. Morphometric techniques have been evolved for utilizing various topographic information about the earth's surface configuration to arrive at numerical indices. The information provided in toposheets, aerial photographs and landsat imageries and data collected directly by the field investigation are utilized for the purpose.

1. Worcester,P.G. - A text book of Geomorphology, Van Nostrand East-West Ed. 1965, p.3

The science of geomorphology has not been treated as only an academic discipline but it has more practical applications in the field of soil science, economic, geology, geohydrology, ecology and for rural and urban development. For the agricultural resources the terrain assumes special significance, so far as agricultural planning is concerned geomorphological studies at regional level have great significance. In a country like India, the applied geomorphology particularly for agriculture, horticulture, forest management, selection of sites for large dams, development of transport communication etc. Geomorphology plays a very important role specially for successful planning in the region like Garo Hills.

Oldham (1858) was the first to initiate the geological work in Meghalaya after the inception of geological survey of India in 1851. He came to Cherrapunjee from Rangpur in the erstwhile Bengal State now Bangladesh. He was followed by Medlicott (1869). In the post-independence period, large areas of Meghalaya have been mapped by the Officers of the Geological Survey of India and the Geology of Meghalaya is very well established by now (Fig.No.1). However, due to the restricted area provisions, much of the information is classified and unpublished. The compiled geological framework of Meghalaya is given by Anon (1974), Murthy et al (1976 a, 1976) and Mazumdar (1986).

The growth of this science in India is rather recent and the whole credit of carving the ways for this branch of science goes to the geologists. Among the geologists whose contributions are immensely valuable, mention may be made of A.M.Heron, D.N.Wadia, J.A. Dunn, W.D.West, S.C.Chatterjee, J.B.Aude, Arogyaswamy and Radhakrishna. At the early state initiative was also taken by geographers like H.L.Chibber, S.P.Chatterjee, S.C.Bose, R.P.Singh, E.Ahmad and K.Bagchi.

Geomorphological studies in India received new impetus with the work of young geologists and geographers since 1950. The scope of their geomorphological studies is now becoming wider[2]. There is now emphasis on various aspects of geomorphology, from regional to coastal, fluvial, structural, climatic and applied geomorphology. But most of the work has been done in the field of regional geomorphology with the emphasis to establish the denudation chronology of region and recognition of erosion surfaces (R.P.Singh, 1956; E.Ahmad, 1958; Bagchi and Sengupta, 1958; R.K.Rai, 1969; Biswas, 1974; Vaidyanadhan, 1964, 1971). The recent emphasis is on quantitative geomorphology of drainage basins by applying various

2. See Chatterjee,S.P.(1968) Progress of Geomorphology in India,(Ind.Sc.Cony.Ass; Calcutta).
Subramanyam,V.(1967),Proceeding,Seminar in Geom.Studies, in India,Saugar Univ.
Vaidyanadhan,R.(1977): Recent Advances in geomorphic studies of Peninsular India: A review, Ind.J. Earth Sc.(S.Roy Vol) pp.13-35.

morphometric techniques and measures to establish the the interrelation of basin parameters.

Few recent studies related to channel characteristics, rills and gullies, meanders, floods, slope profiles and characteristics in the field of fluvial geomorphology and slope analysis are encouraging. Application of monchometric techniques in classification of landforms into morphological units of various order has been initiated by R.L.Singh (1976). Recent research in regional geomorphology incorporate the study of the processes modifying the landscape.

For the present study, the author has selected the particular area to find out the nature of geomorphic characteristics, lithology and structural characteristics of rocks which provide much scope for study of geomorphological processes. In the present research work morphometric analysis have been basically used for the illustration and description of landscape, i.e., relief, average slopes, drainage analysis etc. which has focussed the light on particular topographical features.

LOCATION OF THE STUDY AREA

Geographically, the present study area Tura and

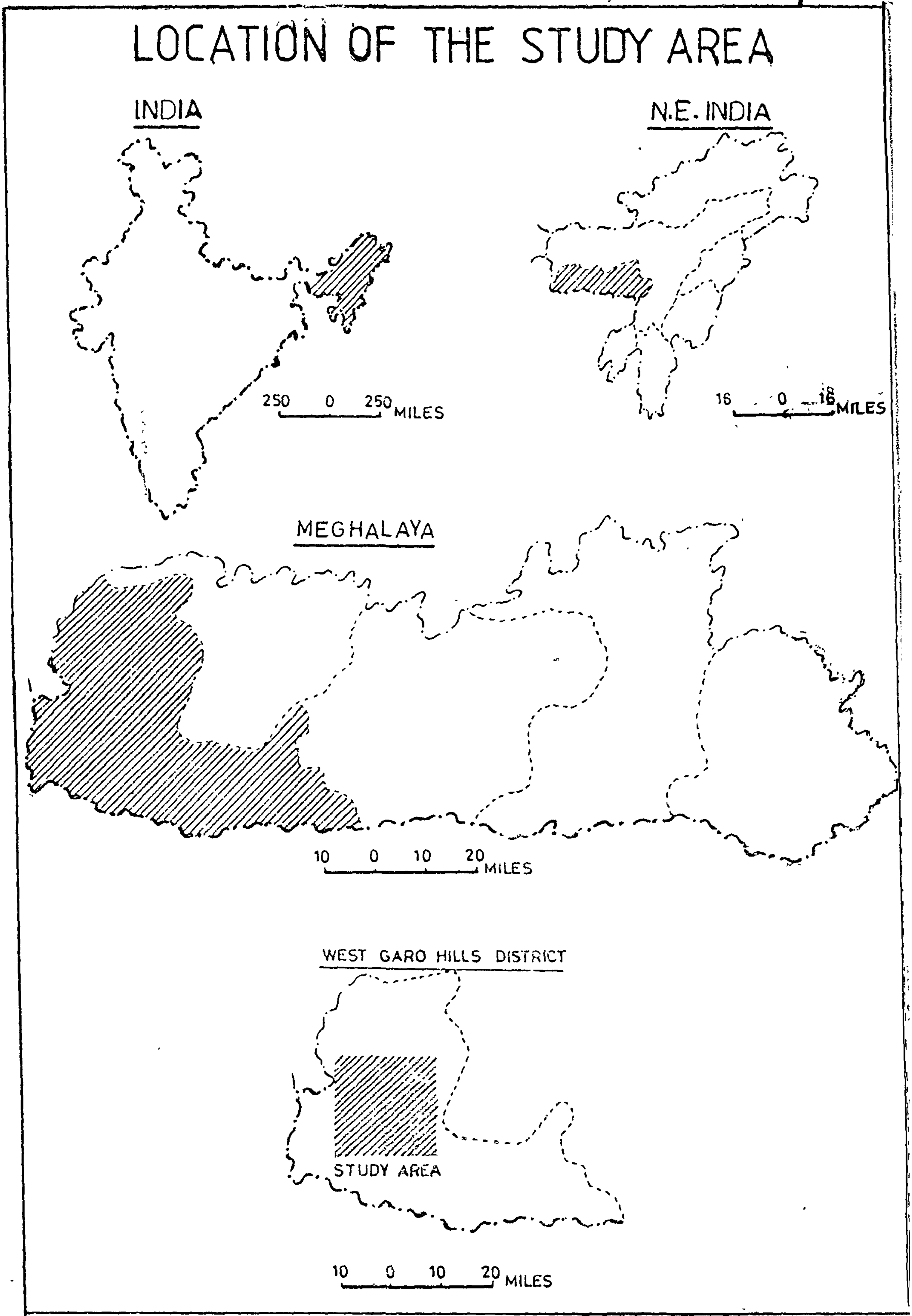

LOCATION OF THE STUDY AREA
INDIA
250 0 250 MILES
N.E. INDIA
16 0 16 MILES
MEGHALAYA
10 0 10 20 MILES
WEST GARO HILLS DISTRICT
STUDY AREA
10 0 10 20 MILES

FIG.No.1.

adjoining area lies in the West Garo Hills district and occupies the western part of the state of Meghalaya (Fig. No.1). The altitude of study area ranges from 100m to 1500m above mean sea level. Tura lies in between 25°31' North Latitude and 90°15' East Longitude. This study area includes the highest spot of the Garo Hills district, Nokrek peak 1515m standing like a water divide which forms watershed. The slope of the study area gradually decreases both towards the north and south direction from the central Tura range.

OBJECTIVES

The following are the main objectives as given below :-

1) the basic objective is to investigate and interpret the geomorphic characteristics of Tura and its adjoining area in relation to lithology and structural characteristics of rocks and geomorphic processes.

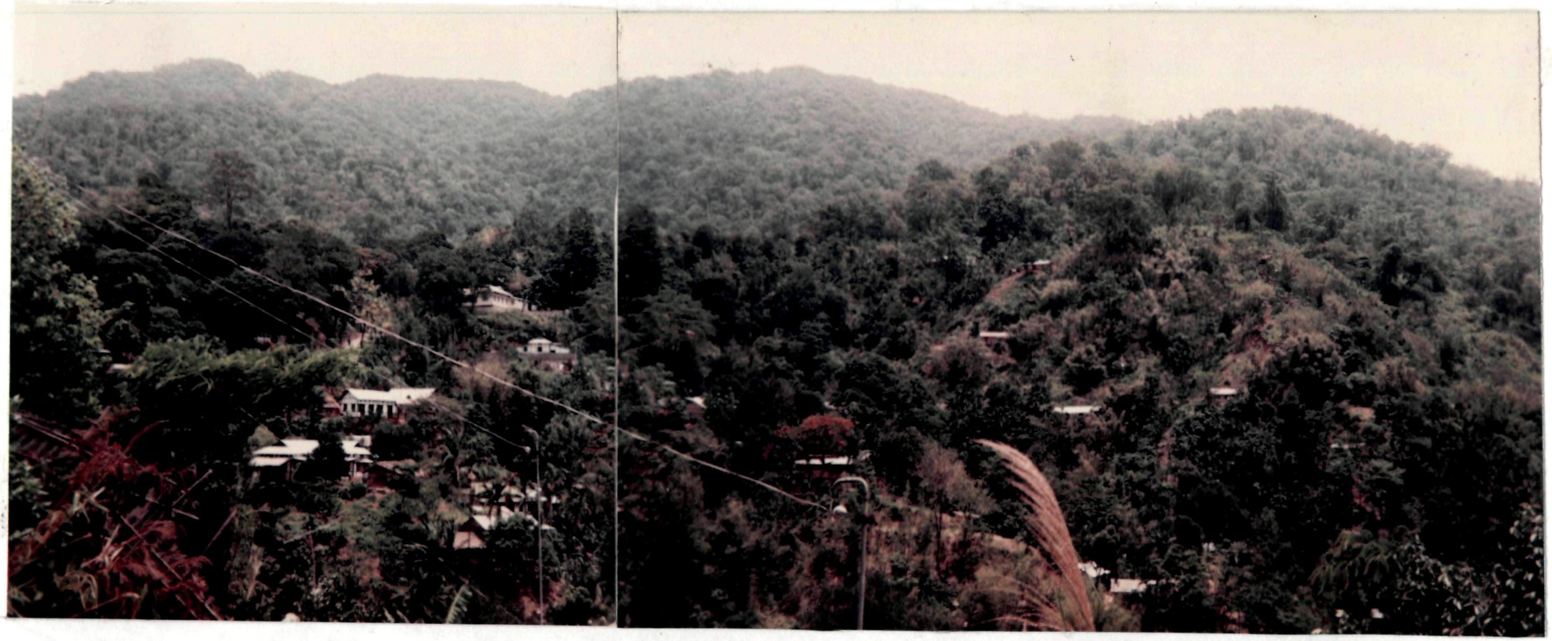
2) to examine the nature of average slope, drainage patterns and characteristic features.

3) to describe and interpret the erosional activity mainly under the impact of weathering processes and fluvial action of streams, and

rivers and also to identify the erosion surfaces with the help of morphometric tools and techniques and field evidences.

SALIENT FEATURES OF THE REGION

Topographically, the present study area characterised by undulating hills and deep narrow valleys. Average elevation of the study area is 600m to 1200m above mean sea level. The area in and around Tura has a distinct geomorphic tracts. The central part of the area is occupied by the hilly elevated Tura range and undulating hills, where several streams and rivers originated and form deep narrow valley with huge boulders on the river bed. The rivers originated from the Tura range flows towards north and south direction. There is a break in the gradient of the streams at about 2.5 to 3 Km west of the source, thereby depositing a major portion of the load at this break which falls in the heart of Tura town. All the stream crossing Tura, however they are small and forming deep gorges and full of boulders in the river bed. The main study area, i.e., Tura is situated at a place of aggradation. Another break of slope is evident at about 5 Km towards west from the source of streams beyond which only finer load of sediments is carried away.



Central part of the Tura range covered with thick forest. Fig. (p. 1)

The areas to the west of Tura are relatively flat with gentle slopes along edges of the flat areas, and from the depositional surface of the Tertiary sediments dissected by present streams. There are laterite formations on top of these flats, derived from the Tertiary sediments.

The Garo landscape, broken up by rising precipices and ravines, has a number of water falls. The most famous falls are the Khanchurisik, Mokma, Rongbang, Chibok etc. Some of them are quite sharp, steep having height about 50 to 150 m.

As the study area falls in the western part of state of Meghalaya, geologically it is composed of precambrian, Archaean gneisses with acid and basic intrusive and cretaceous Tertiary sedimentary rocks. There is also a small patch of limestone series which is a continuation of Jaintia limestone series, exposed to the ground at Samphalgri hills towards the south of Tura range.

EARLIER INVESTIGATION

The present study area has been taken up for the geomorphic study. The area has not been investigated from geomorphological point of view. However, Geological information has been contributed by the Geological Survey of India. As Fox (1937) mentioned that the contact of tertiary shales and underlying gneisses in Darrangiri village, just south of Tura as reverse fault. Similar work was carried out by Bhattacharya and Chakravorty (1967) La-Tonch (1887) Narula (1985) described briefly the Tura range as an asymmetric horsts back, meaning that the hill mass has been uplifted along fracture plane and also studied the landslides in Tura. In 1965-66, A.C. Bhattacharya and O.Barman have contributed geological information around Tura. Sukumaran P.V.(1986-87) submitted report on the Geo-environmental studies carried out in Tura township and its surrounding, Garo Hills district. However, some of the geomorphological studies of Meghalaya have been contributed by R.P.Singh (1968) P.C.Panda(1985) R.K.Rai (1985) and G.C.Panda (1984) etc.

METHODOLOGY

For the present study, the methods adopted have been extensively based on the field investigation and lab. work. The toposheet No.78K has been used for generating morphometric data of the study area for the analysis of average slopes, drainage frequency and drainage density of the study area. The data of rainfall, temperature, humidity etc. are collected from mateorological station fixed at Tura town. The field investigation has been done by practical observation of the study area, like nature of slopes, rivers, waterfalls, weathered zones and other related geomorphic features.

LIMITATIONS

The geomorphic study of Tura and adjoining area has been undertaken. Yet there were many constraints in conducting the field work in remote places of the study area because of lack of transport system. Sometime, weather conditions were coming in the way to conduct field work. The Garo Hills district lacks the detailed geological literature.

PLAN OF WORK

The present research work has been divided into following chapters.

In the first chapter, deals with the introduction of study area, its location, physiographic characteristics, the methodology used and the earlier investigation and plan of work, etc.

The second chapter deals with geology and structural characteristics of rock formations. It also describes the physiographic characteristics and drainage basins present in the study area.

Chapter third deals with Geomorphic processes, physical and chemical changes which effect modification of the earth's surficial form. The climatic data for about 20 years have been shown in the table No.4. This chapter also deal with the drainage systems and the action of erosional activity.

The fourth chapter deals with the morphometric analysis of average slope, drainage, density, frequency etc.

The last chapter brings out summary and conclusions of the study area.

CHAPTER II

GEOLOGY AND STRUCTURE

The Meghalaya Plateau is the North-Eastern tip of the Indian Peninsula. The State of Meghalaya comprising of Garo, Khasi and Jaintia Hills District, was a part of Assam till January 1972. Geographically, the state covers an area of 22,429 Sq.Kms. Physiographically, it is a prominent geomorphic unit stretching across the Garo, Khasi and Jaintia hills in east-west direction. According to Murthy et al (1976) and Mazumdar (1986), Meghalaya is a geomorphic arch bounded on all the sides by faults. The Northern boundary is marked by the Brahmaputra lineament, to the south by the famous Dawki fault while the Eastern boundary is a NE-SW lineament separating the massif from the sediments of Bengal - Assam shelf and to the West it is detached from the main shield by the north-south trending Rajmahal Garo gap. This major gap has been filled by the spreading of the Ganga and the Brahmaputra alluvium. The resemblence is seen in the rocks found in the Meghalaya Plateau to that of Chota Nagpur plateau of Bihar and West Bengal. Structural trends of rocks of the two parts are matchable. The geological, geomorphological and biotic evidences strongly support the assumption that the Meghalaya Plateau is a continuation of Chota Nagpur plateau. The Meghalaya plateau is massif horst, forming a plateau region block uplifted to its present height about 200 to 1900mts above mean sea level.

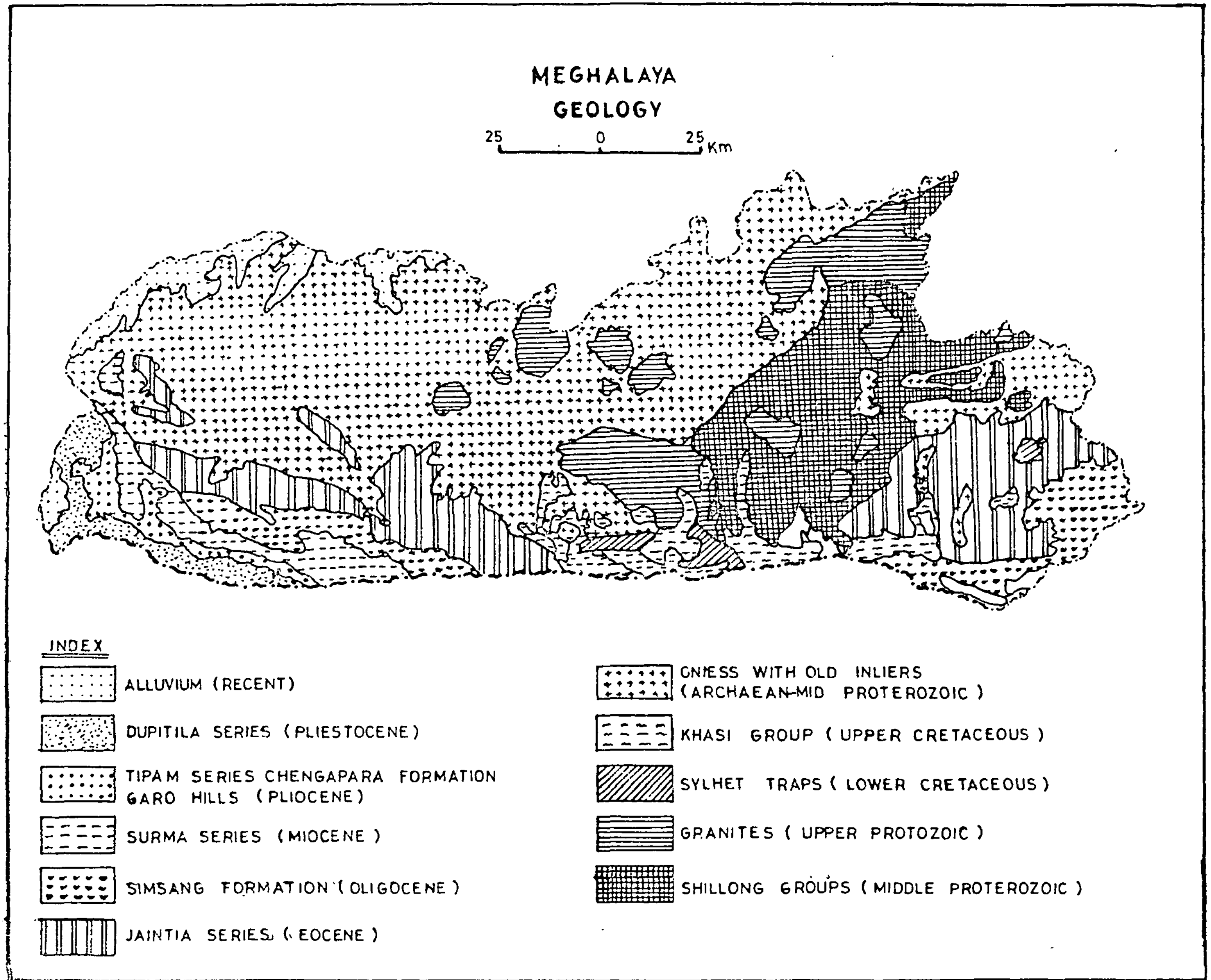

MEGHALAYA
GEOLOGY
25 0 25 Km
INDEX
ALLUVIUM (RECENT)
DUPITILA SERIES (PLIESTOCENE)
TIPAM SERIES CHENGAPARA FORMATION GARO HILLS (PLIOCENE)
SURMA SERIES (MIOCENE)
SIMSANG FORMATION (OLIGOCENE)
JAINTIA SERIES (EOCENE)
GNIESS WITH OLD INLIERS (ARCHAEAN-MID PROTEROZOIC)
KHASI GROUP (UPPER CRETACEOUS)
SYLHET TRAPS (LOWER CRETACEOUS)
GRANITES (UPPER PROTOZOIC)
SHILLONG GROUPS (MIDDLE PROTEROZOIC)

FIG. No. 2

The earliest geological investigation were made sometimes in 1850s, Oldham (1858) was the first to initiate the geological work in Meghalaya after the inception of Geological Survey of India in 1851, Oldham came to Cherrapunjee from Rangpur in the erstwhile Bengal state now in Bangladesh. Later on the systematic geological mapping of Meghalaya was carried out in detail by H.B.Medlicott(1969), Godwin Austin (1869), La Touche (1883), 1887 and F.R.Mallet (1975). Thus in post independence period, their account helped considerably in continuation of systematic mapping of different parts of Meghalaya by the Officers of the Geological Survey of India and the Geology of the state is very well established by now(Fig.No.2). However, due to the restricted area provisions of the geological information is classified and unpublished. The compiled geological map of Meghalaya is given by Anon (1974), Murthy et al (1976a, 1976) and Mazumdar (1986).

Since the inception of the Assam - Meghalaya circle of the Geological Survey of India at Shillong in 1961, a more systematic detailed geological mapping still continued. The work led to the delineation of different litho units of the Archaean and Pre-Cambrian rocks, but also revealed the relationship of these two major rock groups and brought out an interesting structural features. The structural and geomorphic features which are quite prominent and interesting have been analysed and classified by using landsat imagery of the region. The landforms have been interpreted on the basis of relief and geological set up.

The Meghalaya Plateau is mainly composed of:-

(1) Pre-Cambrian Archaean gneisses with acid and basis intrusive.

(2) Shillong series rocks.

(3) Sylhet traps rocks.

(4) Lower Gondwana rocks.

(5) Cretaceous Tertiary Sedimentary rocks.

(6) Alluvium.

Geologically, Garo Hills area is characterised by the presence of wide variety of rocks types originated during various epoch of the earth-evolution starting from archaean period (about 3600 million years) upto the recent time. The oldest group of rocks the archaean group, is represented by the hard and massive gneisses, granulites, migmatites and minor banded ferruginous quartzite which occupy about 60 percent of the area in the northern part, patchy occurence of sedimentary rocks belonging to Gondwana group permocarboniferous (about 350 million years) and comprised of pebble bed, sandstone with streak and lenses of coal. They contain fossils imprint of vertebraria

Narrow valleys are noticed in between the different Hills slope. Fig. No. (P. 2) indica and other lower Gondwana plants that once upon a time grew abundantly in the neighbouring shallow basins in which the Gondwana sediments were deposited.

Sediments of Tertiary age (about 65 million years) occur along the southern part of Garo hills, i.e., south and west of Tura range. These rocks are represented by shella formation, Kopili formation, Garo group and Dupi Tila group.

All along the fringe area of Garo hills except to the east alluvium consisting of unconsolidated sand clay and soil of the Quarternary period (about last one million year) of the earth's geological history followed by recent alluvium were deposited.

The greater part of the Garo hills are formed of gneissic rocks, upon them are super-imposed strata referable to the cretaceous system, which consists of sandstones and conglomerates with subordinate clays and occassional coal beds. The cretaceous beds are overlaid by rocks of numulitic age, consisting of lime stone and sandstone with interstratified shales. Above the numulitic there are Upper Tertiary rocks composed mainly of sandstones which forms low hills along the border of the Mymensingh district marine fossils have been made within the lower beds of these sandstone.

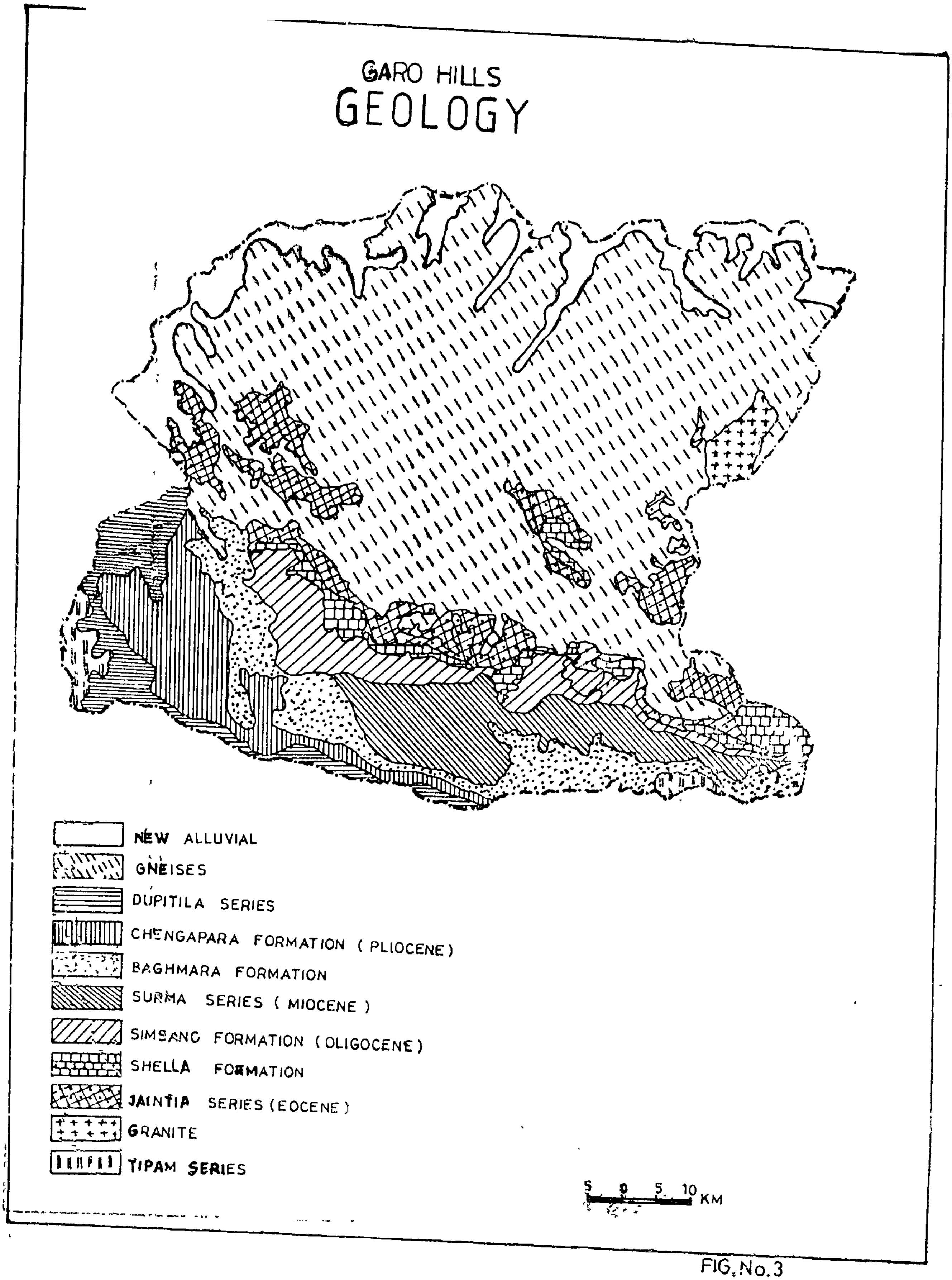

GARO HILLS
GEOLOGY
NEW ALLUVIAL
GNEISES
DUPITILA SERIES
CHENGAPARA FORMATION (PLIOCENE)
BAGHMARA FORMATION
SURMA SERIES (MIOCENE)
SIMSANG FORMATION (OLIGOCENE)
SHELLA FORMATION
JAINTIA SERIES (EOCENE)
GRANITE
TIPAM SERIES
5 0 5 10 KM

FIG.No.3

The stratigraphic sequences of various rocks formations as observed in the Garo hills are given below:-

Archaean Rocks

The Archaean gneissic complex is exposed on the northern part of Garo hills including the Tura range. The rocks are believed to be the northern extension of the Indian Peninsular shield, which is separated by the Garo-Rajmahal gap (i.e.,of the Bengal plains).

Geological Name	Group Name	Formation name with thickness	Rock types.
Recent	Newer Alluvium	-	Sand, Silt and clays.
Unconformity			
Pleistocene	Older Alluvium	-	Sand, clay, Pebbles, Gravel & boulder deposits.
Unconformity			
Mio-pliocene	Dupi Tila Group	-	Mottled clays, Sandstone and Conglomerate.
Unconformity			

Oligo-Miocene	Garo Group	Chengapara formation.	Sand, Siltstone, Clay marl(700m).
		Baghmara Formation (530m).	Felspathic sandstone, Pebble, Conglomerate clay,silty clay.
		Simsang Formation (1150m).	Siltstone,Sandstone, Alternation,Sand.
		Kopili Formation (500m)	Shale, Sandstone, Marl.
Eocene	Jaintia Group	Shella Formation (600m)	Alternation of Sandstone and Limestone.
	Unconformity		
Jurassic	Sylhet trap (600m)	-	Alkali, lemprophyre, delerite, basalt, dykes, agglomerates.
	Unconformity		
Permocarboniferous	Lower Gondwana Group	-	Pebble bed,Sandstone, Carboniceous shale, Lenses of coal, dolerite dyke.
	Unconformity		

Pre-Cambrian	Acid intrusive	-	Granite, Pegmatite, Aplite, Quartz, Veins.
	Unconformity		
Archaean	Non Prophritic migmatitic granitoiou rocks.		
	Diffused Contact Gneissic Complex (Unclassified)	-	Ortho and Paragneisses & achists, granulites, amphibolites etc.

Source : Geology and Mineral Resources of the States of of India, Part IV Miscellaneous Publications No. 30, Geological Survey of India, Dec.1974, p. 69 - 79.

PRE-CAMBRIAN ROCKS

Several bodies of porphyritic granite cut through the Archaean rocks on the Eastern and Northern parts of Garo hills. Aplites, pegmatites and vein quartz are found associated with older rocks. Origin of these rocks are likely to be related with the granite bodies. It is probable that there were more than one phase of granitic pegmatitic activity during the long Pre-Cambrian time.

PERMO-CARBONIFEROUS ROCKS

Lower Gondwana group - A very small patch of Lower Gondwana rocks is exposed in the Singrimari area located in the extreme western part of Garo hills. The rocks include pebble beds, sandstone, carboniciousm shale with streaks and lenses of coal and impression of vertebraria indica. The sandstone dips westward and is intruded by dolerite dykes.

JURASSIC ROCKS

Dolerite and basalt dykes are found in the Archaean rocks of Garo Hills, trending between NNE-SSW and NE-SW which is nearly coincident with the grain of country rocks. Alkali lamprophry dykes are also found in the Archaean rocks of North- Eastern Garo Hills, probably belonging to the ignious activity during the Jurassic period.

Several occurrences of rhyolite, tuff and agglomerate together with associated diamictite of possible volvanogenic origin are found over a fairly large area around Rongbu village on the right bank of Dudhnai river in migmatitic gneiss country. These volcanic rocks are thought to be belong to the Sylhet trap rocks of the Southern Khasi Hills.

TERTIARY ROCKS

Sediments of tertiary age occurs all along the southern border of the Garo Hills and many other localities in the south-eastern part of this area. These sediments are thick and extensive and considered to be physically continuous in the west with the creteceous - tertiary sediments of the Bengal basin and on the east with the sedimentary rocks of the same age in Khasi and Jaintia hills of Meghalaya.

The Shella formation of Jaintia group of rocks consists of sandstone, lithomargic clay, shale and coal seems followed by Siju limestone formation which locally contains potential reserve of suitable raw materials for making port land cement.

The Kopili formation comformably overlies the Shella formation. This formation is about 500m,in thickness and consists of alternations of thin bed of sandstone and thick shales beds with sporadic thin fossiliferous bends on limestone. Phosphatic nodules are found scattered throughout the shales of this formation.

The Simsang, Baghmara and Chengapara formations constitute the Garo group. The Simsang formation conformably overlies the Kopili formation without any break in sedimentation. This formation consists of a cycle of massive festoon of cross beded sandstone alternating with silt-stone, sandstone unit can be traced from near a place in the Garo Hills uninterrupted eastward upto Shella in the Khasi Hills.

The Baghmara formation conformably overlies the Simsang formation in the eastern part and consists of irregular bed of coarse, fespathic sand with minor mudstone, pebbles-conglomerate and massive silty clay beds, near Tura Dalu road, the Simsang formation generally grades into sediments of the Baghmara formation.

Conformably overlying the Baghmara formation is the Chengapara formation consisting of poorly cemented fine grained Miceacous and blue to brown sandstone and clays with a few marly beds at its base. A fossiliferous calca-reous siltstone lying horizontally between Baghmara and Chengapara formation can be traced from near Baghmara to a place few kilometers west of Baghmara.

A prominent unconformity is observed at the top of the Chengapara formation ever which rest Dupi tila group of rocks. This rocks includes alternation of coarse, fels-pathic, sandstone with lenses and beds of pebbles of vein-quartz and sandy molted clay.

QUARTERNARY DEPOSITS

Isolated patches of older alluvium overlies the tertiary rocks along the southern and western borders of Garo hills.This deposits consists beds of assorted pebbles with coarse, loose sand and brownish clay and usually from flat topped. Older alluvium occurs at various level along the abandoned river courses representing a kind of river terrace.

RECENT DEPOSITS

Recent deposits are found in the river valleys in the northern foothills region, along the western border and also in the southern foothills of Garo hills. The alluvium consists of fine silty sand and light to dark greyish clay with occassional pockets and layers of course and pebbles.

Shillong is a horst which has been block uplifted since Jurassic times to its presents heights of about 610-1554m above mean sea level, and its tectonic history begins with the effusion of plateau basalt (Sylhet Traps) through fractures of adjacent blocks. These were followed by upper Creteceous-Tertiary sedimentation into the relatively down thrown portions along faults. The trend of these faults is found to be NW-SE and EW in the north western parts of Garo Hills, EW in the south Khasi Hills and NE-SW in the eastern margin of Khasi Hills. The tectonic force has been vertically dominated and controlled by differential movements along these basement fractures.

In the western parts of the plateau in the Garo hills, the E-W lineaments are represented by monoclines and faults among which the Dapsi reverse fault at the base of the Tura range is spectacular. The Tura range, a horst, is bounded to the south by the Dapsi fault (upthrust). In the Garo hills, there is ample evidence to indicate activity along a number of E-W, N-S and NW-SE basement faults throughout the tertiary period. In the west Garo hills in the study area, are found the consequent streams which are mostly controlled by the sedimentary rocks.

The Garo hills has been subjected to vertical block displacement in the middle upper Eocene time. Fox (1933) has identified two major faults in the following places.

(i) Daranggri normal fault on northern side of Tura range.

(ii) Dapsi reversed fault on the southern side.

Darang fault runs in the N-W and S-E direction with local variation to EW direction. The dip of the fracture zone is about 45° to the north-east. These fault zones coincide approximately with sharp break in slope of the topography of the Tura range in the western and southern escarpment. It is thus most likely that the Tura is a horst block uplifted along the fracture fault system, where first fracture fault passes through the heart of Tura and second fault passes through southern parts of Tura. There are also many minor faults like Artheka near Siju which steeply dips towards east, some other minor faults lie along the Tura Dalu road, dipping towards east.

Generally joints are scanty in the sedimentary formation (eocene) of Garo hills. However, the clay bed of the Tura sandstone stage exhibit more conspicuous joints in the north eastern parts of the Nangal bibra and in the western and southern parts of the Tura town. They are either vertical or horizontal in nature. Similarly, limestone beds display the vertical and horizontal represented from the Siju limestone bed.

PHYSIOGRAPHY

Physiographically, Garo hills is a part of Meghalaya Plateau, represent a remnant of ancient plateau of Pre-Cambrian peninsula shield, block uplifted to its present height of Nokrek 1515m, the highest spot in the district. The kernel of the plateau the Archaean gneisses and schists are covered over the district[1]. The plateau standing as watershed between

1. G.S.I.Pub.,No.3, Part IV "Physiography" pp.72

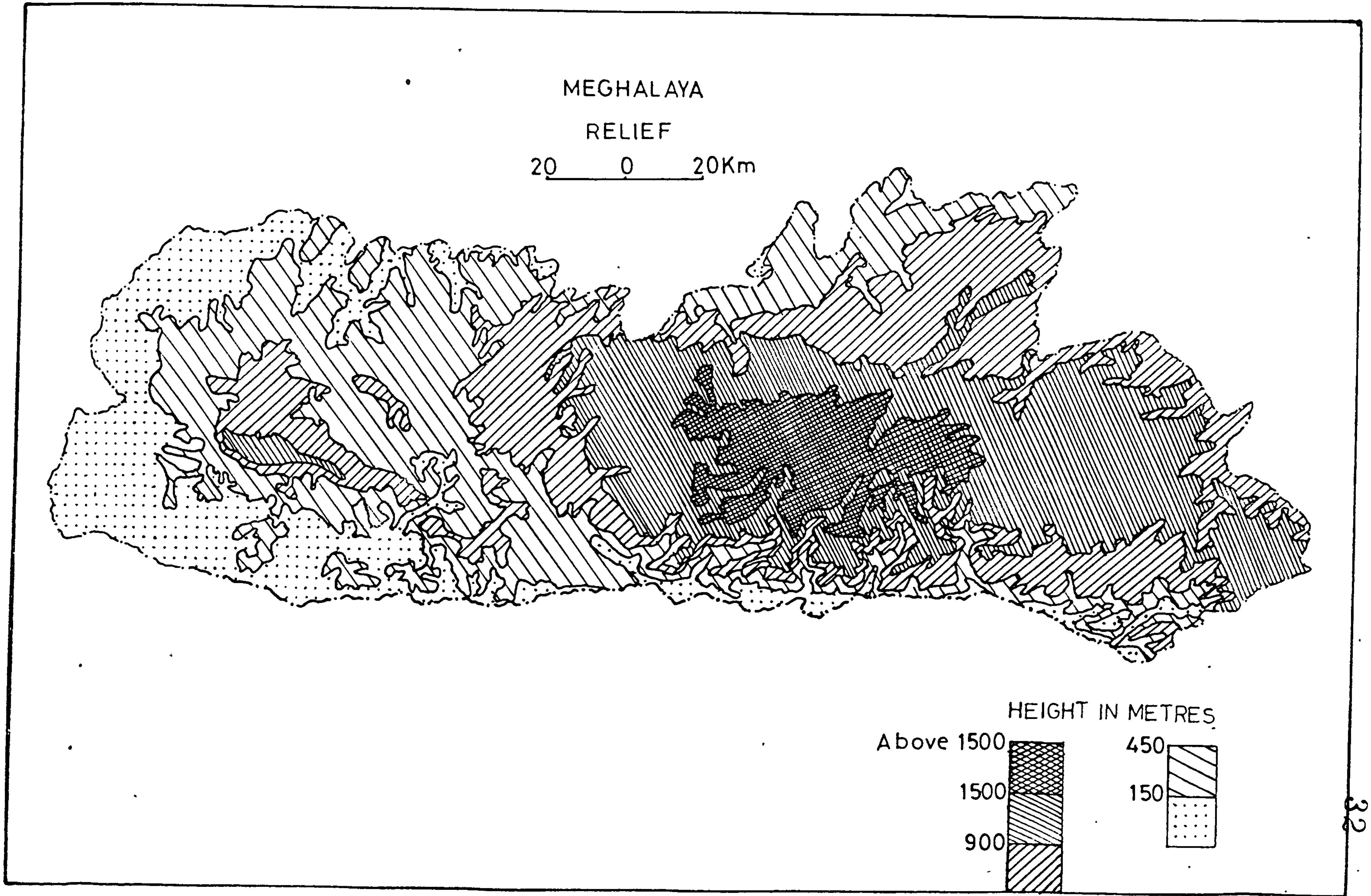
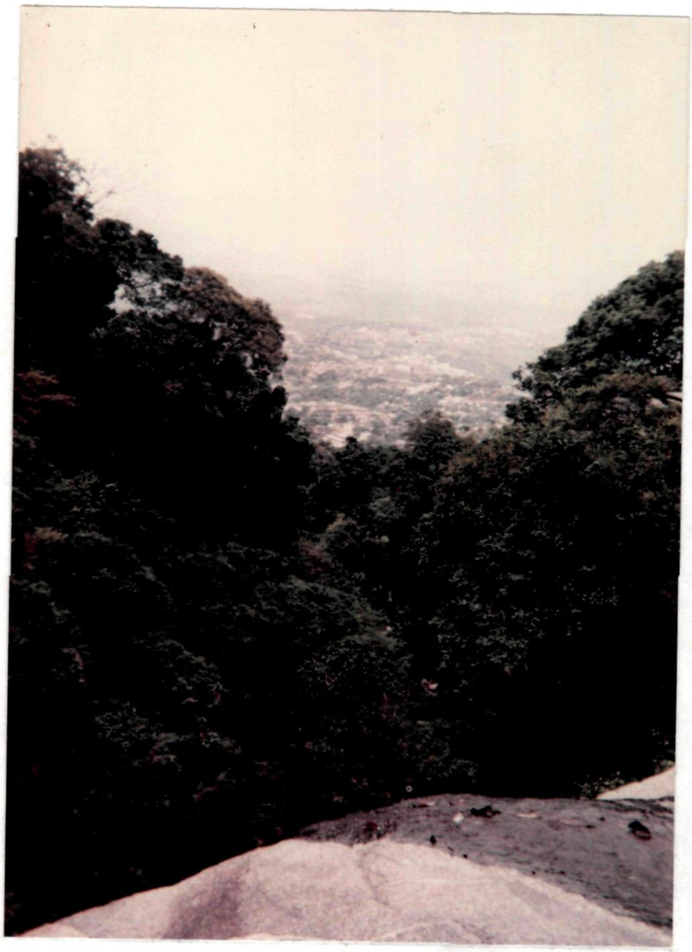

MEGHALAYA
RELIEF
20 0 20Km
HEIGHT IN METRES
Above 1500
1500
900
450
150

FIG.No.4

the Surma valley on the south and the Brahmaputra valley on the north, dissected by several rivers and a network of their tributaries and lateral streams. The western part of the Meghalaya, i.e., the study area is an extensively dissected tract with an average elevation of 600m, or less. The highest peak of the study area is the Nokrek peak situated 15 kms north east of the Tura town. Among the other several peaks, Moheskola, Adagiri range divides the Khasi and Garo hills, seperately. The most important physiographic features of Garo hills are the Tura range and the Simsang valley. Tura range runs almost through the central part of the district, west to east extending from Tura town to Siju, a distance of 50kms. The hills in the north of Tura range including Arbella hills running parallel to Tura range are low, gradually decreasing in height until they reach the later in the south[2]. Kailas hill, east of the Simsang and the Balpakram on the border of the Khasi hills. The rest of the district consists of a tumbled mass of hills whose general tendency is to run to the north and south. The Kailas hill which is called Chitmany by Garos stands out an abrupt hog-back mass, which towers above most of the hills in vicinity, it thus appeared to be higher than it really is and it is probably on this account that it is regarded by the Garos as the "Home of the Spirit of the dead"[3].

2. Singh,R.L. India. A Regional Geography,Meghalaya Mikir Region p.690.
3. Pakinthain,E. District census Hand Book,Garo Hills,1961 p.2, "Mountain System".



Gully erosion with 'v' shape section and rills along the slope. The gully is covered with thick vegetational cover along the side of the stream. Fig.No. (P.3)

The new road construction is seen over the Samphalgre range leading to the New tura stadium; this construction also causes the minor erosional process. Fig. (P.4)

Jhum cultivation over the low hill slopes at Edenbari 12 km. north of the tura town. Fig. (P.5)

Physiographically, Garo Hills can be divided into following three regions:-

(1) The Northern Sub-Montane Region

(2) The Central Main Plateau Region

(3) The Southern Hill Slope Region.

The Northern Sub-Montane Region

This region forms a continuation of the central plateau of the district till it merges with the plain of Brahmaputra valley of Assam. Generally, the slope is steep and abrupt in certain places, but it decreases gently towards the plains of Assam Valley. The northern sub-montane region is covered with thick vegetation.

The Central Plateau Region

The central plateau region is the highest part situated between 900m-1500m above mean sea level. The central plateau region forms the major parts of area. It is a dividing line of catchment area or watershed for river and streams traversing both to the north and south direction. Numbers of streams originate from this central range of plateau flowing towards the north and south direction.

The Southern Hill Slope Region

The southern hillslopes begins where the central plateau ends at about 900m of elevation and stretches down-

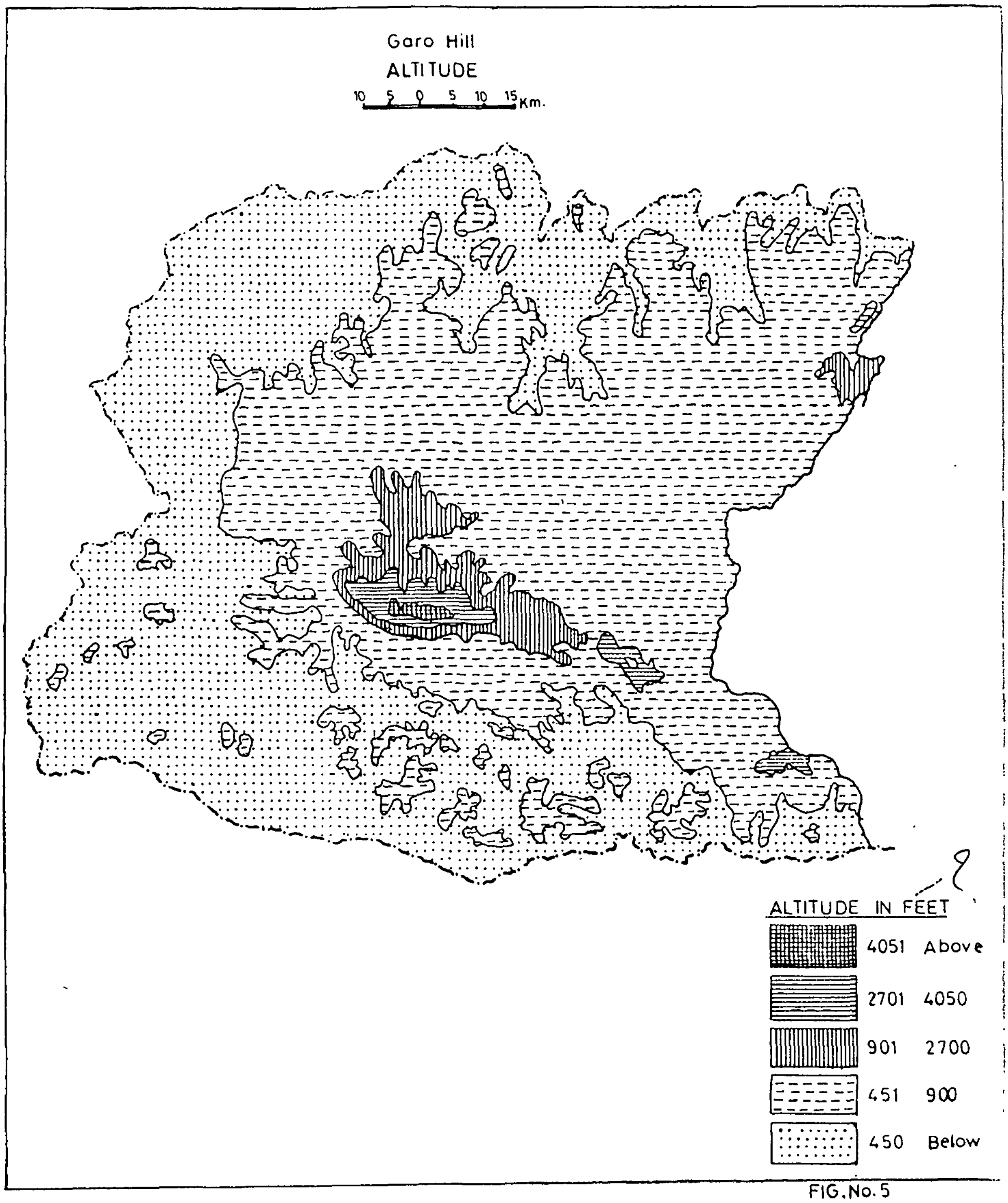

Garo Hill
ALTITUDE
10 5 0 5 10 15 Km.
ALTITUDE IN FEET
4051 Above
2701 4050
901 2700
451 900
450 Below

FIG. No. 5

wards upto the Bangladesh plain. The slope gradually decreases as it reaches the plain of Bangladesh. In some places, slope is found very steep and rivers have formed deep gorges with huge boulders on the river bed.

The study area has a distinct geomorphic tracts. The geomorphic features are undulating hills and forms small narrow valleys along the lower part of the plateaus, it shows more or less diverse topographical features over the area. The western and northern part of the study area is characterised with valley plain land. One of the important valley plain land is found at about 12km north ofthe Tura town which is known as Command Area in Edenbari. This plain land is highly utilized for the agricultural purposes by providing flow irrigation scheme constructed on 1986-87. Covering an area of 398 hectares, the command area irrigated plain land have been shown in the photograph taken during the field work which is stretching along the foot hills.

River Basins

In the study area there are numerous river basins. The Tura range lies in the central part of the study area, most of the river originate from the Tura range and the drainage system of district is divided directly by the central upland zone.

The drainage basins of the district can be divided into two distinct zone:

(i) The Northern river basins

(ii) The Southern river basins

The northern river basins zone can be demarcated into several river basins. Among them, the largest river basin isthe Damring river and its tributaries and there are six sub-basins, like Didram, Manda, Galwang, Ringgi, Didak and Diti. The rest of the rivers have smaller basins.

On the other hand, the southern river basins, Simsang is the largest out of the total 14 rivers. The other larger river basins are Ganol, Bugi, Dareng and Bandra. Both to the north and south of central upland zone have become the catchment area of several rivers found in the study area.

There are some major rivers in the study area which flows to the north and south direction from the Tura range. The principal river is the Simsang (Someswari) which rises in the northern part of Tura hill, and flow towards south and falls into the Kangsa river in Mymensing district of Bangladesh. Other important rivers flowing towards south are Moheskali, Mahadeo, Dareng (Nitai) and Bugi(Bogai).

The north flowing important rivers are the Krishnai, Dudhnai etc. and some of the north west flowing important rivers are the Ringgi (Rongai) Ganol(Kalu), Rongkai and Jingiram.

The rivers found in the study area are mostly perinial one. It characterises with less volume of water duringthe winter season, but it flows in high volume of water during rainy season.

Some of the important lakes found in the district are:

(1) Dangga-Chi (Boro hill) Near Rajmahal hat which is the biggest lake in Garo hills.

(2) Chimite (Katta bill) which is believed to have been constructed by the Garo King named Lengta, the lake lies near Nagorpara village nor very far from Mohendraganj.

CHAPTER: III

GEOMORPHIC PROCESSES

The geomorphic processes are all those physical and chemical changes which effect a modification of the earth's surficial form. A geomorphic process may be epigenic or exogenetic and hypogenic, endogenetic in nature. But the most common geomorphic processes are weathering, mass wasting which are generally an exogenetic processes. Other geomorphic processes originate within the earth's crust and are designed as endogenetic, for the present study area the exogenetic processes have been taken into consideration which are combined to physical and chemical weathering and mass wasting.

Weathering

The disintegration or decomposition of rock is generally referred to as weathering. Normally, there are two distinct kinds of weathering -

(i) Mechanical or physical weathering

(ii) Chemical weathering

Though both the types of action commonly co-operate in producing the mantle of rock waste. Each has its region of optimum activity. In the present study area, it is noticed that the chemical weathering is more active than the mechanical weathering.

Chemical weathering is the change in the chemical composition of rock and sediments that is caused by atmospheric agents, namely water and gases. Four basic kinds of changes take place; additions, removals, transfers and transformations (Simonson, 1959)[1].

The simplest kind of addition is hydration, which is the chemical combination ofwater with a particular mineral. As the study area experiences heavy rainfall in rainy season, the impact of water on weathering is profound. Complete dissolution of minerals in water is observed in limestone bearing series etc. Water enriched with free carbon dioxide dissolves limestones and it relatively readily redeposits the dissolved carbonate of lime.

THE MAJOR FACTORS RESPONSIBLE FOR WEATHERING IN THIS STUDY AREA ARE:-

1) Climate
2) Petrological and lithological characteristics of rocks
3) Structure and
4) Vegetation

---

1. Simonson, R.W.(1959) Outline of a generalised theory of Soil genesis. Soil.Sci.Soc.Am.Proc. 23:152-170.

The processes of weathering in the region are greatly influenced by the type of rock, the climate and relief. These factors play an important role in both individually and collectively. Among physical weathering, rainfall plays most important role to play in the intensity and the extent of weathering. The steep slope along the ridges where the rocks are exposed are weakest part where the effect of physical weathering are noticed.

Climate and Weathering

The climate factors especially temperature and rainfall in study area are the vital physical factors which keeps active weathering and erosional processes. The climate is characterised by sub-tropical to semi-temperate type of climate. The study area experiences with heavy rainy season and short winter. Due to the heavy rainy season, the chemical weathering keeps active erosional work especially during rainy days.

Temperature

The climatic date for the study area was available for Tura recorded in the Tura station, West Garo Hills, Meghalaya. The mean monthly temperature recorded of study areas is from 14.20°C minimum to 34.75°C maximum. The lowest temperature recorded in the month of January is quite low, temperature gradually goes up till the month of May. During the month of May, temperature goes upto maximum as recorded 34.75°C. Thereafter generally, from the middle of May, the rainy season begins and it brings down the temperature due to the heavy rainfall and temperature continues to fall with the break of rain. The low temperature is experienced from the month of November to January, the temperature recorded is very low.

Table No.1 shows the monthly mean temperature for the year of 1988-89. It can be noticed from the table that the minimum temperature recorded is 10.38°C in the month of January and the mean maximum temperature is highest in the month of June (34.75°C). The monthly temperature of last 6 years of study area is given in table No.2, the monthly mean temperature of 1988-89 are represented by a graph Fig.No.6.

In weathering process the effect of average annual temperature and monthly average temperature is quite significant. The mechanical disintegration of rock are common during high temperature. The alternate heating and cooling during day and night helps the mechanical disintegration of rock easily. However, temperature alone does not control the rate of weathering, and quite apart from the topographic factor, humidity and the supply of ground water and of organic matter are of particular importance.

TABLE NO. 1

Mean Monthly temperature of 1988-89

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum	17.10	17.90	22.54	26.50	24.50	24.60	24.43	23.90	23.90	23.67	23.50	18.16
Minimum	12.74	13.62	17.10	20.10	20.00	21.16	21.40	20.02	20.87	18.46	18.04	14.52

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum	14.20	19.20	21.64	28.10	34.75	32.18	29.60	30.66	28.36	31.50	29.85	27.38
Minimum	10.38	12.80	15.83	23.40	25.00	26.80	26.00	26.53	26.30	23.00	18.81	15.63

Source : Meteorological station, Tura, West Garo Hills, Meghalaya.

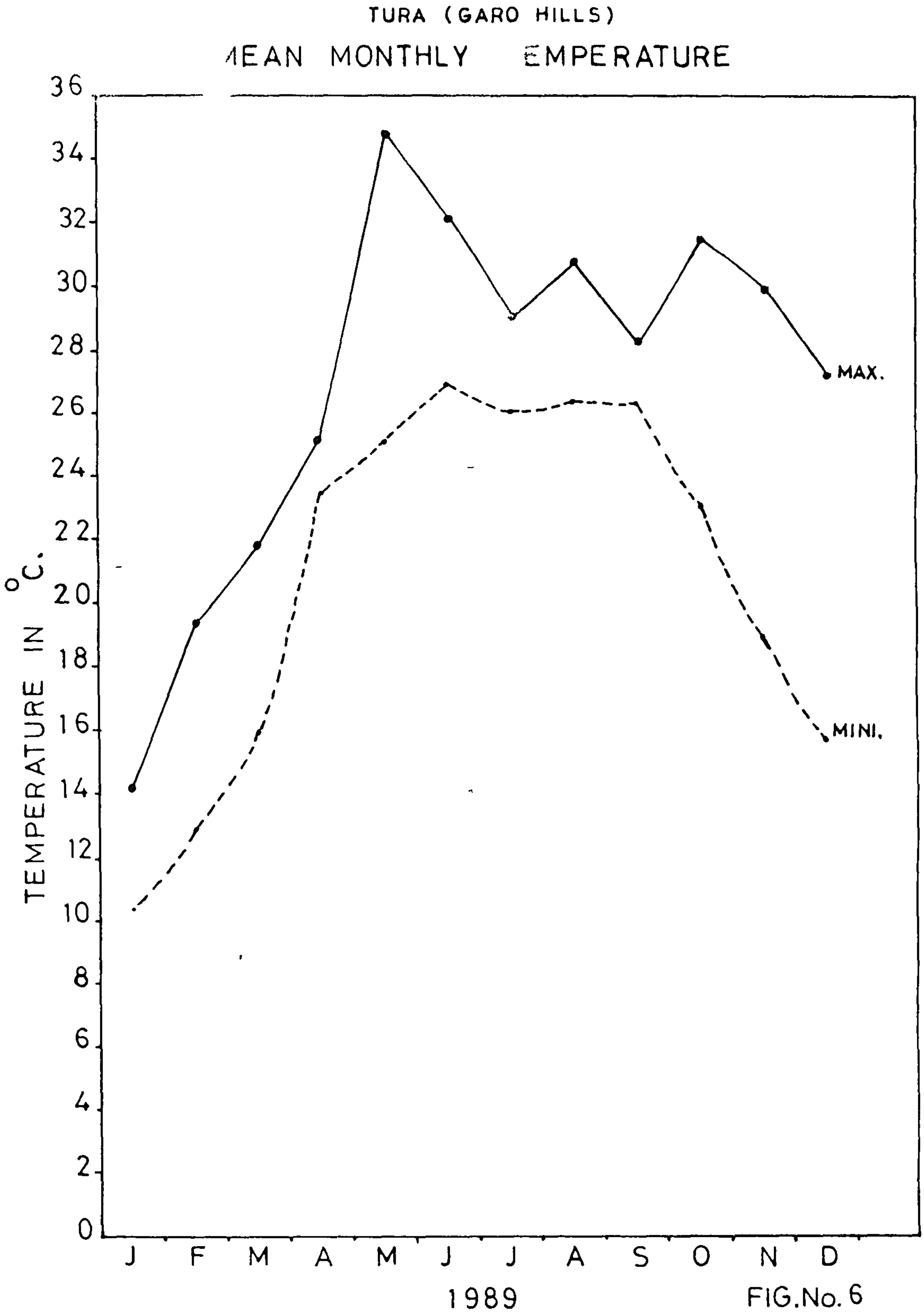

TURA (GARO HILLS)
MEAN MONTHLY EMPERATURE
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
TEMPERATURE IN °C.
MAX.
MINI.
J F M A M J J A S O N D
1989

FIG.No. 6

TABLE NO.2

Monthly Mean Temperature Recorded, Station - Tura, West Garo Hills, Meghalaya

1984	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum	18.19	21.98	25.33	27.33	26.17	26.04	26.86	30.17	32.76	32.78	25.29	18.50
Minimum	11.21	9.13	9.58	10.31	10.59	11.51	23.87	22.88	20.67	19.39	16.94	15.14
1985												
Maximum	19.02	18.60	24.52	26.40	25.30	26.06	25.05	27.00	25.64	24.28	19.86	18.00
Minimum	14.76	13.48	19.92	21.53	18.50	19.83	20.40	20.66	20.13	19.18	15.00	12.00
1986												
Maximum	20.46	25.17	30.74	27.31	29.20	30.30	28.74	29.58	27.71	27.10	25.06	22.21
Minimum	12.24	15.90	23.04	22.30	22.30	25.26	24.83	25.03	23.73	21.38	16.58	14.51
1987												
Maximum	22.30	22.40	24.87	26.25	28.64	27.20	25.30	25.50	25.16	24.51	21.50	18.19
Minimum	13.42	16.14	18.04	20.65	20.74	22.63	22.45	21.83	21.01	19.25	16.56	14.20
1988												
Maximum	17.10	17.90	22.54	26.50	24.50	24.60	24.43	23.90	23.90	23.66	23.50	18.16
Minimum	12.74	13.62	17.10	20.10	20.00	21.16	21.40	20.05	20.87	18.46	18.04	14.52
1989												
Maximum	14.20	19.20	21.64	28.10	34.75	32.98	29.60	30.66	28.36	31.50	29.85	27.38
Minimum	10.38	12.80	15.83	23.40	25.00	26.80	26.00	26.33	26.30	23.00	18.81	15.63

Source : Meteorological Station, Tura, West Garo Hills, Meghalaya.

Humidity

It is the relative humidity at a place that affects the amount and process of precipitation at that place. It is the humidity the amount of water present in atmosphere. It is also the humidity of climate whose variation appear to exercise the greatest influence on the evolution of relief. The high amount of humidity determines the mode of weathering and characteristics of rocks decomposition, high humidity generally associated with the high rainfall which also causes the decomposition of rocks by chemical processes through the action of water infiltration below the surface. In the area of humid climate like Tura of West Garo Hills, the weathering processes are quite active and it becomes continuous processes for erosion work, which makes irrigularities of the landforms.

In the present study area, it is noticed that humidity plays an important role to disintegrate the exposed rock surface by chemical processes. In many respects, it is mainly due to the heavy rainfall in the area the principal chemical re-agent, involve in weathering processes which become most critical, especially within humid tropical climate zone like West Garo Hills District. The diagramatic representation of relative humidity ofthe study area is shown in the Fig.No.7 which showsthe high humidity almost throughout the year. Table No.3 showsthe relative humidity in percentage of Tura, West Garo Hills District, Meghalaya.

TABLE NO.3

HUMIDITY IN PERCENTAGE, TURA, WEST GARO HILLS? MEGHALAYA

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	55.98	53.77	61.58	66.76	71.87	77.31	79.20	79.38	80.73	72.51	69.90	73
1986	64.70	62.66	59.24	71.31	75.03	82.20	82.67	83.20	84.60	74.40	76.0	74.38
1987	71.60	66.64	70.25	76.13	78.30	84.66	84.70	82.77	80.26	80.90	78.4	75.72
1988	85.73	86.60	87.0	81.96	79.12	75.03	73.22	74.64	73.72	68.61	76.00	83.73
1989	84.50	86.40	85.60	87.63	79.48	75.50	76.20	85.40	60.00	72	66.80	81.80

Source : Meteorological Station, Tura, West Garo Hills, Meghalaya.

TURA (GARO HILLS)

RELATIVE HUMIDITY

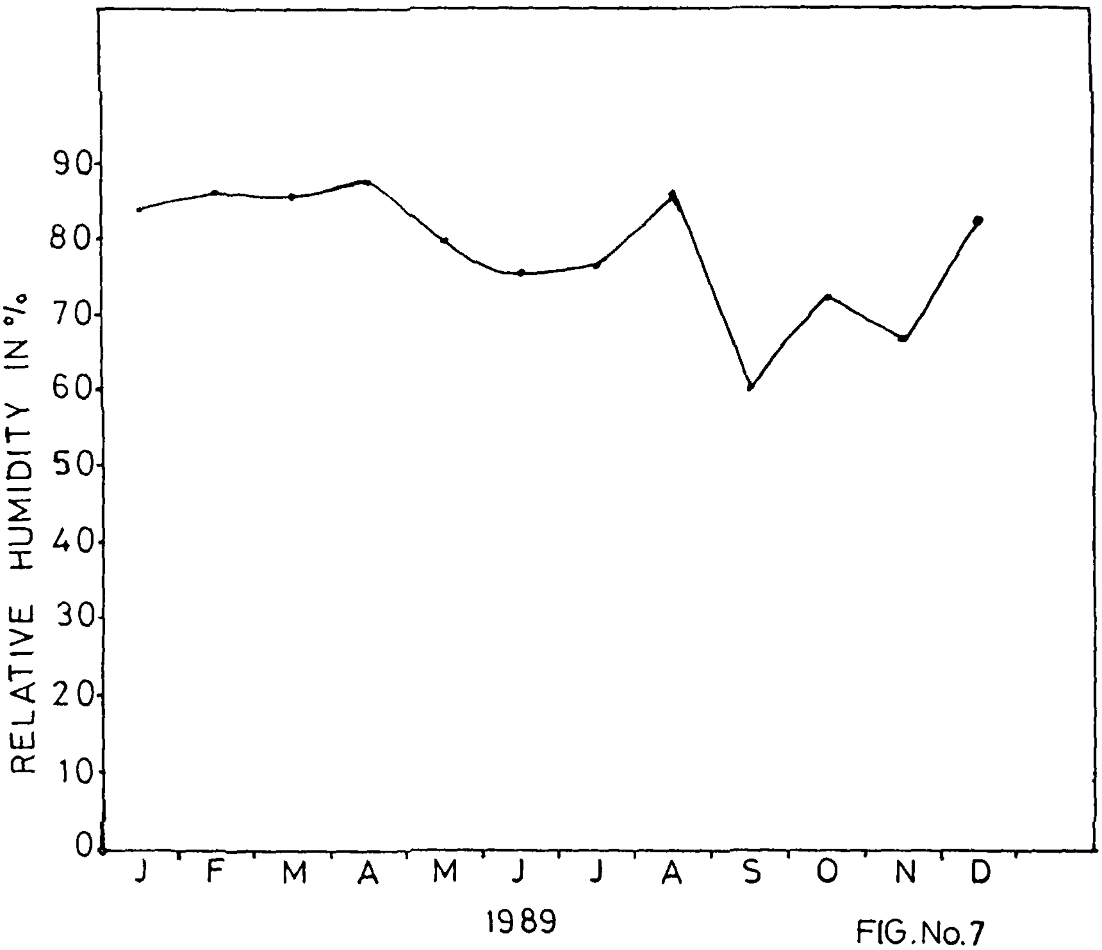


FIG. No. 7

Rainfall

The present study area is characterised with sub-tropical to semi-temperate climate, the mount of rainfall received is quite high during rainy season. In the study area, the rainy season begins from the month ofMay and continues to the month of August. During rainy season, the area experience excessive rainfall. The abundant rain-fall causes the flood especially to the extreme north and south western part of study area.

According to the monthly rainfall data collected from the Meghalaya additional Secretariat, Department of Agriculture shows that the maximum rainfall is 1090.84mm occured in the month of July(1989). The data available for monthly rainfall of Tura, West Garo Hills, Meghalaya are given in the table No.4 for last 20 years.

The study area experiences violent storms from the north west swept over the hills in the month of April and May, from the given table ofmonthly rainfall it is noticed that the monthly rainfall has some variation from year to year. The monthly rainfall of 1989 have been presented digramatically, which shows higher rainfall in the month of July.

Table . No. 4

Monthly Rainfall (in mm.)

Tura, West Garo Hills, Meghalaya.

Years.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
1970.	36.8	10.5	55.4	130.9	368.0	935.9	932.4	302.0	430.4	285.8	10.5	-----
1971.	11.5	-----	----	501.5	559.2.	634.4	457.1	360.2	292.9	293.6	54.0	0.4
1972.	5.3	40.4	87.2	225.4	533.9	639.2	527.0	368.7	379.2	218.9	2.8	-----
1973.	11.2	6.0	41.3	142.2	651.1	1032.6	617.3	463.5	612.1	152.0	81.2	51.0
1974.	----	-----	42.0	213.4	499.5	450.6	1286.1	569.7	773.7	226.5	----	-----
1975.	----	4.4	6.0	225.0	721.9	2535.7	746.6	238.2	392.1	89.2	----	------
1976.	2.4	24.2	3.5	127.7	279.6	712.9	439.9	947.2	215.1	138.0	23.2	23.2
1977.	----	-----	5.0	700.0	429.5	989.1	605.9	495.1	416.5	251.6	-----	-----
1978.	-----	------	0.1	277.0	555.2	798.8	565.9	398.5	605.4	86.3	44.9	-----
1979.	9.0	6.7	2.2	153.1	101.1	395.6	1554.0	-----	-----	-----	-----	-----
1980.	-----	136.1	39.2	37.3	498.2	657.8	631.5	548.8	348.9	237.0	------	-----
1981.	20.0	-----	69.4	262.6	769.3	636.4	598.0	-----	-----	N.A.	-----	-----
1982.	-----	-----	132.0	179.0	135.0	848.0	618.4	822.0	655.0	N.A.	N.A.	-----
1983.	-----	14.0	31.0	48.0	417.0	332.0	700.0	603.0	577.0	301.0	-----	20.0
1984.	12.0	-----	~~31.0~~	96.0	480.0	726.0	162.0	278.0	539.0	297.0	------	-----

Table No. 4.

Monthly Rainfall (in mm)

Tura West Garo Hills. Meghalaya.

Year.	Jan.	Fab.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
1985	-----	32.2	101.0	80.0	258.0	723.0	184.87	410.71	469.9	69.09	-----	-----
1986.	-----	-----	-----	330.6	628.75	796.8	521.25	674.15	641.62	665.18	8.75	12.75
1987.	-----	-----	31.25	144.5	333.75	432.25	634.25	1233.0	633.25	590 75	328.75	61.0
1988.	-----	-----	100.0	152.25	409.75	1122.25	992.5	1304.96	1358.75	805.0	211.75	40.87
1989.	39.89	36.00	10.20	18.36	465.00	419.26	1090.84	326.52	718.22.	160.78	-----	4.00

Source:- Meteorological station Tura, West Garo Hills, Meghalaya.

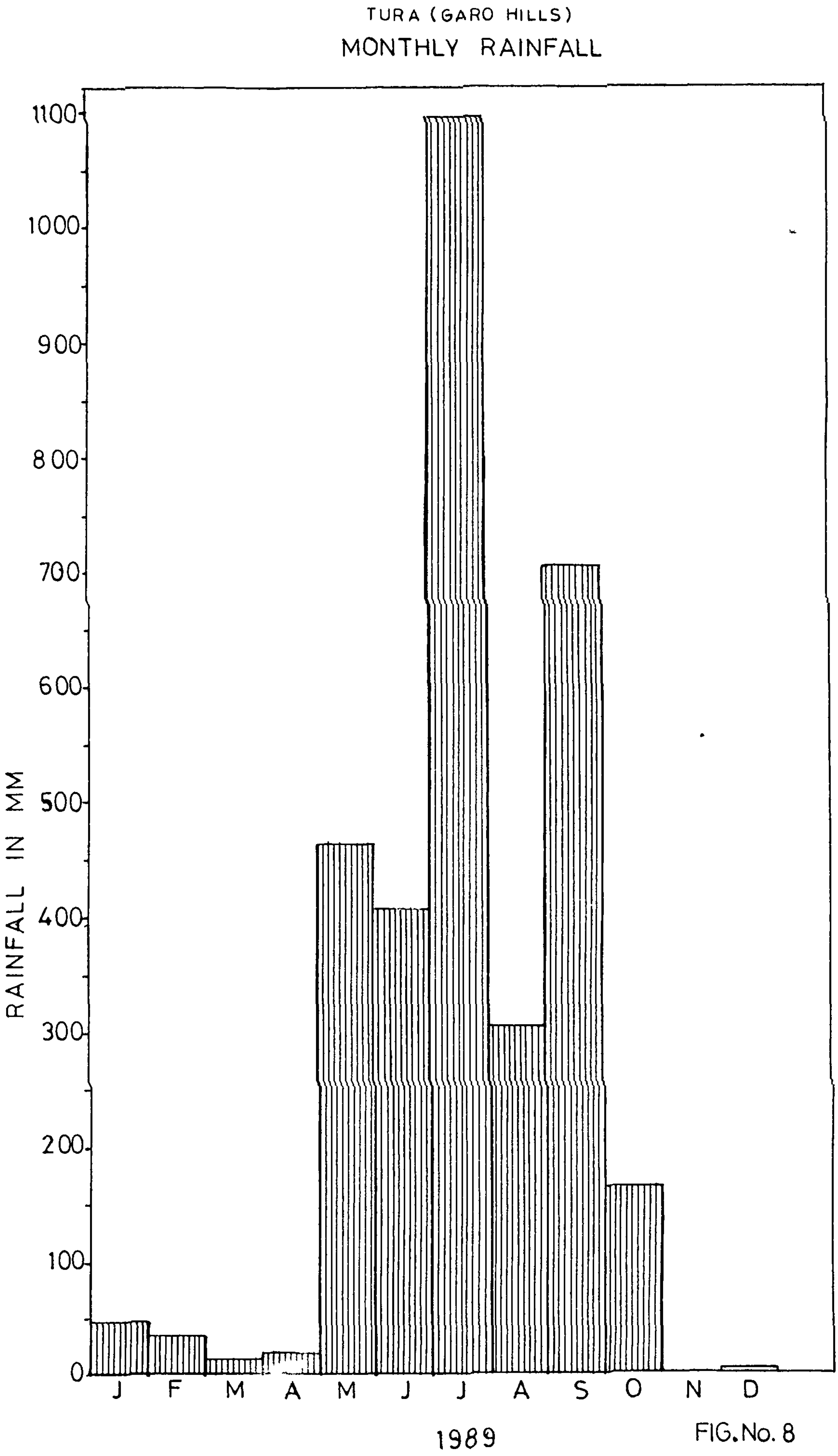

TURA (GARO HILLS)
MONTHLY RAINFALL
RAINFALL IN MM
0
100
200
300
400
500
600
700
800
900
1000
1100
J F M A M J J A S O N D
1989

FIG. No. 8

Physical or Mechanical Weathering

Mechanical weathering isthe breakdown of material entirely by mechanical methods brought about by various causes. Some of the forces originate within the rocks, while some others act externally. The temperature conditions mainly determine the type of mechanical weathering. The effect of temperature causes the mechanical disintegration of rocks. High degree of temperature helps the surface of the earth getting heated and during the night subsequent fall in temperature cool down the surface, alternating cooling and heating gives rise to mechanical disintegration of rock easily. The repeated process of heating and cooling of sandstone and shales, which are poor conductors of heat, give rise to stress and strain in the upper layers of rock mass in the temperature, thus, ultimately disintegrate the rock surface. Various processes have been recognised as mechanical by Ollier(1964)[2], Thornbury(1971)[3], and Sparks(1971)[4]. Amongst these only slaking caused by fire are noticed in the area under study.

Alternate wetting and drying of rocks is a very important factor in weathering, a process known as slaking. On the steep and gentle slope of study area the Tertiary

2. Ollier,C.D.(1969),Weathering,Hongkong,Longman.
3. Thornbury,W.D.(1971),op.cit
4. Sparks,W.W.(1971),Rocks and Relief,London,Longman.

sandstone and shale shows the type of mechanical weathering, to the North and North-Western part of study area are noticed this type of minor weathering.

Chemical Weathering

Chemical weathering is the result of interaction of rocks of the superficial layers of the lithosphere with chemically active constituents of the atmosphere, and the biosphere. Chemical weathering is basically carried by rain water and atmospheric gases. The chief chemical weathering processes are hydration, hydrolosis, oxidation, carbonation and solution(Thornbury 1971)[5].

The chemical weathering is at its maximum in the rainy season due to the presence of sufficient rain water and moderate temperature. On the contrary, the intensity of chemical reaction reaches its minimum in the dry season due to less ground water and comperatively high temperature.

The action of chemical weathering is study area caused by hydration and solution upon the sedimentary rocks. The water enters through cracks and joints which reaches to a considerable depth. The process of hydration and solution takes place with limestone and other mineral constituents of the sedimentary rocks. In the study area, there is an exposed limestone series towards the samphalgre hills causes

5. Thornbury, W .D.(1971), op.cit

the chemical action upon the surface during the rainy season.

Biological Weathering

A critical role in the weathering process may be played by both living organismsand by organic compounds resulting from the decay of plant materials. The process of biological weathering the root of the trees penetrate through the crack and joints of the rocks and produces the mechanical action over the rocks, it causes the gfrag-mentation of rocks. The dead roots of plant become swollen with rain water and widen the cracks.

This biological weathering of the study areas is less significant. However, the effect of roots of the trees in penetrating along the joints of the weaker rocks cannot be ignored. This type of weathering is noticed less in the study area except along the joints, and in the steep slope and along the cliffs and river banks.

Mass Wasting

Weathering and mass wasting contribute to the gradation of the earth's surface to a much greater degree than is usually realized. These process alongwith sheet wash, are important not only in the general lowering of the land but in the shaping of details of the topography of interstream areas. The process of weathering loosen, decompose, and dissolve rock debris everywhere on the land and the process of mass wasting then moves this debris to lower altitudes where streams, ice and wind transport them away. Rock falls, landslides, soil slump, creep, mudflows and slope wash are the example of mass wasting. In the study of geomorphic processes mass wasting is also an important process, which is a part of weathering (R.K.Rai 1980)[6].

In the study area during field work, it has been noticed that there are several landslides along the road which is newly constructed in the samphalgre hill north of Don Bosco the road which leads to stadium, the mass wasting is also caused by the human interference in the area for example, in the study area towards New Tura town. The construction of new buildings causes dumping of waste material which ultimately causes movement of loose mass. Such materials begin to move down under the gravitational force. Hence, it is more effective or steeper slopes, as well as an slopes which are bare rock surfaces.

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6. R.K.Rai,(1980) Geomorphology of the Sonar-Bearma Basin, Concept Publishing Company, New Delhi.

Development of New tura, causes the modification of slope due to the several building construction. Fig. (P. 6)-

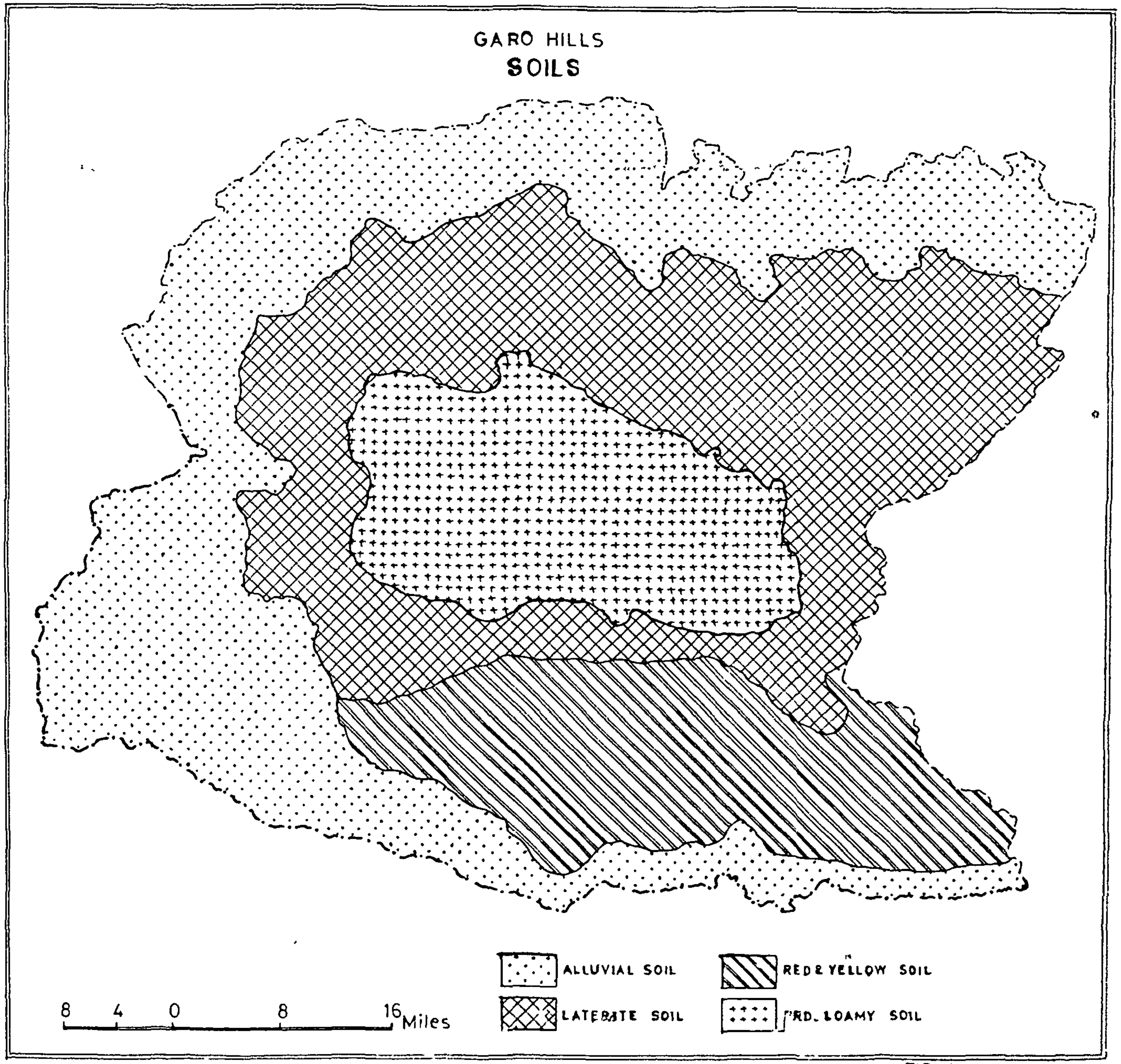
GARO HILLS
SOILS
ALLUVIAL SOIL
LATERATE SOIL
RED & YELLOW SOIL
"RD. LOAMY SOIL
8 4 0 8 16 Miles

FIG. No. 9

The intensity of mass wasting depends on such factors like -

i) lithology(unconsolidated or weak materials)

ii) strategraphy (thinly bedded rock and alternating weak and strong or permicable and impermeable beds).

iii) structure (closely speed joints, faults and foliation planes)

iv) topography (steep slope and vertical cliffs)

v) climate (large durinal and annual range of temperature and abundant precipitation).

In the present study area, it is noticed at many places where the hill slope is quite steep, the rain water disintegrate and decompose rocks into fragments. They fall down from the slopes and scarps.

CHAPTER IV

MORPHOMETRIC ANALYSIS, SLOPE ANALYSIS AND DRAINAGE ANALYSIS

MORPHOMETRIC ANALYSIS

Introduction

"Morphometry may be defived as the measurement and mathematical analysis of the configuration of the earth's surface and of the shape and dimension of the landforms. The main aspect examined here are the area, altitude, volume, slope profile and texture of the land as well as the varied characteristics of the drainage basins.

James Hotton, as the leader of plutonist group have recognised the evidence for metamorphism of rocks and found the concept, "present is the key to the past". Geo-morphometry differentiate the measurement of the shape of landforms from geology. After the Second World war, the study of physical geography and its objectives have changed. Thus morphometric analysis is essentially needed for identification of geomorphic characteristics of a region like Garo Hills. Morphometric methods and techniques are of great significance from the point of view of geomorphic investigation. Morphometric interpretation is of the earth's surface features, their characteristics, properties and process of evolution of landscapes, even experimental laboratories have been set up in United States of America and some other developed countries, for correct determination and accurate application of hydraulic laws, to wave current and stream action. In fact, the study of landforms can never be fully explained and be reduced to mathematical equations without laboratory experiments.

The term morphometry is used in several disciplines to mean the measurement and analysis of landforms characteristics. But in geomorphology, it is applied to numerical examination of landforms which may be more properly termed "geomorphometry".

In the present study, the analysis of slope and drainage has been made by applying certain morphometric techniques.

Introduction

Slope is a function of relief inclination usually shown in degrees. In the development of slopes various factors are involved including tectonic and climatic factors. Since the very beginning of geomorphological studies the slope analysis and its categorization have received remarkable attention. But the scientific and systematic studies of slope were started in present century.

Significant contributions in the field have been made by Finsterwalder (1890), Rich (1930), Wentworth(1930), Smith (1938), Monkhouse (1953) and Starahler (1956) and King(1962).

According to L.C.King (1962)[1] slopes are fundamental elements of the landscape, while Fairbridge (1968)[2] is of the view that slopes in its broadest sense are an elements of the interface between lithosphere and either hydrosphere or atmosphere. Slopes have been a favourite subject for research not only by geomorphologists in their analysis of landforms but also by agriculturists and civil engineers and by soil conservationists.

Slope which made up a large part of any land surface, are important landforms for geomorphologists, pedologists and engineers. Slopes are also formed by erosion, deposition or a combination of both the processes. When a stream cuts into a land surface, a valley is created and slope forms that descend to the valley bottom and ascend to the upland. Slope form by constructional processes, such as glacier deposits, wind deposits and mainly by water deposits, sediment. Soon after a slope is

1. L.C.King(1962) Morphology of the Earth, Oliver and Boyd Edingurg p.699

2. R.W.Fairbridge(ed)(1968) The Encyclopedia of Geomorphology, Encyclopedia of Earth Science Series Vol.III, Reinhols Book Corp. New York pp.1295

formed, it is subjected to alternation by weathering, erosion, sedimentation and mass movement. By their inherent nature slopes are unstable geomorphic feature in long run and so it is not surprising that the study of slopes has become one of the foremost branches of geomorphology.

Since the Second World War, the study of slopes has been recognised as an integral part of other branches of geomorphology. In the field of applied geomorphology, studies of landslides and of accelerated erosion are concerned with slopes and involve links with the techniques of soil mechanics, hydrology and soil science. There are direct effect of slopes, as it affects micro-climate which in turn influences vegetation. There is no doubt, however, the angle of slope has become main property of landforms that affect man, in agriculture, transport and urban activities. The study of slope developed for the intellectual challenge that it offered.

The morphological character of the study region is depicted by the appearance, dimension and magnitude of slope. The study of slope provides not only the variety of topographical features, but it enables the man to interpret the complex form of landscape.

Factors affecting slope Evolution

The broad parameters which control the evolution of the hill slopes are structure, process and time. According to Pecsi (1970)[3], "The existing type of slopes are the result of the joint dynamism of the tectonic, structural morphological and lithological conditions of the relief and of the climatomorphologic processes acting perennially on a given region of the surface".

Like the other parts of Meghalaya plateau convex, concave form of slope is found in the study area. The upper convexity is due to soil creep (Gilbert 1902)[4] and the lower concavity is mainly due to concentrated rill action (Fennamen 1908)[5].

The primary aim of slope analysis is to identify the slope elements of the study area, According to King (1957)[6] there are four elements in a fully developed hill slope.

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3. Pecsi,M.(1970) Factors affecting slope evolution and formation of slope elements in Hungary, Auguments geographical Bond, 12 pp.193.
4. Gilbert,G.K.(1902) The convexity of hill tops, Journ. of Geology, Vol.17 pp.344-350.
5. Fenneman,N.M.(1908) some features of erosion by unconcentrated wash yourn. Geol.Vol.6 pp.746-754
6. L.C.King(1957) The Uniformatarian nature of Hill slope. Trans Edinb.Geol.Soc. Vol.17 Pt.I pp.102

i) Crest (Waxing slope)

This type of slope generally developed in the summit area of hill or slope, which is usually convex. Weathering and soil creep are the main processes of forming this convexity. The hill slopes which observed here is characterised convex slope as the slope nearer to the Tura range. During the summer season because of heavy downpour the surface soil is washed downwards in the form of rill or gully erosion. The rills descending down the slope are flooded with the weathered material in the form of solution and suspension. The bedded gneiss and sandstone are resistant to weathering.

ii) Scarp (Free face)

This type of slope generally present just below the crest slope and is the most active element in back wearing of the slope caused by rill wash and landslides. Since the zone has a steep slope, the soil does not accumulate and only few shrubs and long grass are noticed along the joint and cracks of the rocks. There is no possibility of soil accumulation, as it is a zone ofbare surface with very steep slopes. The soil produced on the crest is completely washed under the force of gravity and running water. The zone is very much prone to rillwash and landslides.

iii) Debris slope (constant slope)

This slope has been formed by detrious fallen from the scarp above and resting at its angle of repose against the lower part of the scarp face. In present study area, the height of debris slope zone varies in different hill profiles. This slope elementing also causedby the human interference where jhum cultivation is highly practised.

iv) Pediment or Wanning slope

This type of slope generally formed by the accumulation of debris from higher slope to lower area. This is produced by surface wash and is a broad concavity extending from the base of the other elements to the stream or alluvial plains.

In the present study area, the Gandrak river valley formed the small plain right from the river bed to the hill slope at Edenbary where later on Gandrak river joined the river Ganol.

Commonly, slopes are classified in terms of slope profile which is a slope belt to unit width extending from drainage divide at the upper extremity, down to lower terminus,which is commonly a stream channel or a natural

Rengsa n graph water fall which is very close to the tura peak with height about. 50m. Fig. No.(P.7) discontinuity such as terrace, pediment or cliff (M.Agarwal) (1989)[7].

The slope of the study area characterised simpler towards the north and west of Tura range, the slope is gradually steeper towards the central Tura range.

On the other hand, towards east and south east slopes are found quite steep and sharp river side, and to the east and south-east characterised with deep gorges of river valley with thick vegetational cover along the river side.

Average Slope Analysis

In order to determine the average slope of the present study area, C.K.Wentworth's method has been used to analyse the average slope features of the study area. The method used is one of the widely accepted in presenting the slope morphology, which isthe most convenient technique of average slope determination of the preparation of slope zone. Wentworth's method is a "general and random method and is easier to follow. First, the east-west and north-south grids are drawn on the quarter inch contour map of the area at one inch interval grids then counted all the contour crossing per 16 miles.

7. M.Agarwal(1989) Geomorphological Studies around Umiam Lake and Adjoining Areas, East Khasi Hills,Meghalaya, M.Phil thesis, Dept.of Geography,NEHU,Shillong.

To determine the average slope of the study area, the following formula have been used:-

$$TQ = \frac{\text{Average Number of contour crossings per mile X Contour Interval}}{3361}$$

Or

$$TQ = \frac{N \times I}{3361}$$

Where N = Average Number of contour crossing per mile.

I = Contour Interval

Q = Average angle of slope in degrees

3361= Constant

In the present study area, it has been observed that the variation of slope is quite significant. It varies from 8°-40° and above, the general average slope analysis has been shown by preparation of slope map for the study area. The slopes characterised in declining manner to the both north and south and also to the west from the central part of Tura range significantly.

The following table reveals a clear picture of the average slope distribution ofthe area.

TABLE NO.5

Frequency Distribution of Slope

Slope in Degrees.	Frequency grids.	Percent age of total Frequency	Cumulative Percentage of Frequency	Slope Categories
8 -16	4	5.71	5.71	Gentle
16 -24	25	35.71	41.42	Moderate
24 -32	25	35.71	77.13	Moderately Steep
32 -42	10	14.29	91.42	Steep
40-Above	6	8.58	100	Very Steep

Considering the above given table frequency, distribution of slopes one can understand the nature of slope of this area, the slope analysis has been done by grouping them into different categories of slopes,which has been divided into 5 different categories.

The average slope map(Fig.10) shows the distribution of slope and concentration of major slope categories in certain section of area. Isopheth lines express the intensity of slope change and demarcate the five; gentle, moderate, moderately steep, steep and very steep

TURA (WEST GARO HILLS)

AVERAGE SLOPE

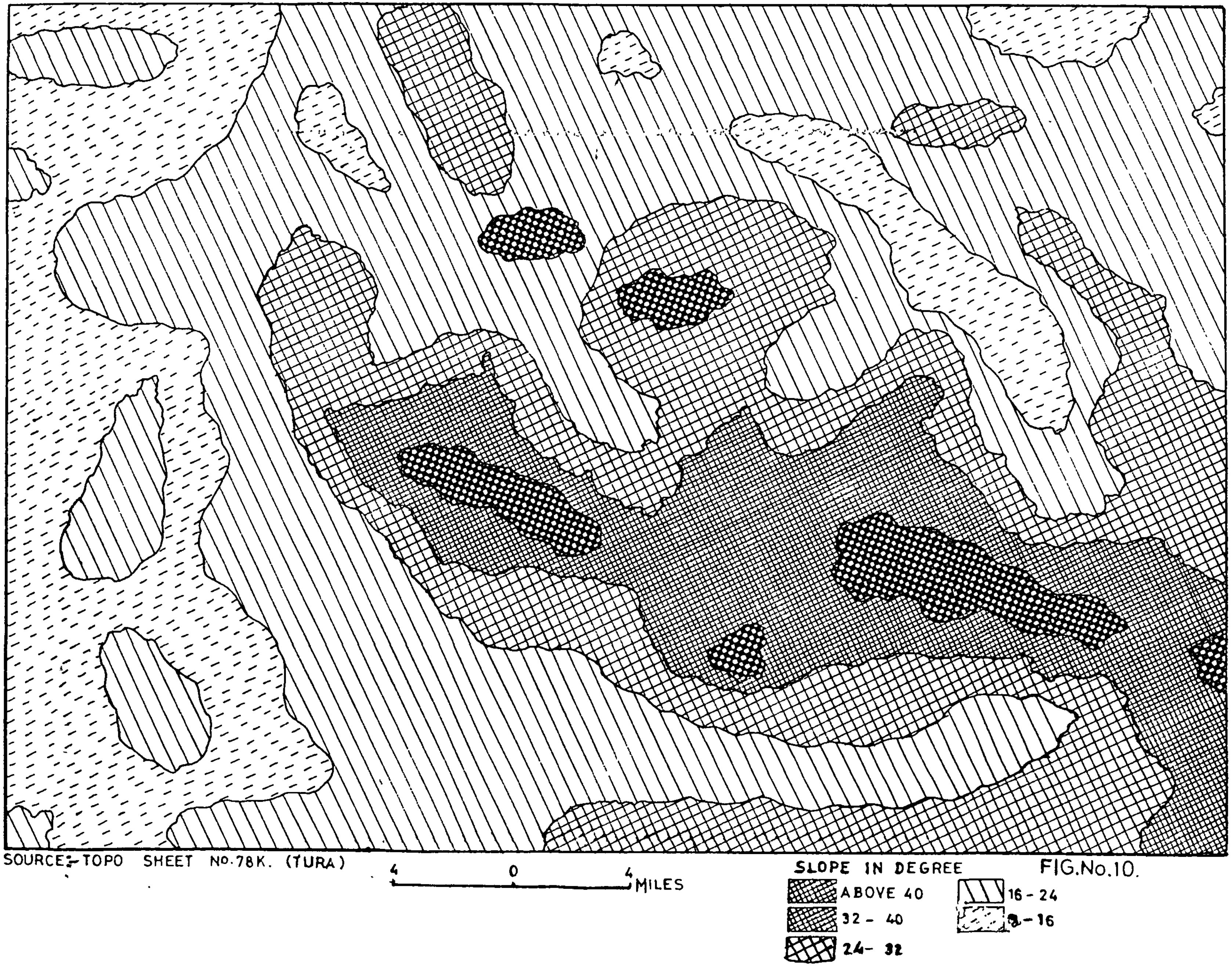


FIG.No.10.

average slope zones. The areal distribution of these five average slope zones of study area are discussed below :-

1) Gentle slope(8°-16°)

In the present study area, the gentle slope categories are below 16° occupying the area towards the south, north and western part. The study area covers the area which is basically a low relief about 800m in average. Area covered by this type of slope category is found to be suitable for jhum cultivation and as well as for permanent settlement. The soil found in this area is suitable for agricultural growth especially in the down to the foothills. Soil found in this area is Alluvial, laterite and Red yellow soils. The area also has noticed with the thick vegetational growth.

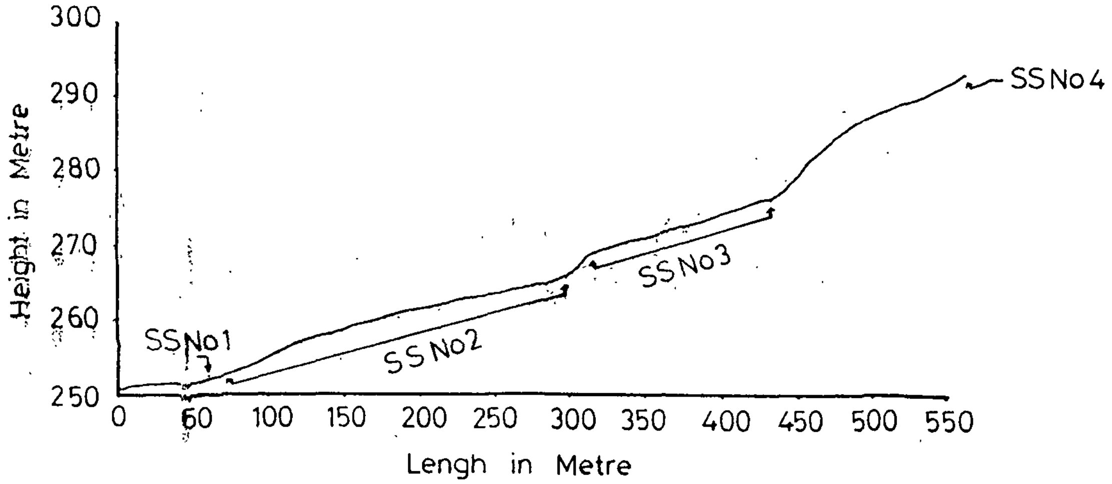
This category of slope have been observed that it covers less area and relatively small patches towards the further west where it reaches the plain of Brahmaputra valley, it is one of the important slope region for future agricultural development in the area.

2) Moderate Slope(16°-24°)

This categories of slope is ranging from 16°-24° over the study area. It is seen that slope is more or less gentle and relatively moderate. This type of slope is mainly

SLOPE PROFILE
(By Dumpy Level)

AGLANGIRI
(Tura)



SURVEY NAGAR
(Botanical Garden Tura)

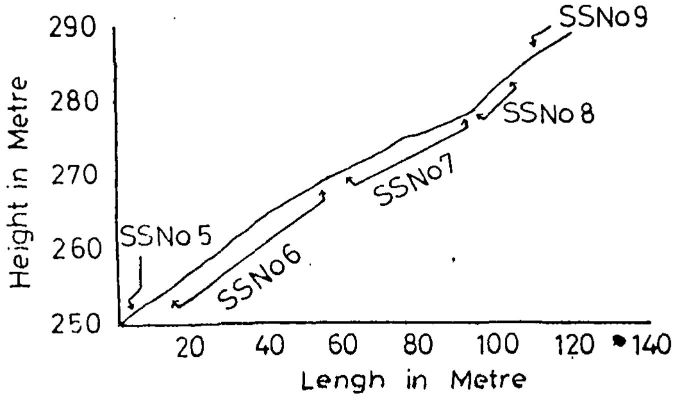


FIG. No. 11.

associated with the inter-fluvial tracts of south and undulating western part of study area, the development of number of streams are observed in the western part of the region where some river basins are useful for agricultural practices.

Since the slopes are moderately slope, it is quite suitable for the jhum cultivation over the plateau surface, it has been observed that in the Edenbary area, 12 Kms NE from the Tura town where the area is under jhum cultivation which causes the soil erosion during rainy season, and quite a good amount of loose material are transported to the lower level of plateau as debris and the upper surface of the soil become less fertile due to the erosion. In this categories of slopes some of the area is observed the rocks are exposed on the surface, it is mostly due to the fluvial erosion and it is quite possible that in the long period by continuous active erosion will remove the soft and loose material later on which may cause the degradation of plateaus and aggradation may developed in the low level of land by the deposition of huge amount of eroded materials. This moderate categories of slope are also present towards the north and south of the study area, the area covered by this category of slope are extending into large area in the study region.

3) Moderately Steep and Steep Slope(24°-32° to 32°-40°)

The real extent of this category of slope are to the north and south of the study area, where it occupies a small patch of study area, forming several streams and narrow deep valleys, full of huge boulder on the river bed. The river bed is shown by presenting a photograph of Gandrak river bed where it gives a clear picture of river bed with full of huge boulder on the bed. It is very interesting that in this moderately steep slope thenumber of permanent settlements have developed along the streams. The new Tura town is developing in thise categories of slope area, coming up with number of new buildings and also settlement in the area. Most of the villages are located in this moderately steep slope.

This slope zone of study region is witnessed by landslides and debris flow, most of the rivers are found with deep narrow valleys towards the north west. The prominent river Ganol which is a perinial stream forming steep gorges along the river side. In the upper course of the Ganal river valley, river characterises with headward erosion, and other side of the river slope in upper course thick vegetational cover has been cleared up recently for the jhuming purposes which may later on cause the top soil erosion and possibility of debris flow may take place in the long period. This area is noticed increasing the density of drainage formation.

In this category ofslope, land has been highly utilized for the settlement as well as fruit gardening. It is also seen that half of the Tura township has developed in this category of slope. The lower part of the slope seems to be fertile which supports luxuriant vegetational growth along the river sides. It is also observed during the field study that some parts of Tura town have occupiedthe steep slopes towards the east, but highly extended to the south west of main town, it is due to the gradual declining of slope which favours easy mean of transport communication as well as favourable conditions for the permanent settlements along the low relief features. This category of slope is ranging from 24-40 degree.

4) Very Steep Slope(40° and above)

The very steep slope is present in the central part of study area, which covers comparatively less area than the other categories of slopes. It is associated with very high relief of the region with high steep slope. It is observed that it occupies the small patch of relief on the northern part and in the central part, it also occupies in the north eastern part ofthe study area.

Gandrak dare water fall at upper Chandmari, Tura.
Fig. No. (P.8)

This category of slope zone in the region is the highest steep slope which is40 and above 40 degrees. Area of very steep slope are scattered in small patches along the main central range of study area. As it has been mentioned that the central range of study zone is standing like a watershed, from the central range of Tura peak, numerous rivers flows, both to the north and south direction. This range is having altitude of 1515m, above mean sea level which is a highest peak in the Garo Hills district, known as Nokrek peak.

In this category of slope river characterised as seift flowing in nature and has formed number of waterfalls having height about 50-100m for example, Rengsan graph waterfall which is very close to the Tura peak and another fall at Upper Chandmari known as Gandrak dare waterfall. These waterfalls of the study area are shown by presenting photograph, which gives the clear picture of the different fall. Slope has been found very steep where landslides become one of the significant feature during the rainy season. In this category of slope settlements are not found many.

It has been noticed that from the Average slope analysis the variation of degree of slope is very much

The area shows the gradual decrease in the elevation towards the western parts of the study area.
Fig. No. (P.9)

Gentle to steep hill slopes shows the deforestation due to the jhuming activities and timber exploitation over the gentle hill slopes. Fig, No.(P.10) significant and undulating relief features, as slope varies from one region to another within the selected area of uniform condition of climate, vegetation, soils, and bed rock and stage of development. The analysis of average slopes depict the close relationship among relief, drainage texture and slope.

Drainage analysis

The significance of drainage in the evolution of the landscape has long fascinated geomorphologists, hydrologists as well as geologists. "Epitomiges the history of a region's physiography as the history of its river"[1]. For rivers and valleys have a special place in the development of landforms. W.M.Davis remarked that, "Landscape is a function of its structure process and time"[2] while talking about his normal cycle of erosion.

The study area located in the humid tropical climatic region of the world where chemical weathering is a dominant process of landscape development, drainage tends to constitute one of the most important element of surface Geodynamics.

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1. N.W. Fenneman(1938), Physiography of eastern United States, McGraw Hill,New York, Preface(iv).
2. W.D.Thornbury(1969), Principles of geomorphology,2nd ed.pp.17

In the present study most of the rivers and streams are radiating from the central range of Tura, towards the north-south direction, maximum number of streams are consequent streams. The upper courses of rivers are characterised with headwarderosion and deep narrow valleys.

After hills and mountains, which are in many cases fashioned by rivers and perhaps also by vegetation, river courses are among the most conspicuous features of the landscape. Rivers and their activities are therefore, been among the first to be described by perspective observers. Among these was playfair, who, in 1802 wrote as follows:-

"Every river appears to consist of a main trunk (segment) bed from a variety of branches, each running in a valley propetion to its size and all of them together forming a system of valleys, communication with one another, and have such a nice adjustment of their declivities, that none of them join the principal valley, either on too high or too low a level, a circumstance which would be infinitely improbable. If each of these valleys were not the work of the stream that flow in it".

Drainage analysis is a techniques to understand evolution of landforms. In the present study area, the drainage analysis depict the picture that the net work of drainage are along the hill slopes into different direction where number of narrow river valleys are formed due to active degradation and aggradation of river activities.

Drainage Frequency

Drainage frequency refers to the ratio of the total number of channels of all orders in a basin to the area of the whole basin. Horton(1945)[3] introduced stream frequency (FS) as the number of streams segments per unit area.

Melton (1958)[4] analysed in details the relationship between drainage density and stream frequency both of which make up the drainage texture of an area which in turn is affected by climate, structural characteristics of the rocks, relief, infiltration capacity and vegetation of an area.

Drainage frequency is computed by the following formula.

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3. R.E. Horton(1945) "Erosional Development of Streams and their drainage basins : Hydrological approach to Quantitative Morphology" Geol. Soc. American Bull. No.56 pp.285

FU = (1) U/AU

Where,

FU = Drainage frequency in No. sq.mile

(1)U = Sum of the total number of streams of all orders.

AU = Total area of drainage basin in 16 sq.mile

METHODOLOGY

In the present study to determine the drainage frequency the following method has been used, first, the entire drainage area has been divided into one inch grides by drawing East-West and north south grides,which represents 16 sq.mile and the number of channel segments is recorded in per unit area. The following formula has been used for the drainage frequency distribution.

$$FS = \frac{N}{A}$$

Where

FS = Stream Frequency

N = Total Number of Streams per unit area

A = The Unit Area.

The distribution of drainage frequency is given on table No.6 which express the drainage frequency distribution in the study area.

TABLE NO.6

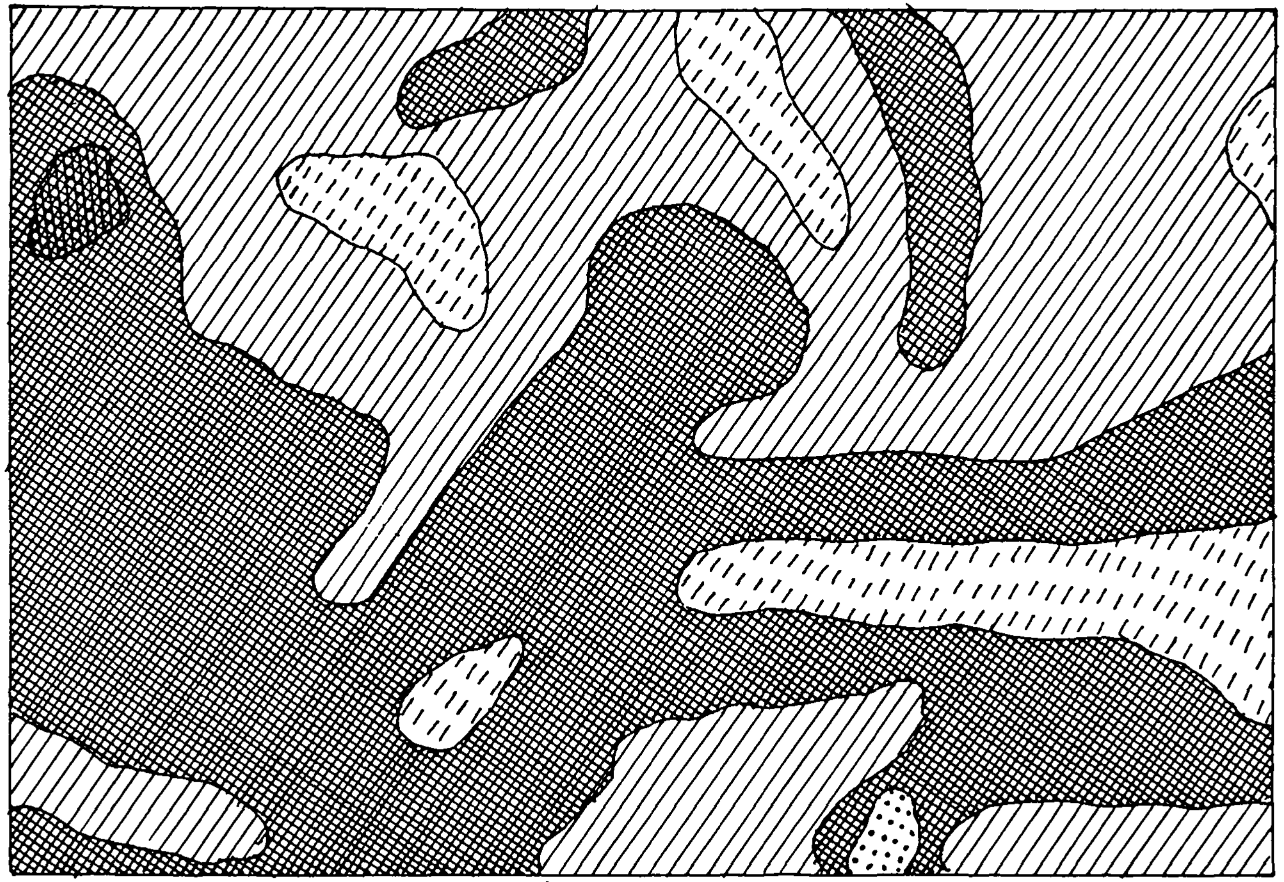
Drainage Frequency Distribution

Drainage Frequency per sq. mile	No.of grids occurrence	Percentage of total Frequency	Commulative Frequency	Remark
Below-4	1	1.42	1.42	Coarse Frequency
4 - 8	12	17.14	18.56	
8 - 12	31	44.28	62.84	Moderate Frequency
12- 16	21	30.02	92.86	Moderate high Frequency
16 - above	5	7.14	100	Very high Frequency

Drainage frequency distribution has been done by grouping them into different categories like low or coarse frequency, moderate frequency, moderately high frequency and to very high frequency.

(TURA) WEST GARO HILLS

DRAINAGE FREQUENCY



Source: Topo Sheet No.78K (Tura) INDEX. FIG. No.12.

Above- 16
12 – 16
4 – 8
4–8
Below-4

4 0 4 Miles

According to the above value if reveals that the frequency of drainage in the study area is showing the variation from one area to another. These five groups of different stream frequency is discussed below:-

<u>Coarse Drainage Frequency</u>(Below 4)

This categories of drainage frequency is noticed in the northern and south-east part of the area and also to the south in small area. This category of drainage are confined to the small area may be due to the Relief feature which keeps the development of streams under control.

<u>Moderate Drainage Frequency</u>(4-8)

Moderate drainage frequency occurs on northern part of study area, and small patch of area on the south. From the Drainage map, it can be seen that the area under this category of streams is covering large area. It is due to the presence of permeable rocks and favourable relief for the development of streams. The streams originated from central Tura range along the hillslope characterises with narrow deep valley creating a several falls on the river bed.

<u>Moderately High Drainage Frequency</u>(8-12)

Moderately high drainage frequency occurs towards the southern part of study area, covering the area from west to east. The stream occurance are quite significant, along the hill slopes and joints. Thishhigher frequency may be attributed due to the heavy rainfall and the litho- logical and structural characteristics of the Archaen rocks and also presence of large groups of permeable rocks on the earth surface. In the southern part of the study area, some of the major river like Ganol, Gandrak etc. are originated from high relief. Most of the small streams found there are joining the main river in their later courses.

High Drainage Frequency(12-16 & 16 above)

High drainage frequency occurance in the study area is very insignificant, there is only a small patch of land having such high drainage frequency in the north western part of study area. It may be due to the high relief, which favour large number of streams formation.

From the above drainage frequency distribution, it can be concluded thatthe frequency of streams are controlled by relief, lithological, structure as well as the climatic conditions. No doubt the area hasthe frequency distribution from coarse to very high drainage frequency in the study area.

Drainage Density

Horton (1945)[4] defined drainage density as the total length of the stream(L) in a given drainage basin divided by the areas of the basin(A). It is therefore expresses that the drainage density is simply length of drainage per sq.unit. Numerically, it is defined by the relation as,

DU = (I) U/AU

where

DU = Drainage density in per sq.unit

(I)U= Sum of total lengths of streams of all order in per sq.unit

AU = Total area of drainage basin.

TABLE NO.7

DRAINAGE DENSITY DISTRIBUTION

Length of Stream per unit area in sq.mile	No.of grids occurance	Percentage of total density	Cumulative Percentage	Remarks
Below - 3	10	14.28	74.28	Low
3 - 4	21	30.01	44.29	Moderate
4 - 5	22	31.42	75.71	High
5 - 6	14	20.01	95.72	Very high
6 -Above	3	4.28	100	

4. Horton,R.E.(1945) op.cit pp.275-350.

(TURA) WEST GARO HILLS

DRAINAGE DENSITY

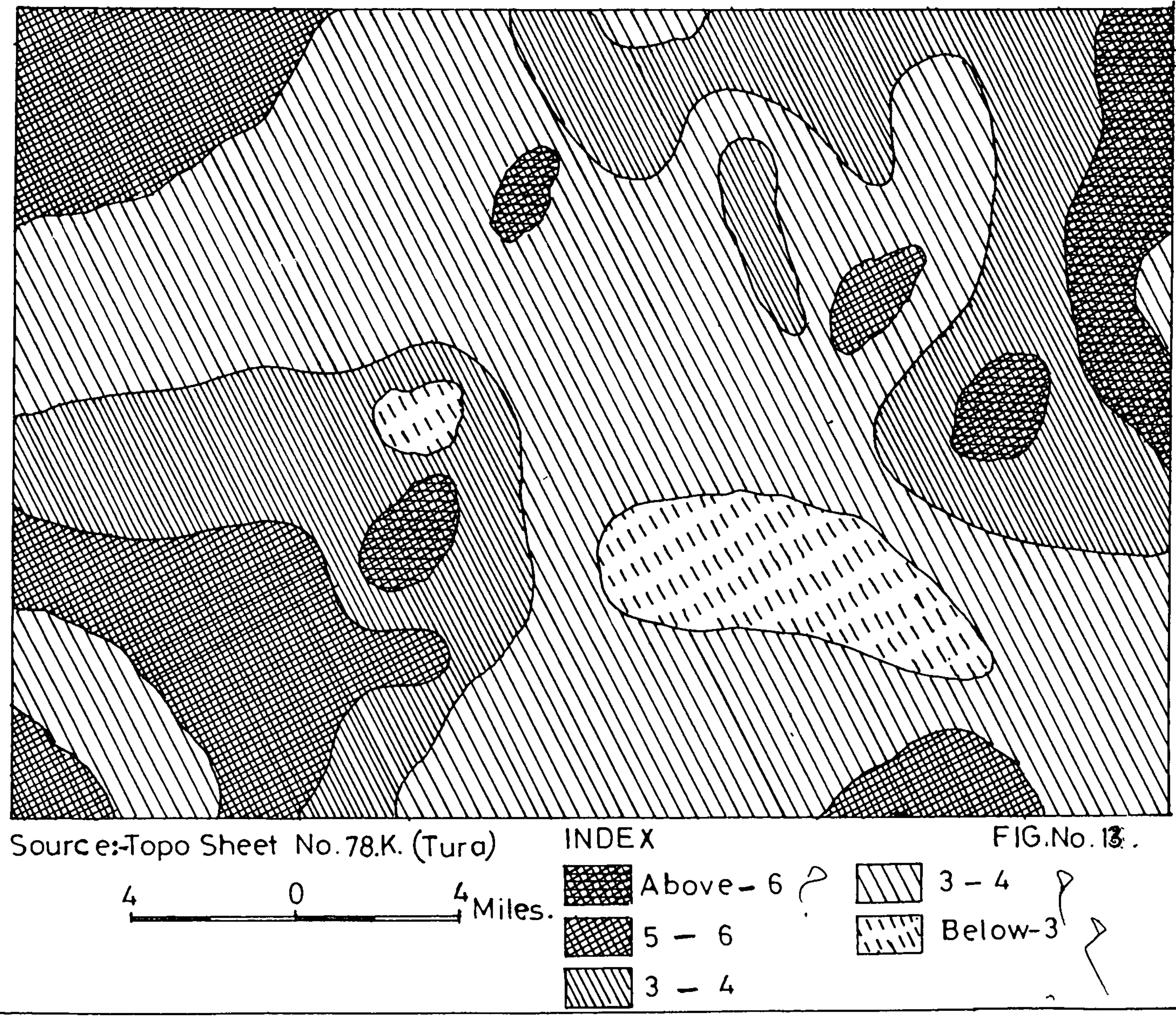


FIG. No. 13.

Using the above mentioned formula, the drainage density map has been prepared with the help of toposheet No.78K from the drainage map of Garo Hills district, the drainage has been traced from toposheet No.78K. The drainage map hasbeen divided into one inch grids, north- south and east-west, representing each grid 16 sq.miles on the surface. The total length of the stream of all orders are measured by running Rota meter for each per sq.units and then divided by Area. Accordingly after categoring of all categories of drainage density into different category isopheth lines has been drawn for each category.

The drainage density of study area has been divided into following broad category like low, moderate, high and very high density.

<u>Low Drainage Density</u> (2-3)

Low Density of drainage in the study area is occuring only towards the south-eastern part of study area as well as to the north-west corner and small area in the central part. The low density occurance of drainage expresses that the area may be under the hard bed rock slope of the relief is higher where does not favour much for the drainage development, where infiltration of rain water is very less. Low category drainage density is confined to the small part of the study area.

Moderate Drainage Density(3-4)

The moderate category of drainage density occurance are highly significant in the study area, it covers the large area. It is occupying the central part of the area and extends to North-West and also reached to the south-eastern part. About 30 percent of the study area is under the moderate category of drainage density is found, which shows the density from 3-4 or miles. Gradual increase of drainage density isexpress the relief gradual decline and presents of joints, faults and presents of soft permeable bed rocks.

The area of moderate category of drainage density is one of the distinct picture of the study area where thick vegetational cover is also found. Most of the rivers and streams which follow the hill slope brings narrow deep river valley in the area.

High and Very High Drainage Density(4-5, 5-6 & 6-7)

High drainage density is noticed in the south-west, south-east and small area in the North-eastern part of the study area. High drainage density is specially found in the area where the slope of hills is decreasing towards the Brahmaputra plain. This high drainage density shows and expresses that the soil and rock present in the area is highly favourable, and the structure of rocks is permeable, which hasthe high infiltration of rain water.

The development of high drainage density is also due to the numbers of small basin or valley where the central range of Tura become catchment area and its increase the water infiltration to rocks.

On the other hand, a very high drainage density is found in limited area which covers the area is quite small zone. It can be shown from drainage density map that occurance of very high drainage density is found in the north-south of central part and very small area in the east.

This category of drainage density is indicating that river basin is located at a region of highly permeable rocks struta.

All above from drainage density expression, it is seen that density of drainage in the study area is varying from one region to another, where moderate density of drainage is occupying the large area of the region followed by higher density. In this study area, the density of drainage is very much with variation of altitude and relief as well as gradual decrease of slope.

Drainage System

In and around the study area, the drainage systems are found radiating from the central Tura range both to the north and south direction. Tura range is standing like a water divide forming watershed. Quite a number of streams, originated from the Tura range. As the slope of Tura range is declining both to the north and south the rivers and streams originated in the ridge flows to the north and south. The north flowing rivers join to the river Brahmaputra in the plain of Assam whereas the south flowing rivers reach to the Surma valley of Bangladesh plain. Most of the streams have developed along the joints and faults. It is noticed that most of the small and big rivers are characterised with huge boulders and find particles on the river bed. The river originated from Tura range is shown by presenting a photograph in the following page.

There are three important rivers, Ringre, Gandrak and river Ganol. These three important rivers originated from Tura range. The river Ringre flows through heart of the Tura town and later on it joins with river Gandrak at Leporcy colony near Samphalgri hill andthe river Ganol

DRAINAGE (GARO HILLS)

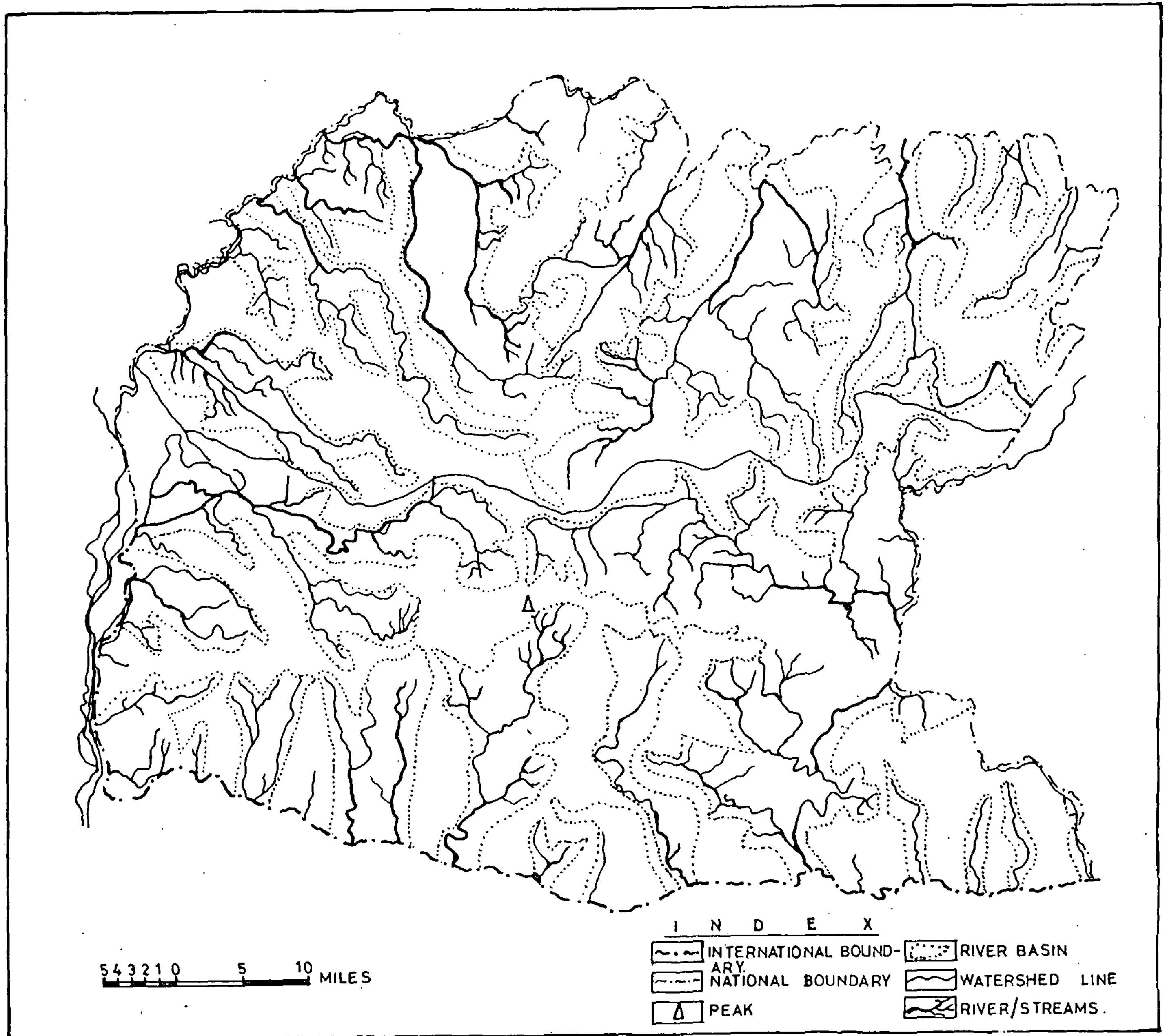


FIG. No. 14

Expose lime stone surface are seen on the Gandrak river bed near main road Gauhati- Tura road, 4km. north of the tura town. Fig. No. (.P.11)

Upper course of the river Gandrak with huge boulders on the river bed. Some expose rocks are seen on the river side. Fig. No. (P.12)

It shows the command area land under the flow ir rigation scheme at Edenbari 12 km. north of tura town, cnstructed on 1986-87. It covered the area 398 Hectres.
Fig. No.(P. 13)

Gandrak river bed near Laporcye colony. tura.
FIG No (P.14)

which flows towards the west direction forming deep river gorges. These rivers are perinial rivers. River Ganol is one of the largest river in the study area, which generally causes deep bed erosion on the river bed.

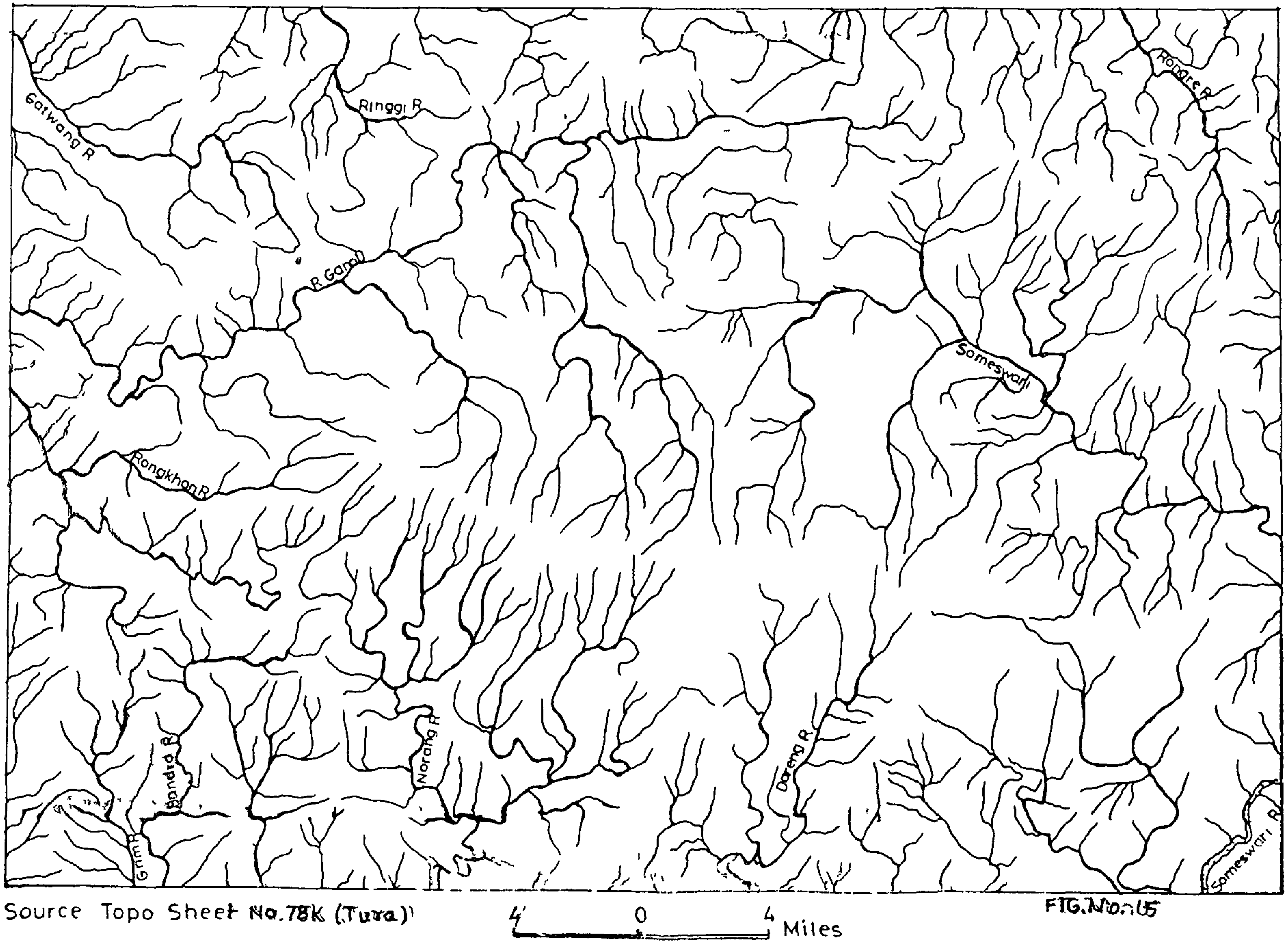
Rivers found in study area are quite significant in the depositional work specially in thelater stage of the river. It is due to the rugged hilly topographical region, where large amount of eroded materials brought down by river water and reaches the plain of Brahmaputra valley.

In the river between Gandrak and Ganol there is a high peneplane at Edenbari, which has become more suitable for wet paddy cultivation. That plain is under flow irrigation scheme constructed in 1986-87. This command area is covering 398 Hectares of land.

The drainage system in the study area is found quite significant, it has been observed that in the higher altitude the development of streams are higher than the lower altitude. As it is well identified that most of the rivers and streams originate from Tura range.

TURA

DRAINAGE



Source Topo Sheet No.78K (Tura)

FIG. No. 15

Minor water fall at the lower part of tura range.
Fig, No. (P. 15).

Western part of the tura area which showsthe gradual decrease in elevation Fig. No. (P.16).

Drainage Patterns

In the present study area, the drainage patterns represents a most spectacular features revealing extra ordinary straight courses of the river and streams, evidently along the joints and faults, to the south and south western part of the study area river result a massive headward erosion by antecedent streams. Along the joints of the sedimentary rocks over the block experiencing over the greater uplift. Consequent streams are mostly controlled by the structure, faults and monocline in the sedimentary rocks.

The northern part of the study-area is marked by long incisive valley formed due to the headward erosion along the joints in the gneissic rocks and granites. Drainage patterns, found in thestudy area are generally noticed in the following patters.

i) Dendritic pattern

ii) Trellis pattern

iii) Recangular pattern and

iv) Parallel patterns.

The following drainage patterns have been shown by diagramatic representation in the following page Fig.No.16.

Dendritic Pattern

In this pattern, the tributary streams come from all directions to meet the main rivers. The stream gives an impression of a tree whose main stream is joined by various bfanches. Streams areboth big and small, like the branchesof trees, the small streams meet larger streams andthe larger streams meet still larger streams and in the end meet the main stream. This stream is also called pinnate. In the present study area, this type of streams developed in north, south and western part.

Such a drainage pattern is found on a land with rocks of similarresistance. In the initial stage, initially the stream elonggates itself by headward erosion. The number of tributaries increases, whereas in the later stage larger valleys capture smaller valleys. This make the dendritic form more distinct and identifiable. The texture of this drainage type depends upon the amount of rainfall and the porosity of the rocks. The presence of other rocks also influences the texture. The streams of this drainage type are usually insequent.

Trellis Pattern

In this pattern, the tributary streams are long and parallel to the main stream. This type of streams develop when there are belts of hard and soft rocks at right angles to the initial surface, the subsequents often make right angles with the consequent streams. This type of streams are found in the northern and southern part of the study area. The subsequent streams develop into soft rock belts. When thesoft rock belts are eroded down,belts of hard rocks appear among them seperating them in the form of long and parallel hills. This category or pattern is shown in the figure No.16.

Rectangular Pattern

In this pattern, the tributaries can be seen meeting the main stream at right angle. This pattern generally develops where joints and faults are found. The geomorphic joints of metamorphic rocks give rise to rectangular drainage pattern.

In the present study area, this type of drainage are noticed towards the south of central Tura range and also to the north eastern corner of study area, it is due to the several joints in the metamorphic rocks which favour by the formation of such drainage development around the study area. This pattern of drainage has been represented in the Fig.No.16.

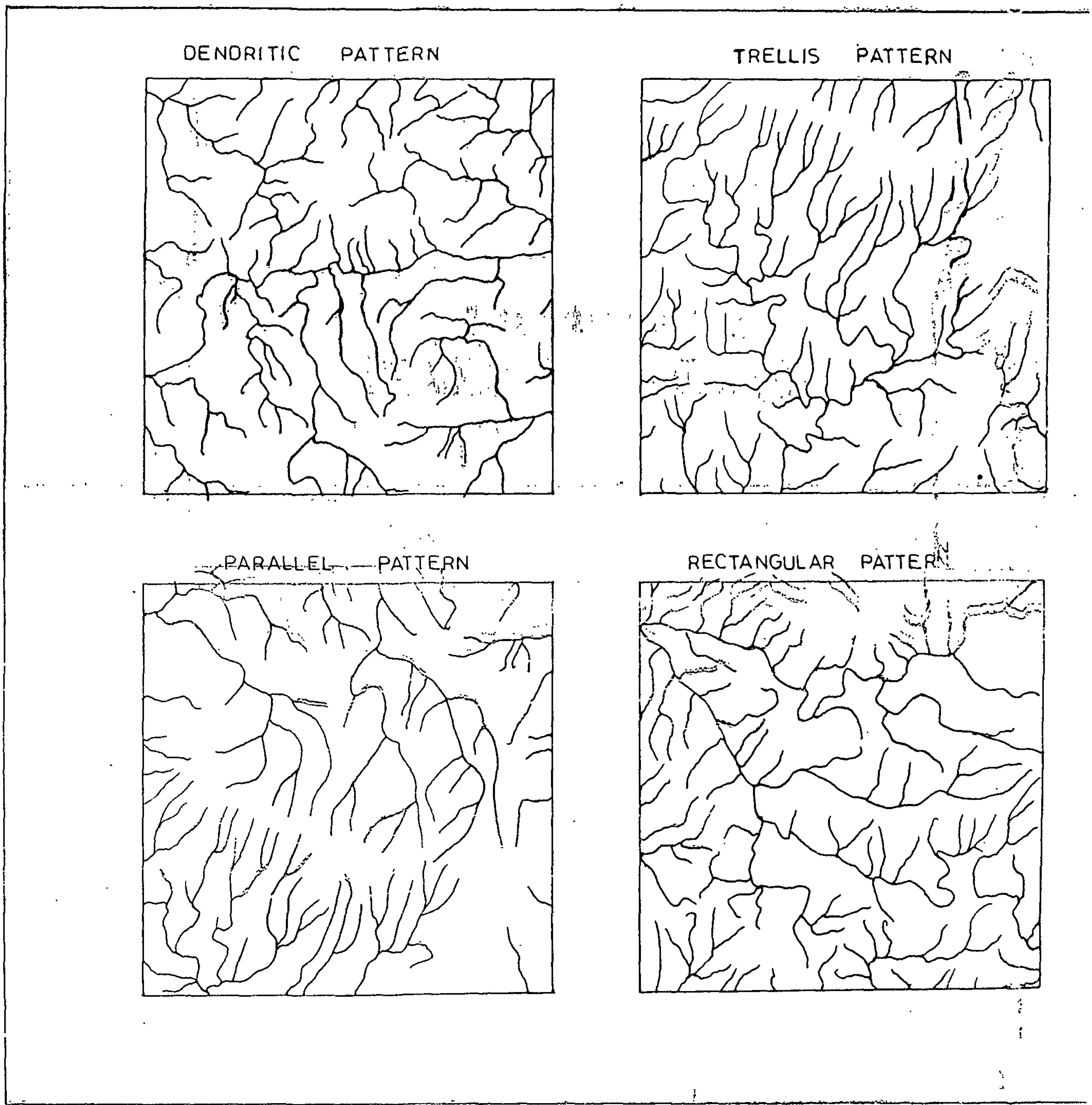
Parallel Pattern

In this pattern, the consequent streams flow parallel to each other. The drainage pattern is known as parallel pattern. Parallel landforms such as sandstone ridges and steep regional slope play a significant role in the development of such drainage pattern. In the present study area this type of streams are found to the south and to the northern part of area where the slope of hill gradually decreases, where some of the streams are characterised as parallel courses along the slope of the terrain. For example, the tributaries of Norang river on the south shows the parallel pattern of drainage. This has been shown in Fig.No.16.

Thus in the study area, depict the picture of different types of drainage patterns, occuring in the different part of the study area, among all these drainage patterns, trellis patterns are noticed quite common in the region.

TURA WEST GARO HILLS

DRAINAGE PATTERNS



Source:- Topo Sheet No. 78.K. Tura.

FIG. No. 16

SUMMARY AND CONCLUSION

SUMMARY

Physiographically, Meghalaya Plateau is a remnant representing the north-eastern extension of the Indian peninsular shield. It has a cheqered history of geological evolution. The plateau has been block uplifted to its present height of about 600-1900m above mean sea level, during post Mesozoic times.

The core of the plateau comprising oldest rocks in the region, the gneissic complex with Shillong group of rocks. Tectonostratigraphically, Meghalaya plateau can be divided into three domains, where each has got its distinct evolution.

(1) The peninsular shield extension comprising the Gneissic complex.

(2) Intracratonic sedimentary basin represented by Shillong group.

(3) The Mesozoic-Tertiary sedimentary sequence along the Sylhet trap occupying the southern fringe of the plateau.

The northern part of the study is occupied by the gneissic rocks and to the west by the Surma series. Towards the west and southern parts of the study area is covered by the Chengapara, Baghmara formation and Jaintia series of rocks.

Geologically, Garo Hills area is characterised by the presence of wide variety of rock types originated during various epoch of the earth evolution starting from Archaean period about (3600 million years) up to the recent time. The oldest group of rocks is the Archaean group is represented by the hard and massive, granulites, Migmatites and minor banded ferruginous quartzite occupy about 60% of the region. The general structural trend of the rocks of this region is NE, SW direction. The rocks are folded and lineated.

The relief analysis revealed manifestation of fragmental shapes arising due to denudational agencies.

The maximum elevation of the study area is 1515m located in the central part of the study area, and gradually the altitude decreases both to the north-south direction from the central part.

The slope analysis revealed five categories of slopes (8°-16°, 16°-24°, 24°-32°, 32°-40° and above 40°), the lower categories of slope are generally found towards the north and western part of the study area. and high degree of slopes are occuring in the central part of the study area. There are several waterfalls in the central part of the study area, for example, the Rengsangraph water fall, near to the Tura peak which has height about 50m. There are numbers of falls which is located in the lower part of the Tura range.

The climate of the study area is Sub-tropical to Semi-temperate type. The area is experienced with heavy rainfall during rainy days and plateau nature of the area is conducive to deep chemical weathering. It is due to the heavy rainy season the area during summer causes a significant erosion by running water, where chemical weathering keeps active process of erosion work over the region. It is quite natural that during rainy days, the running water carried down the large amount of loose materials and deposited at the low level of land. Numbers of landslides are identified in the area, these landslides are also caused by human interference on the land surface especially of constructional activities. The maximum rainfall occurance is noticed in the study area in the month of July, the study area also experienced maximum temperature is in the month of May.

The drainage analysis shows that the streams segments have a very spectacular structural control. This is reflected by the reclined 'v' shaped channel network and develop the deep gullies, in some part of the study area.

The drainage system of the study area is noticed, that there are generally four types of drainage patterns are present, like Dendritic pattern, Trellis pattern, Rectangular pattern and Parallel pattern. The development of these various patterns of drainage are due to the diverse and undulating topographical features of the region, where it has different categories of slopes and upland small plain.

CONCLUSION

From the present study, the following conclusion have been made.

1. The area has a undulating topographical features covered with the thick forest and grass.
2. The relief rises to the central part of the study area from both north-south, where central part of study area act as water divide, having elevation of 1515m high above mean sea level.
3. The variation of slope between 8°-40° and above 40° have been identified in the study area. a general pattern of slope rises with the rise in absolute relief is observed. The slope also rises

significantly with the rise in relative relief.

4. The drainage network of the area shows strong lineaments of the Meghalaya massive.

5. Stream density is noticed in the study area is very much significant. The higher density occurs towards the south west of the study area, and high drainage frequency is noticed to the south west corner. It showsthe clear picture of drainage network in the figure No.15 and 16.

6. Due to the extension of Tura town towards the New Tura area, there are number of constructional work like Building, construction, road construction etc. which added more erosion work and landslides along the hill slopes, and due to these construction activities, the normal natural slopes are modified till some extent.

7. Another important erosional work is also noticed in the study area by practicing the jhum cultivation over the gentle slopes and also the lumbering activity which leads to deforestation of the land.

B I B L I O G R A P H Y

Ahmed,E.(1977)- Geology, Structure and Geomorphology of trans Himalayan Nepal, Geog. Outlook

Asthana V.K.(1967)- Morphometric evolution of landforms in Almora and its environs, Nat.Geog.Jr. India 13(1) pp.37-35.

Anon,(1978) - Slope analysis(Development in Geotechnical Engineering). Vol.22 Elsevier Scientific pub- Co. Amsterdam.

Alistair F.Pitty(1982)- The Nature of Geomorphology

A.Faniram and L.K.Jeje(1983) -Humid Tropical Geomorphology. A Study of the Geomorphological processes and Landforms in warm humid climates.

Bandhopadhyaya M.K.(1972) - Geomorphological characteristics of the southern part of the Khasi Hills. Geog. Rev. India. Vol.34(2) pp.184-189.

Bania N.C.(1968) - Geomorphology of Barapani area in Meghalaya Plateau, Pro. Pre-Cong Symp. IGU, Gauhati, Nov. pp.25-32.

Bareh,H. - The History and Culture of the Khasi People, Calcutta, 1967.

________ -Meghalaya, North Eastern India News & Features, Service, Shillong -2.

Chorley,R.J.(1957)- Illustrating the law of Morphometry, Geo. Mag. Vol.94, pp.140-150.

Craig,R.G. & Craft,J.L.(ed) 1982 - Applied Geomorphology, George Allen & Unwin, London p.253

Deornkamp,J.C. & King, C.A.M.(1971) -Numerical Analysis in Geomorphology,an introduction, Edward Arnold, London p.372.

Douglas,I. & Spencer T.(ed) 1985 - Environmental change in tropical Geomorphology, George Allen and Unwin, London p.378.

Emblet on C. Brunsden,D., & Jones,D.K.C.(ed)1978 - Geomorphology, present problems and future prospects Oxford Univ.Press, London p.281

Fairbridge,R.W.(ed) 1968 - The Encyclopedia of Geomorphology, Encyclopedia of Earth Science Series Vol.III, Reinhold Book Corpn.,New York p.1295

Fox,C.S.(1934) - The Lower Gondwana Coalfield of India, Mem. Geol.Surv.Ind.Vol.59, p.386

Ghose,B. and PandeyS.(1966)- Geomorphology of Central Luni Basin, Western Rajasthan, Annals Arid zone. 15(1).

Gregory K.J. andWalling,D.E.(1973) - Drainage Basin form and processes. A Geomorphological approach. Edward Arnold (Pub.Ltd) pp.3-4 & p.46)

Goswami,D.N.D. - Geology of Assam, Gauhati,1960.

Gogoi,K.(1975) - The Geology of the Pre-Cambrian rocks in the NW part of the Khasi and Jaintia Hills, Meghalaya, Geol. Surv. Ind. Misc. pub.No.23, Pt.1, pp.37-48.

Geyl,W.F.(1981) - Morphometric analysis and the worldwide occurance of stepped erosion surface. Jour. Geol. Vol.69 pp.388-416.

Godwin,A.(1873) - On the Garo Hills Jour Royal Geog. Soc. Vol.43

Gassah,L.S. - Garo Hills, Land and the People.

Horton,R.E.(1945) - Erosional development of Streams and their drainage basins, hydrophysical approach to Quantitative morphology Bull.Geol.Soc; Amer. Vol.56,pp.275-370.

King,L.C.(1962) - Morphology of the Earth, Oliver and Boyd. London.

King,C.A.M.(1966)- Techniques in Geomorphology. Edward Arnold (Pub.Ltd) London.

Kumar,A.(1971) - Geomorphic interpretation of drainage and relief of eastern Ranchi plateau. Uttar Bharat. Bhugal Patrika 7(1) pp.18-33.

Kar,P.C. - British Annexation of Garo Hills, Nao Bharat Publication, Calcutta, 1970,

Khar Kwal,S,C.(1971) - Slope studies in a Himalayan terrain, Nat.Geog.Jour, Ind.Vol.17, No.1 pp.1-75

Krishna,M.S.(1982) -Geology of India and Burma,C.S.B. Publisher & Distributors, Delhi p.536.

Mukhopadhyaya S.C.(1969)- Some Aspects of Geomorphology of part of Subarnarekha Basin around Mahali Murup, Bihar, Geog. Rev. India 31(2) pp.33-40.

Murthy,M.V.N.(1968) - Geomorphological evolution of the Assam region, Proc. Pre-Cong. Symp.IGU,Gauhati pp.10-15

Majumdar S.K.(1976) - A Summary of the Pre- Cambrian Geology of the Khasi Hills, Meghalaya,Geol.Surv. Ind. Misc. Pub. No.23. Pt. 11, pp.311-334.

Majumdar S.K.(1978) - Morphogenetic evolution of the Khasi Hills, Meghalaya India. Geol.Surv.Ind. Misc. Pub. No.Pt.111, pp.208-213.

Majumdar S.K.((1986) - The Pre-Cambrian frame work of part of the Khasi Hills, Meghalaya. Rec.Geol. Surv. Ind. Vol.117 Pt.2, p.59

Medlicot,H.B.(1869) - Geological sketch of the Shillong plateau in N.E. Bengal Mem. Geol.Surv.Ind. Vol.7 Pt.1 pp.151- 207.

Miller,O.M., & Summerson,C.H.(1960) - Slope zone maps, Geog. Rev. Vol. 50 pp.194-202.

Murthy,M.V.N., Mazumdar,S.K. & Bhaumik,N.(1976a) -Significance of tectonic trend in the geological evolution of the Meghalaya Uplands Sincethe Pre-Cambrian. Geol. Surv. Ind. Misc. Pub. No.Pt.11. pp.471-484.

Mazumdar,S.C.(1984) - Geomorphic Study ofTripura. Ph.D. Thesis, Deptt.of Geography, N.E.H.U.,Shillong.

Mali D.D. - An Introduction to the Economy of Meghalaya. *Head of Economics Deptt.,Sankardev College,* Shillong.

Patnaik,S.N.(1979) - Geomorphology and Agriculture in Meghalaya Plateau, unpublished M.Phil Dissertation, Geog. Deptt.,N.E.H.U.,Shillong.

Pofali R.M., L.R.Hire Kerur - Geomorphological studies in Vicinity of Nagpur.

Prasad Haushila - Mussoorie and its Environs -A Study in Applied Geomorphology.

Rai,R.K. (1982) - A study on average slope of Khasi and Jaintia Hills, Meghalaya, Hill Geog. Vol.1(i) pp.42-46.

Rai R.K.(1976)- Geomorphology and Rural Settlement in Sonar Basin(M.P.) Essays in AppliedGeography Saugar.

Rai,R.K.(1980) - Geomorphology of the Sonar Bearma Basin.

Rai,R.K. - Structural and Geomorphic Evolution of Meghalaya Plateau India on landsat imagery.

Rai,R.K.(1980) -Morphometric analysis of Umran basins of Meghalaya. Trans. Inst. Ind. Geog. Vol.2 No.2

Rai,R.K.,Patnaik,S.N., Panda,P & SinghaniaV.(1981)- Hill slope land use and soil erosion around Shillong, Meghalaya, Geog. Rev. Ind. Vol. 43, No.4,pp. 359- 364.

Ray,S.(1978) - Studies in Geomorphology of India.

Singh,S.(1979) - A Morphometric study of average slope of the small drainage basins of the Ranchi Plateau, Nat.Geog. Allahabad 14(1).

Spate,O.H.K.(1952)- Geomorphological Problem in India, A plea for their more intensive study. Indian Geog. Soc. A Silver Jubilee Souvenir,pp.181-85.

Subramanyam,V.(1976) -Techniques of Geomorphic Analysis in Si Applied Geography,(ed), Sagar.

Thomas,M.F.(1974) - Tropical Geomorphology. A study of weathering and landform development in warm climates (Essex, Macmillan).

Twidale L.C.(1973) - Some problems of slope development; slope morphology(Ed); Pensylvania, Dowden Hutchinson & Ross pp.93-111.

William D.Thornbury - Principles of Geomorphology

Wentworth C.K.(1930) - A simplified method of determining the average slope of land surface. Am. Jour. Soi.Vol.20 pp.184-194.

- Geographical review of India, Vol.40,1978. N.E.H.U., Published by the Geographical Society of India, Calcutta.

- Govt.of Meghalaya, Dept.of Economics, Statistics and Evaluation, West Garo Hills; District,1986-87.

- Gazetteers of Garo Hills,1981.

- Govt.of Meghalaya,Deptt.of Economics, Statistics, andE Evaluation, West Garo Hills Dist.,1986-87.

- Working Plan for the Regional forests of the Garo Hills Dist. Meghalaya, 1975-76 to 1990-1991.