GEOMORPHOLOGY AND MINING IN WEST KHASI HILLS DISTRICT

DISSERTATION
SUBMITTED FOR THE PARTIAL FULFILMENT
FOR THE DEGREE OF
MASTER OF PHILOSOPHY

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To

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CERTIFICATE

This is to certify that the dissertation entitled, "Geomorphology and Mining in West Khasi Hills District" submitted by Shri Kyrdondonalstone Diengdoh in partial fulfillment for the degree of Master of Philosophy in Geography of the University is a bonafied work to the best of my knowledge.

The study, therefore, may be placed before the examiners for evaluation and consideration.

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A C K N O W L E D G E M E N T

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15th NOV 1993.

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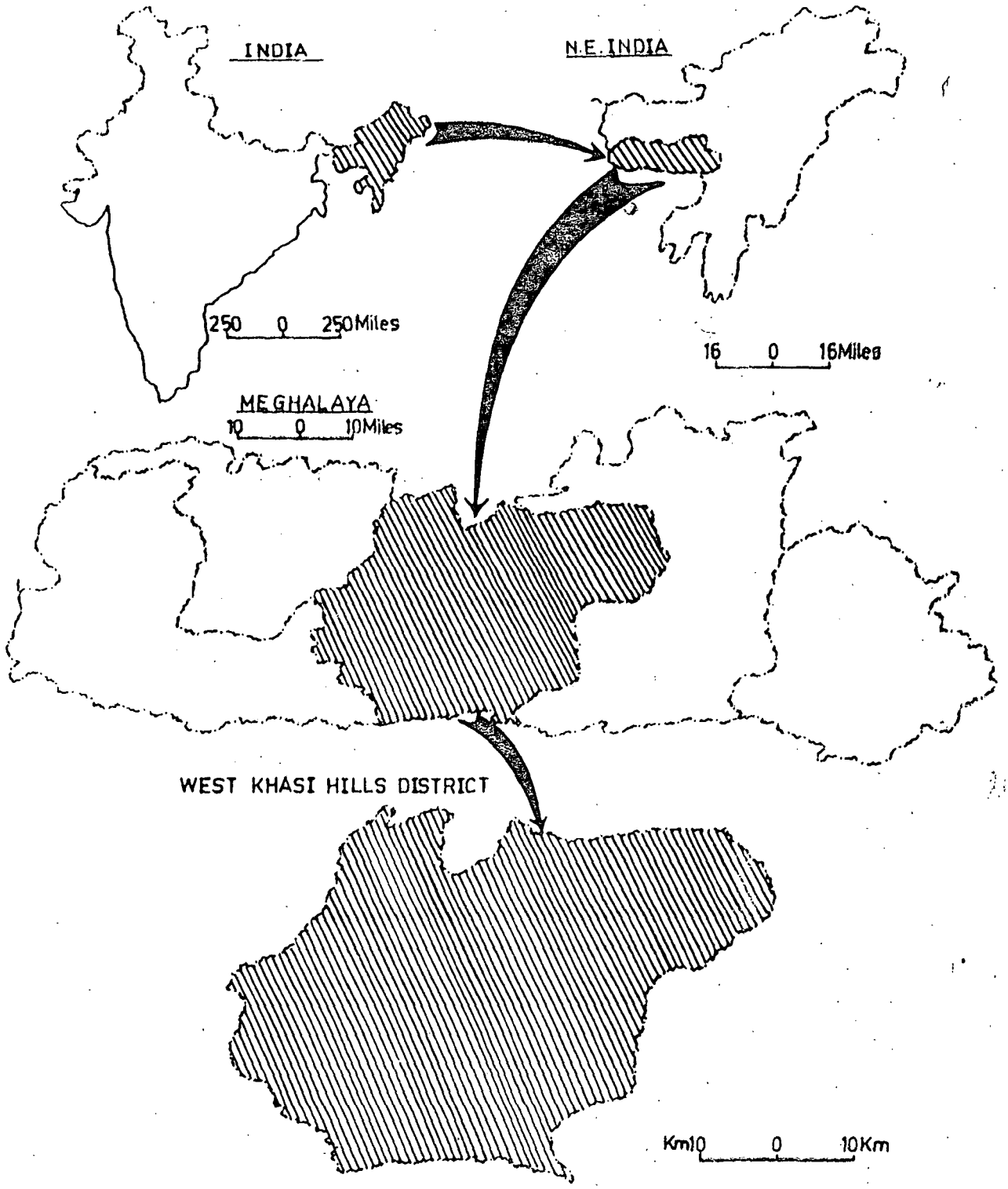
LOCATION OF THE STUDY AREA



CHAPTER - I

INTRODUCTION

"Geomorphology is the study of the earth surface. But the definition is so vague as to be almost meaningless. Instead it is more practical to see that the land surface, and the soil from which landform can rarely be separated, as part of interaction factors, geomorphology is best viewed from a balanced, total prospectives and approached with an ecological bias."

KARL W. BUTZER
- Geomorphology from the Earth -

"The geologists examines the past for its own sake in as much as geology is concerned with the history of the earth; the Geographers examine the past only in so far as it illumines the present."

W. M. DAVIS
- Geographical Essay, 1990; pp.258

Geomorphology is the science of landforms. It is important branch of physical Geography. The term 'Geomorphology' etymologically means (the Greek, 'ge','morphos', shape; and 'logos' , reason) the study of the earth's shape which has been subjected to various interpretations. The status of geomorphology as an autonomous discipline has been controverted, as the discipline like geology, geophysics that claim to be inalianable part of their respective domians. In practice these science overlap, so that hard and fast definitions of geomorphology is neither desirable nor practicable. It is not worth-

while on our part to be a party to the controversy. It would be suffice to say that Geomorphology in its widest sense is that branch of the earth's science which concern itself with the development of the surface features of the earth. In a more restrictive sense geomorphology is the science of those features whose shape is determined by the action of exogenatic processes, i.e., which originated outside the solid earth. It is with this, latter concept of Geomorphology that we shall concerned ourself.

The science of geomorphology tells about the shape of hills and valleys, the degree and frequency of slope, the development of drainage pattern and the nature of materials exposed in all available sections. But the study of this discipline is not limited to this academic sphere only. In contemporary world, it is being increasingly realised that almost in every respect, an application of geomorphological principles could be rewarding. In the field of engineering geology, measure of soil control; soil sciences; economic geology; geohydrology, military geology, irrigation and for landuse and landscape planning which would well be served and strengthened by geomorphological studies.

In an agricultural country like India the application of geomorphology in the field of agriculture; horticulture; forest development; transport and communication network; settlement location and selection of damsite and aerodromes, etc. may be of great significance. It may not be pertinent here to review the history of geomorphology as it has been undertaken by different scholars[1] rather than the main

concerned here is to examine the current trend of discipline and get on without our investigations.

The study of this subject which concerned primarily with the form of the earth, is little more than one hundred years old. The early works in the field led to a variety of approaches giving rise to the development of several schools of thoughts. According to C.A.M. King (1966),[2] there are three major groups, the first assessing out of the work of Walter Penck called the Mobilistic View; the second gives priority to the effects of climate in studying the characteristic of the landscape, and the third is based on the idea of correlation by attitudes and therefore be termed as the Eustic view.

Following World War II, researches in geomorphology broke away from the traditional method, and the field of quantitative and dynamic geomorphology made a break through.Under the disciplinary impetus of R.E. Horton (1945),[3] the description of drainage basinand channel networks were transformed from a purely qualitative and descriptive study of W.M. Davis (1899)[4] to a regorous quantitative sciences.

Horton's work was developed in details by A.N. Strahler (1950,1952,1956,1957)[5] and associates Milton (1956)[6]. Morisawa (1969)[7] and Schumm (1956)[8]. The application of the tools of mathematical statistics to geomorphology became indispensable in making precise measurement and putting forward new hypothesis. But the conclusion drawn from mathematical calculations are not to be over emphasised in relation to data and assumptions upon which they are based, landform charac-

teristics are influenced by many processes and control factors, some of which are difficult to be analysed in term of mathematical specifications. The role played by such factors as lithological stratigraphy; structure diastrophic history and climatic variations in the development of landforms cannot be ignored. All of these relevant factors must be examined and their impact on land features and processes must be analysed in order to understand the genesis of landform features.

The modern trend of Geomorphology is not only towards a quantitative approach but also towards the studies of topographic forms with availability of good quality of topographical and landsat imageries, precise mapping of observed and measured values is now possible. This had led to the process of the study of landscape geomorphology or morphometry with the help of techniques based on hydrology.

In India the growth of this science is rather recent and the whole credit of carving way for this branch of science goes to the geologists. Amongst the Geologists whose contributions are immensely valuable mentioned may be made of A.M.Heron, D.N.Wadia, J.A. Dunn, W.D.Wart, S.C.Chatterjee, J.B.Aude Arogyaswamy and Radhakrishnan. At the early stage 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 receive new impetus with the work of young geologists and geographers since 1950s. The scope of their studies is now becoming wider.[9] There is new emphasis on various aspects of geomorphology from regional to coastal; fluvial structural, climatic,

and applied geomorphology. But most of the work have been done in the field of regional geomorphology with an emphasis to establish the denudation chronology of a region and recognition of erosion surfaces; (R.P.Singh 1956); E.Ahmad 1958, Bagchi & Sengupta 1958, R.K.Rai 1969, Biswas 1974). The recent emphasis is on quantitative geomorphology of drainage basin by applying various morphometric techniques and measures to establish the interrelation of basin parametrics.[10]

Thus Geomorphology can now be visualised as landform processes science and the main thrust of this micro-regional studies is to elucidate this theme in context of Geomorphology and Mining in West Khasi Hills district of Meghalaya. This part of Meghalaya plateau is a region where mining operation has been practiced since long time. This plateau region of West Khasi Hills have been highly affected by mining and its operations. Mining activities and its method of operations have very much disfigured the topography of the region. Topography of the region has been adversely affected by mining and various landforms have been disfigured due to mining operations.

The impact of mining activities has become a sharp focus in this study. Although the industrial or economic gains of mining are no longer seen to provide enough compensation for the geomorphological environment damage caused by it. Thus, the gemmorphological problems associated with mining are diverse. The removal of vegetation, top soil and other strata of overburden in opencast mining brings about the inevitable natural consequences, which manifest in many ways - deforestation, laying barren, erosion, landslides, air and water

pollution landscape despoliation and degradation of soil quality and as well as degradation of ecological balance. Therefore, the study of geomorphology and mining of the plateau region of West Khasi Hills District has become one of the study selected in order to relate these problems due to long continuation of mining processes which altered the natural landscape of the region.

BROAD OBJECTIVES OF THE STUDY :

The present work, covering the area of West Khasi Hills District of Meghalaya, which has become as an exercise in regional Geomorphology. The study examines the landform assmeblage their original and also the landform with the disfigurement processes of mining activities. Local topographical features are loosing their resiliency due to the operation of mining. Therefore, the study area poses varied and complex problems associated with landform and landscape and their exaplanation requires careful consideration of structural, historical processes and form approaches is based on both theoretical and observational methods of study. An attempt is made to evolve a rational approach by utilizing quantitative data and when nenessary to derive qualitative data and when necessary to derive qualitative conclusions.

CHOICE OF REGION :

This study can be considered as an intensive micro-level geomorphological study as any planning for a region now-a-days involves

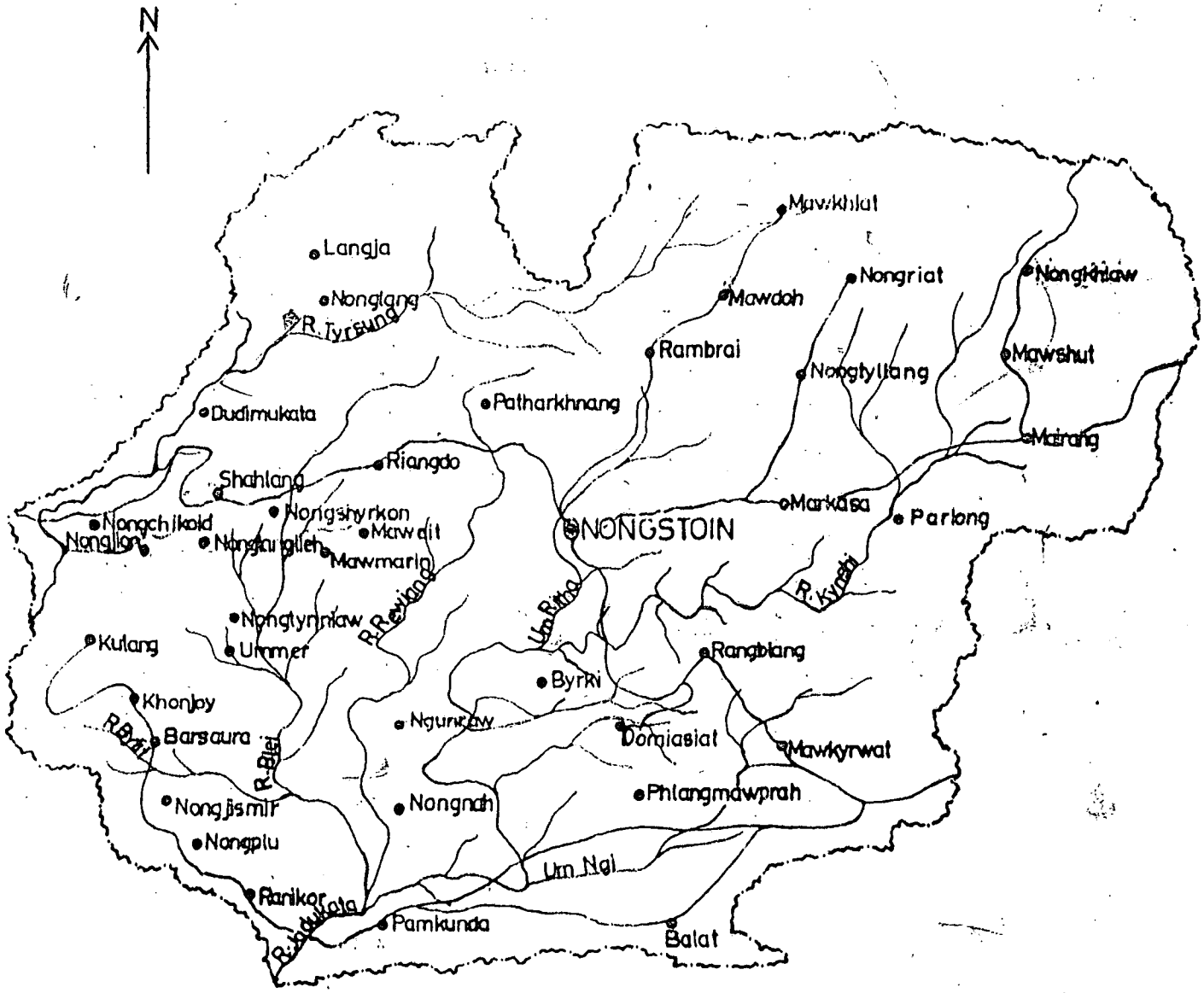
a synthesis knowledge concerning mostly the geomorphology, lithology and geologic structure of that region. The area selected for the present study, though an administrative unit, interestingly more or less coincides with geological and physical features and processes unique to geomorphological characteristics. Besides, this, it can safely be said that no geomorphic study of this region has so far been done. Thus keeping in mind, the above mentioned characteristics of the region, of West Khasi Hills District has been selected for the study of Geomorphology and Mining.

LOCATION :

West Khasi Hills District from the central part of Meghalaya, its district headquarter at Nongstoin 95 Kilometre west from Shillong the capital of the State of Meghalaya. It is connected with the state Highway from Shillong and approach to the part of Garo Hills. Many parts of the area are approachable by unmetalled roads. West Khasi Hills District is a plateau region which lies approximately between east longitude of 91°45' and between north latitudes of 25°30' and 25°45'N. It is the largest in area amongst all the districts in the State of Meghalaya. It covers an area of about 5,247 sq.km. The district of West Khasi Hills is bounded towards the East by the District of East Khasi Hills, towards the West by the District of East Garo Hills and West Garo Hills, towards the North by Kamrup District of Assam, towards the South by the Bangladesh, this is showing in the base map No. 2. Most of the area are composed of hill ranges plateau and very less river valleys. The hills and plateaus are thickly

Map NO.2.

WEST KHASI HILLS DISTRICT
BASE MAP



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District Headquarter	◉
Growth Centre	●
State Highway	——
Drainage	~~~

forested with composed of variety of flora which is of great interest. The rainfall is quite generous and well spread and the climate somewhat temperate with a distinct cold season.

SALIENT FEATURES OF WEST KHASI HILLS DISTRICT :

West Khasi Hills plateau region being the part of Meghalaya plateau its salient features are almost similar to that of the East Khasi Hills. It is an area having generously of mineral resources that nature have endowed in it. This region is comprises of hills and plateau covered with dense forest. The salient features of West Khasi Hills District may be divided into four parts, viz. (1) Ri-Lyngngam, (2) Ri-War, (3) Ri-Lum and (4) Ri-Bhoi.

(1) Ri-Lyngngam is situated towards the west of the district, hills and plateaus are covered with dense forest and bamboos, the elevation is between 600 to 900 metres. (2) Ri-War is situated towards the south, it resembles the wars of the East Khasi. Here the hills fall abruptly to the elevation of about 150 metres or so, over looking to the plain of Bangladesh. The topography is very steep forming deep gorges and characteristics of landforms is very common. (3) Ri-Lum or the middle or the central part, hills and ranges in this part run parallel from east to west. This area is the highest elevation in the district with Mawthadraishan at the height of 1925 metres. It is known to be the second highest peak of Meghalaya next to Shillong Peak 1961 metres. (4) Ri-Bhoi is situated to the northern part of the district and gradually the hills and plateaus

slope down gentle at an elevation of 150 metres or so, till they reach the plain of Assam. Ri Bhoi in the West Khasi Hills region is the mixture of several tribes unlike the East Khasi Hills. It is the combination of Garo, Khasb, Nongtrai, Lyngngam Rabha etc.

Physically the plateau and its elevation starts with the plain in the north with 150 metres narrow valleys are found which drain by river Khri and Tyrsung. Here we have an average elevation of about 300 metres or so. The elevation proceed further towards north eastern direction expanding with ranges between 600 to 900 metres at the Kynshi valley and rises slowly to 1350 metres forming the central plateau of the district. Again the elevation starts decreasing by becoming down to the elevation of 600 to 900 metres. Here the northern part gradually slope towards the Brahmaputra valley through the grassy land of the region that is the small patches of area in the river valley of river Khri-Synnia.

Towards the south, the plateau extends about to the edge of the cliff over-looking Bangladesh and forming an elevation of about 900 metres suddenly dropping to 150 metres and below. The southern part of the plateau look like a massive wall rising from the plain of Bangladesh. The Shillong plateau that traverse the centre of the West Khasi Hills region from a watershed of all the principal river region which drained the Kynshi river, Wah Blei, Umiew river and Rwiang. Some of them flow to the north dropping to the plain of Brahmaputra and some of the rivers like Kynshi, Wah Blei, Wah Rwiang and Umiew follow the southerly turn to the plain of Bang-

ladesh. Kynshi river is known to be the biggest river in the plateau rising from the southern slope of Mawthadraishan peak near Mairang village and follow a tortuous westerly course and then made a bebouches through a deep ravine before it enters into the plain of Sunamganj in Bangladesh.

The plateau of West Khasi Hills district is connected with the Shillong. Mawsynram-Balat-Baghmara road crosses the river at Ranikor and another one connects the Shillong-Nongstoin-Sonapahar-Rongjengiri to Garo Hills. Unmetalled roads are approaching to several areas in the plateau which mainly connected with Nongstoin as it is a district headquarter of the region. These roads are the main transport and communication in the region that materials commodities playing its tracts in the whole region.

EARLIER INVESTIGATION :

As far as the present study is concerned it is is contemplated to study the regional geomorphology a brief review of researches done in this field is called for, particularly of those connected with the Meghalaya Plateau of the country.

The first ever work done on the geomorphic aspects of this region is by Chatterjee (1941),[11] Singh (1968),[12] has presented the Geomorphology and thrown light on the Geomorphology of Shillong Plateau, Baruah (1968)[13] threw light on the Geomorphology of Barapani area in Meghalaya Plateau, Murthy (1968)[14] has also presented one paper titled 'An Outline Geomorphological Evolution

of the Assam Region.'

Some of the recent studies have been undertaken by scholars such as Taher (1971-72)[15] on 'Man Environment Relationship in the Cherrapunjee Region.' Patnaik (1973),[16] has discussed the general geomorphic characteristics of Meghalaya Plateau and its influenced on the Agriculture landuse. Rai et al (1980)[17] in a paper titled, "Hill slope and Landuse around Shillong," he has studied the nature and characteristics of different hills slope elements and their landuse pattern. Again, Rai (1980),[18] discussed the morphometric analysis of Umran Basin of Meghalaya and studied the Geomorphollgy and rural settlement. Studies has been made in the work of Panda (1983).[19] He has also made a significant contribution in the field of Applied Geomorphology through his study of the Geomorphology and Rural Settlement in Khasi and Jaintia Hills of Meghalaya. Panda (1984),[20] contributed to the Geomorphic study of the Mawsynram Block in Meghalaya. Apart from this the region of West Khasi Hills is still awaits unviling of its morphological characters at micro-level.

The proposed geomorphological study consist of the following four aspects :-

1. <u>Collection and study for all relevant informations pertaining to the subject</u> :

Topographical map provided the basic information about the area under study. Various data regarding rainfall and temperature

have been collected from the District Headquarter at Nongstoin (District Agriculture Office) and information about soil and geology were collected from various sources like ICAR Research Complex for N.E.H.Region, Shillong, Shillong Geological Survey of India and also mineral study data have been collected from the Directorate of Mineral Resources, Shillong.

2. Field Investigation :

Field work is an essential tool of Geomorphological analysis, various features of landforms and their character of surface not shown in map have been noted during field work of study region. Information concerning structure of rocks, soil, river beds, caves, meandering, vegetations have been noted for proper discussion and analysis. Photograph and measurement have also been taken into consideration to express some of the significant aspects of the study in relation of mining operation and landscape features.

3. Preparation of maps and diagrams :

This has been based on the various data extracted from the toposheets used for drawing maps and also discussed the mining areas and their relative relief data is used as far as available.

4. Finally, the analysis of data and materials collected from the field study and maps have been made. Various morphological techniques are extensively applied on a micro level in order to

explain the interrelationship and interacts of mining activities with landform of the area. Various data have been used into analysis and interpretations for various mineral resources available in the plateau region of West Khasi Hills.

PLAN OF WORK :

The entire scheme of micro-level Geomorphological work under study has covered the following chapters :

In Chapter One, a general introduction of the area is made which include the definition of the science of Geomorphology. It also includes the objectives and methodology, salient features, earlier investigations and plan of work has been discussed.

Chapter Two, devoted to the geomorphic character of the area, climatic conditions, soils, vegetations, weathering processes and fluvial action in the area. It deals with the geological history of the plateau and Meghalaya as a whole. The tectonic and structural characteristics of rocks is discussed here. It also deals with the soil formation in the area.

Chapter three is engaged in describing the main fold of Geomorphology and mining of the study area. Mineral resources of the study area in particular and also discussed the mining operation at the area concerned. It highlights the effects of mining in despoliation of land surface in various ways.

Chapter four deals with the discussion of mining activities and their impact on landforms, various operations of mineral excavation have been highlighted and also some of the effects of mining activities in reshaping the topography of the area.

Chapter five, discusses the effects of mining activities on the regional geomorphology and the environmental ecosystem of the region, discussion is made in a nut shell correlation with the study of geomorphology.

Finally, chapter six is the last part of the work concludes by giving the summary of findings. Suggestions on the basis of the findings is incorporated here.

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CHAPTER - II

GEOLOGY OF THE STUDY AREA :

Among the seven states of the North Eastern Region of India, Meghalaya is one of the most rugged state in the region. It is full of hills, valleys, plateaus and rivers. Within these ruggedness the plateau of West Khasi Hills is situated. West Khasi Hills is a western part of the Meghalaya plateau. In general, it is known as Shillong Plateau. West Khasi Hills plateau is the northern tip of the Indian Peninsular shield, which is separated by Rajmahal Garo gap. The resemblance of this plateau is seen to be very much similar with that of Shillong plateau because it is an western extension of the Shillong Plateau. To the knowledge of geologists rock assemblage of Meghalaya plateau is also similar to the Chota-Nagpur Plateau of Indian Peninsula. The geological, geomorphological and biotical evidences strongly support that the Meghalaya Plateau and its extension to the western part of the Khasi Hills is believed to be the continuation of Chota-Nagpur Plateau of the Indian Peninsular shield. Thus, the structural and geomorphological features which are prominent and interesting have been analysed and classified in the study that the plateau region of West Khasi Hills is also a part of Chota-Nagpur plateau. Landforms have been interpreted on the basis of similarity in relief and geological formations in the region.

Geologically speaking, the plateau of West Khasi Hills is a western part of Shillong plateau or Meghalaya plateau. It is almost similar in comparison with the geological formation of Shillong plateau. The plateau region of West Khasi Hills as a whole is

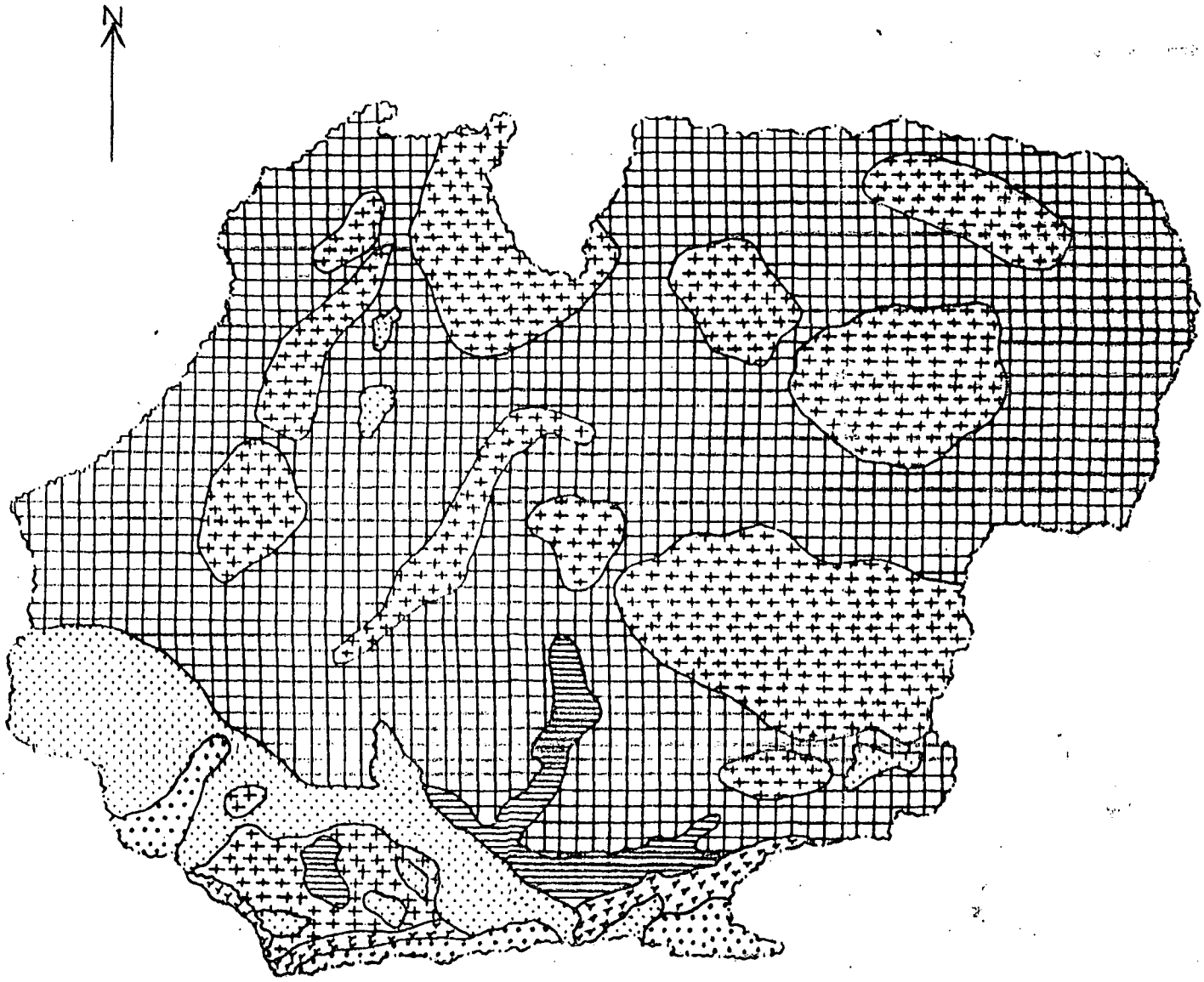
not easily accessible, the main means of communication running through ups and downs of the plateau, the road from Shillong to Nongstoin-Sonapahar and other is the Shillong-Ranikor-Barsaura are the only tracks of the region. Incidentally, the cutting on these roads provide the best exposed rock units that constitute the stratigraphy of the plateau. This area under review is therefore, a part of Shillong plateau and comprises of the Gneissic complex on the northwest and the Shillong series of rocks on the northeast and south. The geological study is shown in a map No. 3.

A detailed study of geology of the plateau is yet to be made, but geological structures occuring in the rock in separate and often distant areas are studied by some workers of different Government and Education institutions.

It is generally believed that the plateau is an autochthon of crystalline rocks that constitute the Foreland Spur of the Indian shield and from the south east by the Naga Hills. The rocks of the plateau of West Khasi Hills are folded and lineated in structures. Folds are generally tight of the elasticus type in more and more metamorphosed rocks. Both folded and mineral lineaments are seen. The plunge of the lineation is moderate to steep but at places it generally becomes vertical or nearly so. A good example of this is a fold in Sonapahar region, where lensoid bodies of massive sillimanite occur in the core and its immediate portions of the flanks of the gold that plunge vertically. Rocks of the plateau region of

Map NO 3

WEST KHASI HILLS DISTRICT
GEOLOGICAL MAP



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GRANITE	
GONDWANA	
SYLHET TRAP	
JADUKATA FORMATION	
MAHADEK FORMATION	

Km5 0 5 10 15 20Km

West Khasi Hills are not only different structurally from the main mass but they are also much more metamorphosed being schists instead of shale or slate as in the main mass.

STRATIGRAPHY OF THE WEST KHASI HILLS PLATEAU REGION :

The major rock type that mainly constitute the plateau region of West Khasi Hills are the metamorphic dominantly of gneissic character in which occur quartizites, high grade schists, being gneisses, calc-selicate rocks, granulites and granites. The quartzites and the argillites with basal and intra formational conglomerate belonging to the Shillong series occur above the gneisses. The acidic gneisses are usually banded out are often streakly, the band being parallel to the schistosity of the patches of schistose rocks that occur in the gneisses. These patches are usually darker in colour and are constituted by biotic calc-selicate rocks occur although infrequently, in on the western flank of the central plateau of the region. Rock are associated closely with sillimanite bearing rocks that bands of rocks contain one or more combination of the following minerals : cordierite, ratile, garnet, corrandum and spinel. Banded iron ore, which occurs in alternating bands of magnetite and quartzite, and often bearing garnet are reported from different localities of these precambrian ages of Assam.

As far as geological information is concerned, multimetallic mineralized zone has recently been reported from the area of Nongchikoid, Umpyrtha where acidic gneisses have been commercially exploited. Patches of amphibolite and diorite rocks are reported

from all over the gneissic country and could be seen as dark patches in the gneisses all along Nongstoin-Rongjengiri and Nongstoin, the Shillong series are metamorphosed to epidiorite and are commonly known as Khasi green stones. Both discordant and concordant types are seen occuring in a well exposed escarpment in the area of Jadukata, Langrin, Mawmarin area of about 45 Km west of the plateau of the district.

Most of the palaeozoic and lower Mesozoic rocks are missing in this plateau region. Crataceous rocks are found to be clearly related in the part of the central plateau region. A distinction between a shelf facies and a geocyncline facies is made in the Tertiary of Shillong plateau. The shelf was constituted by a spur of the Indian shield that extended westward below the Bangla alluvium and the plateau region of West Khasi Hills is part of it.

It seems, therefore, probably true to mention that during the precambrian period the hills and plateau of West Khasi Hills have experienced alternate period of igneous activity and sedimentation till the depositional activities ceased after the intrusions of the granite type. The plateau also remained a high ground till the later part of the cretaceous period when the deposition of rocks belonging to the Mahadek stage began. The sea again moved away from the plateau perhaps during the Eocene-Oligocene period and the plateau gradually rose to its present height, as it is found today.

Table No. 1

GEOLOGICAL FORMATION AND ROCK TYPE IN MEGHALAYA

Geological Age	Group	Formation	Rock Types
Recent	New Alluvium thick ness not known.	Unclassified	Sand, Silt, Clays
		-Unconformity	
Pleitocene	Older Alluvium thickness not known.	Unclassified	Sand, clays, pables, gravel & boulder deposits.
		-Unconformity	
Mio-Pliocene	Dupi Tila group (1050)	Unclassified	Molted clays feldspathic sandstone, conglomerate.
		-Unconformity	
Oligo-Miocene	Garo groups	Cheggapara formation (700 m)	Sand, siltstone, clays and marl.
		Baghmara formation (530m)	Feldspathic, sandstone pables conglomerate, clays.
		Simsang formation (1150m)	Siltstone, sandstone, alternations sands.
Eocene	Jaintia groups	Kopli formation (500m)	Shale, sandstone, malc.
		Shella formation (600m)	Alternation of sandstone, limestone.
		Longpar formation (100m)	Calcoreous shale, sandstone, limestone.
Upper Cretaceous	Khasi groups	Mahadek formation (150m)	Arkose Glauconitic
		Bottom Conglomerate Formation	Conglomerate Arkose
		Jadukata Formation (140m)	Sandstone conglomerate alterations.
		Unconformity	
Jurassic	Sylhet groups (600m)		Basal, Rhyolite, Acid tuff.
		Unconformity	
Precambrian		Intrusive (acid & basic)	Porphyritic and coarse granites, pegmatite, Aplite, Quarty-Vein, Epediorites, dolerite, Basalt,

		Quartzite, phylites Conglomerates
- - - - - - - - - - - - - - - - - -	Unconformity	- - - - - - - - - - - - - -
Archaean	Gneissic Complex	Biotite, Gneiss Biotite, Hornblende Gneiss, Granitic Gneiss, Magmatite, Mica schists, Sillimanite, quarty, schists Biotite-Granulite, Amphibiotite Pyroxene, Granulite etc.

Source : Geological Survey of India, Misc. Publication, No. 30; (1974) Part Iv, p.73.

GEOMORPHOLOGICAL STUDY OF THE AREA :

In the present study a Geomorphological picture of the area in and around West Khasi Hills district under the Meghalaya plateau has been taken into consideration. This part of the plateau with its oldest formations and beautiful scenery has long been subject of attraction to the geologists and sightseers, but at the sametime, this area also hold equal fascination for the students of Geomorphology. With this view in mind, the geomorphology of the region of West Khasi Hills take its importance to our study which at the sametime take our knowledge in our investigation and visualisation to geology of the area in general and morphological features, processes in sculpturing the landforms and various resources interaction in particular. Resources and its deposits play a very significant role which result into the operation of mining. Therefore,

mining in particular has direct impact on landforms resulting into various processes of reshaping landsurfaces.

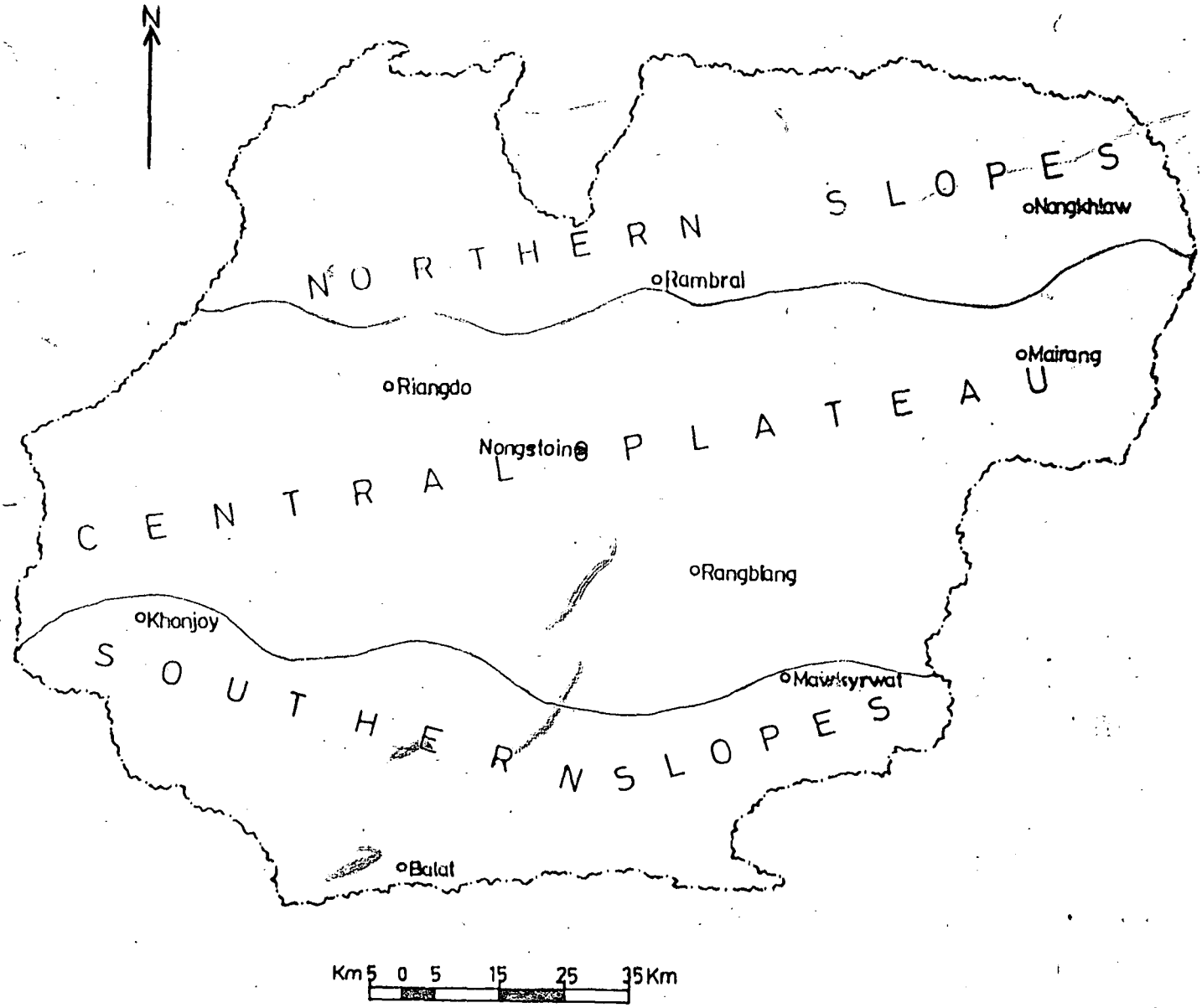
On the basis of landform association, lithology, micro and macro climatic condition and the prevalent fluvial processes of West Khasi Hills, plateau has been divided into the following three main geomorphic provinces. This is also shown in a map No.4.

1. The Central Highlands,
2. The Southern Slopes, and
3. The Northern Slopes.

1. Central Highlands : The Central Highland of the district forms the western part of the Ri- Khasi (Shillong) plateau of Meghalaya. This is the zone that occupies the central portion of the district. This portion forming the region that Mairang, Nongstoin, Markasa etc. lie within this zone. It is an area where the second highest peak of Meghalaya is located. Mawthadraishan 1893 metres, lying between Mairang and Nongstoin. In general central highland climbs down to meet the hills of Garo Hills at the elevation ranging from 1200 metres to 600 metres at various places. This zone comprise mostly the peneplained surfaces, number of rivers, originated on this highland. Rivers and several streams plunging into deep valley and drained into two important river Kynshi and Umblei rivers. The influence of structure may clearly be seen in the adaptation of streams. Kynshi rivers follows the westerly direction and streams following along the joints and cracks in a straight course at places change their

Map NO.4

WEST KHASI HILLS DISTRICT
GEOMORPHIC DIVISIONS



direction almost at right angle. In this zone of the West Khasi Hills the slopes are sttep, number of erosional features have been noticed. Escarpment, rounded hills, Canyons, dissected plateau and number of large waterfall of varying height dominate in this zone. The present landscape and the topographical features show that large part of the region is yet to attain the stage of maturity. Due to intermitten uplift and active erosion, numerous streams have carried their deep narrow 'V' shape valleys. Most part of this zone shows the process of differential erosion and mass wasting and produced a different set of landforms. The hill summits are covered with thick weathered leteritic soil. The field evidences, such as the presence of deep gorges, 'V' shape valley, river terraces, waterfall, break in a slope of thick layer weathered materials and ununiform skyline of hills support the presence of this zone into an erosional surface.

2. <u>The Southern Slopes</u> : The southern slopes comprise a belt of lower hills and valleys, Mawkyrwat, Ranikor Barsaura, etc. are situated in this zone. The hills in this region have north-south alignment. In many places, the slopes are very steep starting and ending abruptly. Cliff and precipbes overlook gorgeous valleys at several areas. This zone touches the plain of Bangladesh in south at an elevation of 200-300 metres and above mean sea level. Rongkhai, Lynshiang and the Umngi are the principal rivers flowing southward through the western, central and eastern parts respectively. There are number of smaller rivers and streams such as the Wah Bytit, Wah Iaw, Um Wosar, Um Waisar, Um Tham and Rilang which join the Kynshiang after criss-crossing the central part of this zone.

It may also be noticed that the southern face of the plateau in West Khasi Hills around Ranikor and part of Trongpleng area stand like a massive wall but as we move from east to west the elevation of the plateau gradually decreased. This part of the West Khasi Hills is a sharp fracture zone. The predominant structure lineament is the Ranikor fault which comprises of at least E-W running normal fault. The study of topographical features of this zone represent mostly spectacular features revealing extra ordinary straight courses of the streams evidently adopted major joints, cracks and faults of the region produced perhaps during an uplift in geological past. It appears that the deep gorges are the results of that relative great uplift of this block. The presence of river terraces, knick points, dissected hills and numerous waterfalls even along small streams are the good evidence of rejuvenation of the region in recent past. In comparison the thickness of soil along hills slope is less than the northern hills region. Limestone covered all along the western part from east to west of Ranikor Nongkulang also represents a typical Karst topography with numerous big and small caves.

3. <u>The Northern Slopes</u> : The northern slopes zone is a belt of low hills. The elevation gradually decreases northwards to meet the plain of Assam at an elevation of 150 metres above sea level. The Khri, Um Synthi, Um Siri, Um Kamram, Tyrsung and part of Um Trew rivers in this zone follows the northerly turn and drops to the plain of Assam or Brahmaputra river. The northern slopes exhibit an undulating topography, hills rising almost at the same height. The valleys formed by the streams are engaged in incising their

valleys by headward erosion. This zone consists of mostly rolling grassy mounds intersecting with river valleys. This area of West Khasi Hills plateau indicate most singificant geomorphic features that erosional surfaces are very common. The upland contains remnants of some peneplained surfaces ranging at the height of 900 to 1500 metres. Hill slopes of this zone are covered by thick weathered lateritic soil. There are places of big rock boulders that are exposed on the surface. Along the northern border of this zone, land surface is covered with thick alluvium deposits. There are numerous short tributaries and gullies extend themselves by headward erosion. Waterfalls are the evidences and also the indications of the youth stage in this zone. The drainage follows the major and minor lineaments and developed mostly in rectangular patterns. Keeping in mind, the main rivers are the Khri and Tyrsung, these rivers form two distinct system that separated the West Khasi Hills plateau and that of the Garo Hills plateau. Numerous river valleys formed by streams are narrow 'V' shape in character.

DRAINAGE :

There are few rivers in the region. The Central Highland is highly control the directions of most of the rivers, and act as the watershed of the district as shown on the drainage map. River Kynshi is known as the largest river coming from this highland and follows the westerly directions. It joins with the Um Ritha, Rewiang and various river/ streams.

In the Southern slopes river Jadukata draining through out the central plateau and flows towards the plain of Bangladesh. This is the main river which connected with various river streams such as Um Blei, river Balat, Um Ngi etc.

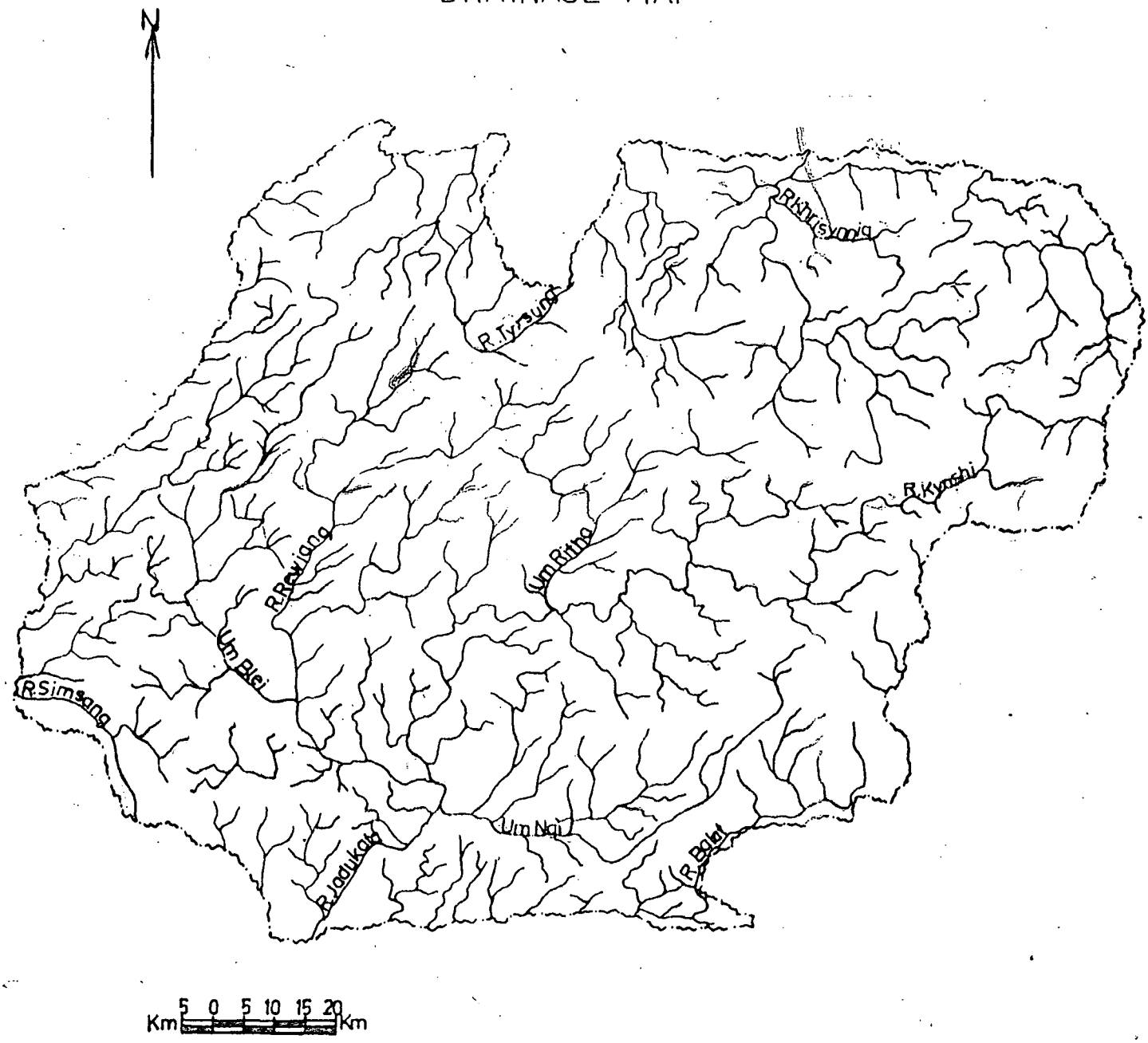
Towards the northern slopes, river Khri and Tyrsung are the main rivers which originated from Mawthadraishan peaks. They follows the northern direction and joins with the plain of Assam. These rivers have overcome the hill ranges and plateau making gorges, waterfalls and carry large amount of debris to the plain area. The rate of degradation is very high and huge amount of soil erosion is carried down especially in summer season. The drainage map is also shown in map No. 5.

CLIMATE OF THE AREA :

Climate is one of the main element that focus on an aspects of environmental condition. It is usually defined as the average of weather conditions prevalent in any place or particular region. Although it is not directly visible in the landscape but it can be observed indirectly through its effects in the area. The climte of the West Khasi Hills district falls under a tropical to sub-tropical climate. The topographical characteristics of the region are highly influenced great significant in climatic variation in the region of West Khasi Hills district. In the northern slopes and in southern slopes, there is prevalence of temperate climatic dondition summer season is hot and in winter is mild. The Central pla-

Map NO 5

WEST KHASI HILLS DISTRICT
DRAINAGE MAP



teau experience the temperate climate with maximum summer temperature generally not rising above 27°C and minimum winter temperature dropping down to as low as 1°C.

The climate of West Khasi Hills district is very much controlled by seasonal wind. The seasonal wind are the southwest monsoon and the north east winter winds. Hence the year be divided into four seasons as follows :

1. Spring season - March and April
2. Summer (Rainy Season) - May to September
3. Autumn season - October and November
4. Winter season - December to February

During March and April the climate is gradually warms up and there is the advent of spring with high cloud cover in the sky. From the middle of April to May the climate is found to be warmer in which the temperature reaches the maximum point. During the month of May, summer season is started with high rainfall and maximum temperature. Rain begin to fall and continue upto the end of the month of September. High precipitation is noticed as well as humidity is also goes high. During the month of October the rain begin to decrease and the sky look very clear till December. In the month of December, high cloud is noticed in the sky which forms the accomodation of snow in the valleys of some areas. At this time the area is very cold with low temperature all over the region. Snow falls continued till the middle of February, cold wind is flowing all around the region.

Rainfall :-

Rainfall in West Khasi Hills plateau region occurs in summer month and during winter it is dry and cold. Rainfall of the area is measured in the District Agricultural Office (D.A.O.). As far as records of rainfall is concerned as well as data available rainfall is very high especially in the month of June and July. The annual average rainfall of the whole year reaches about 300.5cm Some of the data of rainfall that have been available aseaas follows:-

Table No. 2

AVERAGE ANNUAL RAINFALL OF THE AREA OF WEST KHASI HILLS REGION

Year	Rainfall in Centimetre
1985	2229.0
1986	215.0
1987	229.4
1988	263.7
1989	300.5
1990	221.4
1991	240.3

Source : District Agricultural Office, Nongstoin.

Temperature :-

Temperature is one of the most important element of climate that play a very significant role in an area. Temperature of the study region is found very high in summer season. The average

temperature is found as high as Shillong City which is recorded at about 33°C. During winter season temperature gradually decrease at about 14.07°C (approximately). The records regarding the temperature is also collected from the District Agriculture Office at Nongstoin. They are as follows :

Teble No. 3

MAXIMUM AND MINIMUM TEMPERATURE OF WEST KHASI HILLS DISTRICT
(In Centigrade)

	1986		1987		1988		1989		1990		1991	
Month	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
Jan	NA	NA	16.5	9.4	16.9	9.3	15.3	9.3	16.9	9.2	14.0	9.3
Feb	NA	NA	17.2	10.2	18.6	10.5	18.9	11.7	17.2	10.2	16.5	10.3
Mar	NA	NA	21.3	13.5	20.3	13.8	21.2	14.2	21.3	13.5	21.3	14.6
Apr	24.9	18.8	24.6	19.6	21.3	13.8	22.4	18.2	24.6	15.4	25.4	19.5
May	24.6	19.6	24.2	19.7	25.7	20.1	24.1	18.1	24.7	19.6	26.1	19.8
Jun	25.7	21.6	26.9	22.2	25.5	22.2	23.3	21.1	26.9	21.0	26.9	20.2
Jul	24.6	21.2	25.1	22.1	25.0	22.1	25.2	21.7	25.1	22.4	25.2	22.4
Aug	25.5	22.2	26.3	21.7	24.9	18.8	25.7	21.6	26.3	26.3	25.1	21.9
Sep	24.6	18.4	24.2	22.7	24.0	21.7	25.0	21.3	24.2	22.6	22.3	21.0
Oct	24.0	19,4	22.9	17.1	23.2	18.1	24.1	18.1	22.9	20.8	20.4	18.9
Nov	17.6	12.7	20.0	13.6	17.8	14.1	19.4	13.4	12.0	17.6	19.7	16.7
Dec	17.4	10.0	16.7	09.6	17.9	10.0	18.8	12.7	16.7	16.9	17.8	16.4

Source : District Agriculture Office, Nongstoin.

SOIL OF THE STUDY AREA :

Soil is one of the factor that responsible to the physical environment of any particular area. The study region shows a little variation especially in term of climatic condition that rainfall and temperature influence in nature of soil in the area. Geologically, it is also worthnoting, that the different of rock types shown gross homogeneous characters and more or less similar uniform of weathering phenomena effects the soil condition of the region. Consequently the resultant quality of soil and soil profiles are the result of local relief differences and high degree of denudation.

The soil of West Khasi Hills plateau has predominantly form by the in situ weathering rocks, soil profile is thick and derived from the gneissic and it is mostly medium in texture. The colour varies from place to place within the region. It varies from darktant to radish brown, texturally, it is highly loamy to clayey non silky and non plastic in character. In the southern slopes the soil texture are redish and loamy while the northern zone is found to be rich loamy contain thicker alluvium type. In the part of the central zone the soil is much gravelly at places due to the presence of abundant fragment of quarty, this zone is less loamy and clayey in character which constitute less thicken vegetational cover as compare to the zone of southern slopes and northern slopes. In southern slopes and northern zone soil is highly loamy relatively high humus.

However, in much of the slopes of the area the soil is relatively less in humus and highly degraded due to the activities practiced of jhumming cultivation. Keeping in mind, some of the area of the western margin in this region, the soil is constantly being eroded and deposited at lower level and valleys flat, this is cause due to the jhumming activities in the area, vegetation is cleared up and toil soil area washed away especially by rain water in summer season. Hence, lower levels and valleys of low relief soil is developed on super having gnetly and rolling topography are highly eroded.

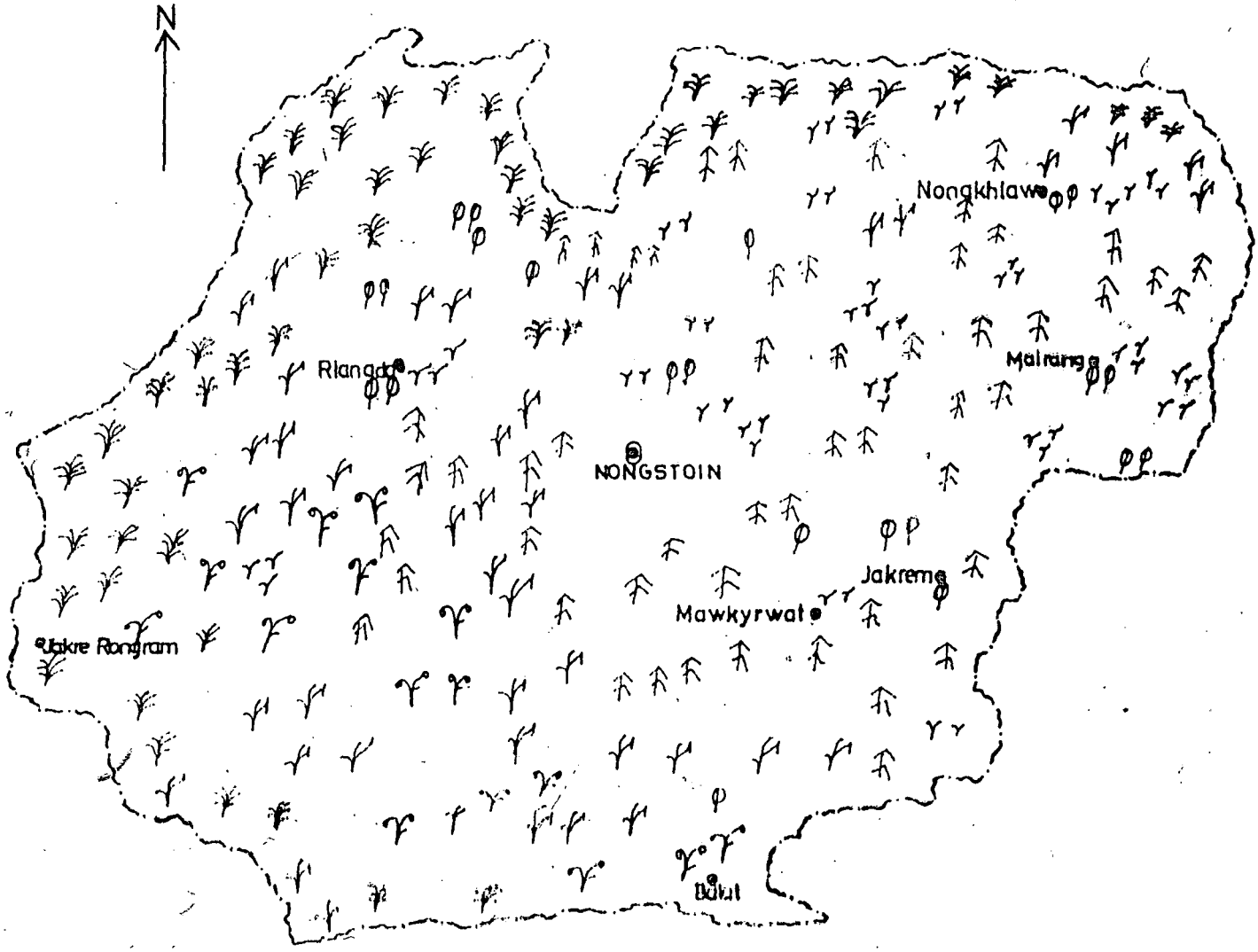
VEGETATIONAL COVER :

Most of the variety of natural vegetation ranging from sub-tropical to temperate flora can be found in the region. Tropical vegetation is seen generally up to the elevation of 600 metres upto 900 metres, temperate forest and grasslands are very common. The natural vegetation has enriched the region especially in the western part of the plateau. It is having endowed with forest of valuable purposes such as timber, pine, sal, teak etc. The flora of the plateau region of West Khasi Hills becomes much commercially important such as pine, cane and bamboo. The area of Sonapahar, Langrin, Mawmarin and Ranikor are thickly forested area with variety of valuable trees. It is also shown in a map No. 6.

The area as a whole are largely constituted of forest, it also estimated that the region contributes to about 35 percent of the total geographical area covered by forest, this is shown in

Map NO.6

WEST KHASI HILLS DISTRICT
NATURAL VEGETATION



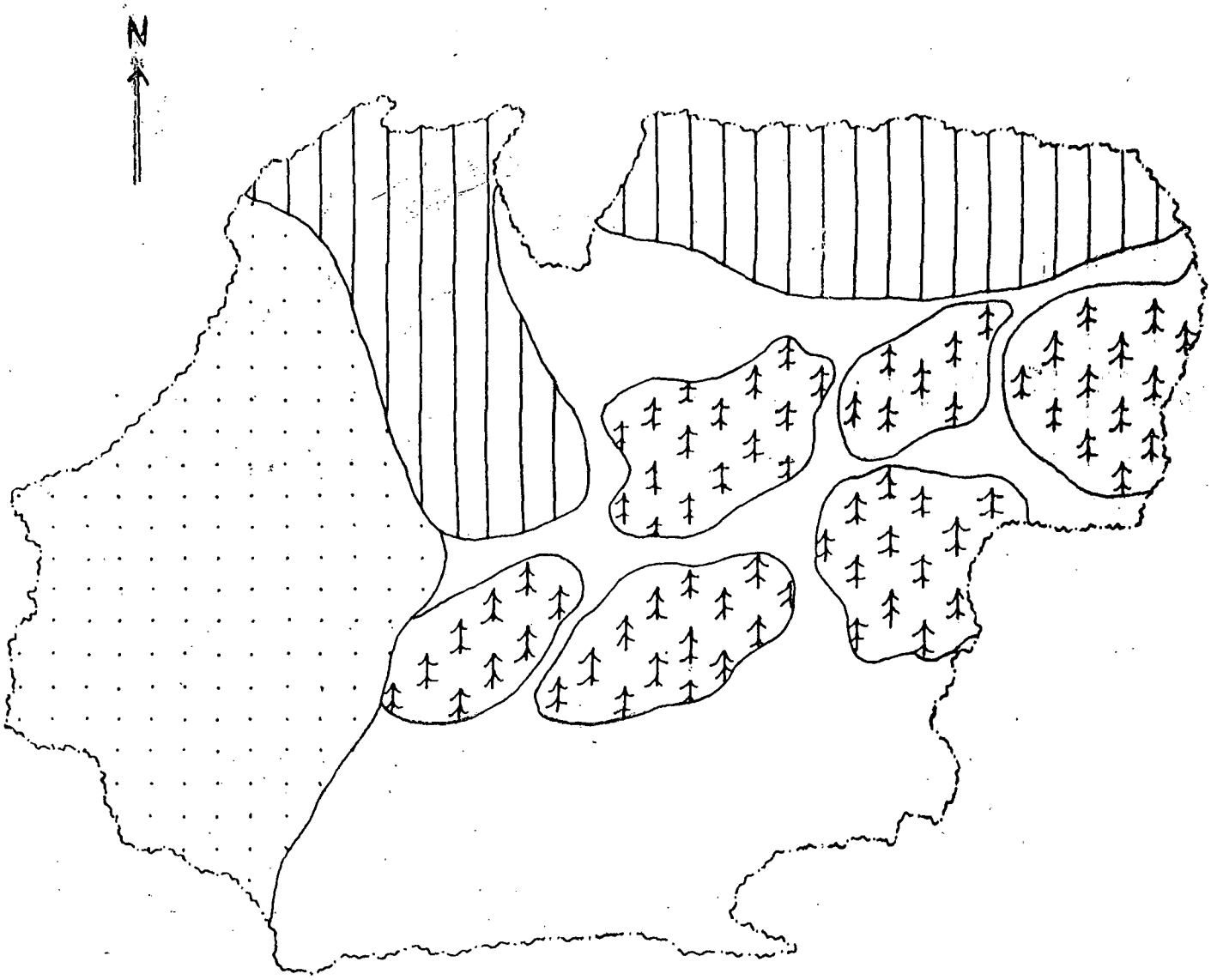
REFERENCES

Grasses	
Shrubs	
Bamboo	
Pine Forest	
Dicidous Forest	
Mixed Jungles	

Km 5 0 5 10 15 20 Km

Map NO.7

WEST KHASI HILLS DISTRICT
TYPES OF FOREST



5 0 5 10 15 20
Km Km

REFERENCES

Sub Tropical Pine Forest	
Moist Mixed Dicidous Forest (with sal)	
Very Moist Sal Bearing Forest	

a map No. 7. Nearly 90 percent of the total forested area is under the control of the District Council and the rest under Government. Hence, West Khasi Hills constitute of richly vegetational covered and it is one of the district in the state having large forest and variety of flora in Meghalaya.

WEATHERING AND FLUVIAL PROCESSES :

From the geological structure that has been mentioned earlier, the area or plateau region of West Khasi Hills is formed by different rock types with varying lithological characters. With this view in mind, it is a region that have varieties of mineral resources, sillimanite and coal formations are found in the region. Therefore, the influence of resources of the earth has endowed the region into one of the area of that mineral has been extracted. The varying differences of such lithological characteristics have found to play significantly in the agent of surface weathering and agent of fluvial erosions. Various agent of denudation like surface water, rain water and change in temperature have played a very dominant role on the rock types in moulding the landscape features of the region. But the far and more important in this respects are the processes of weathering and erosion. West Khasi Hills plateau region falls under the tropical monsoonal climatic condition that exert a very significant influence on landscape excluded the disfiguration of land surfaces made by human activities.

We would therefore, examine in this study that how far landscape are eroded and weathered in such an area of various litho-

logical characteristics. Hence, the most striking and final features of the landscape are the dissected surface that developed in the result of weathering and erosion.

Weathering, as may be expected, starts at two plane : foliations and joints planes. Both vertical and horizontal joints planes are represents in mostly quartzites. As a result weathering along these planes cause into areas of rectangular blocks and slab as seen in the area of Langrin and along the valley slopes of river Kynshiang. Rectangular blocks and slabs are produced with ultimately under the action of gravity role down along the slopes. The blocks near Sonapahar area and as well as the blocks near Mawmarin formed masses of talus below vertical cliffs. The isolated harder gneissic hills on the north west are formed as a result of weathering. With further action of running water, these blocks later turn into sperci-dal bodies. The presence of loose and friable quartzites with brownish grey colour, and the decomposed products of epidiorites with their peduliar reddish colour are the evidences of chemical weathering.

Of equal importance in landscape are the erosional features produced by fluvial action. The climatic which is characterised by heavy rainfall as in the case of the study area favours this action of streams to a considerable extent and high velocity. It is clear in the rainy season, weathering process on the hill slopes are strengthened by the action of gullies and rills particularly along the joints places and fissures of rocks. Further, it is worth noting that the periodicity of the waterflow is in itself a factor in sha-

ping the local topography of the area. In the plateau region of West Khasi Hills during rainy season streams and gullies are formed due to erosion and slope of the hills with its soft top soil are easily eroded. In some areas of thickly covered vegetations, it would ultimately slow down the action of weathering. Valleys formed by streams are narrow and deep especially in the southern slope of the region. The depth and narrowness of such valleys are the result of the steepness of the plateau in which erosional force shaping those valleys into more or less 'V' shape condition. In such a conditions rain water of the plateau get high velocity resulting into a greater erosional forces.

As a result of the above processes of weathering and fluvial activities striking on local topography, the hard resistant rocks like quartzite have built conspicuous features in the landscape, while the softer rocks like phyllite, schists, quartzites, sandstone, etc. have formed at a lower level of the area. Thus, it is certain that the relief features of the plateau region of West Khasi Hills district are due to the exposure of harder quartzites and to some extent gneisses, and to a lesser extent of a softer phyllites with foldings.

As far as weathering and erosional forces is concerned, there are also some of the main agent that played by human interference in the landscape. The striking features of such an agent enhanced the area due to the natural resources and their operation activities. Within such geological character one can be easily iden-

tified some of the most commercially resources. As a result of this, minerals are extracted and landscape is being disturbed, which results to large volume of weathering and erosion by what is known as mining operational activities. In view of evidences detailed, and above mentioned processes play a very significant role in the weathering and erosion of the area. It is also admitted to the fact that as a result of erosion, the origin flat surface has been trenched and dissected and ultimately the present topography are comprises with much ruggedness and undulating surfaces as it is seen in all over the plateau region of West Khasi Hills.

In conclusion, among the bounties of nature, the area is enriched by various natural resources and these resources are also enhanced the area into the practice of mining operations, such as coal and sillimanite of the western part and especially the area of sillimanite at Sonapahar. With this view, the study is made how far the resources and their operations in mining have influenced the topography of the region. Therefore, in the next chapter, analysis have been made in visualisation of mining operations and their effects on landscape in various aspects in those area of abundant resources.

CHAPTER - III

GEOMORPHOLOGY AND MINING

As the development and growth of Geomorphology has taken place, gradually its aspect and applications have become more important to examine and to point out specifically some of the problems that are commonly encountered by the geologists and some engineers. Landforms are therefore the most common features encountered by anyone engaged in geological field.[1] In this chapter we can now visualize its manifold of geomorphological study interlink with mining on a micro-regional study of West Khasi Hills district. It is probably true to mention that almost all over the earth's surface or the world as a whole, due to the increase of scientific industrial development and socio-economic changes, resources of the earth's surface have been exploited on a very large scale from the area which having abundant mineral resources. This development of industrial technology is in need of earth's resources, therefore, minerals has been exploited and resource operations has interact a great significant with the landscape or the topographical features of the particular area or region. Gradually land surfaces have been very much disfigured and as such, many other related problems have become very acute. In this chapter, therefore, a study is made to analyse how far mining operations interact with the topographical features of the region. It emphasise to some extent deeper attention dealing in term of geomorphological aspects and its interrelationship with mining operation taking place in the plateau region of West Khasi Hills district. It also emphasise the interaction of mining activities with the landscape formation in the area.

Although in general, the entire earth's crust can be regarded as it is composed different rocks but yet, it can not be regarded as a mineral deposit, for the minerals of the earth's surface or a part of it becomes deposit only when its concentration is known to its dimension and become sufficient enough to separate it as mining and utilization activities.[2] Therefore, an attempt has been made to find out the links and influence of mining operations on regional geomorphology of the West Khasi Hills plateau region.

The study of mining and their activities is not very satisfying unless we have some knowledge on the background of its associated discipline of geology. Therefore, we are confronted with the question of, what is mining ? What is the nature involved in various fields of its activities ? Well, of course, we could start with its meaning and assume that the earth's crust refer only to an outer surface of the earth extending to a depth of some extent on the mining areas. Therefore, mining is nothing but it is the process of extracting minerals of the earth on economic value.[3] Mineral exploitation is an unpalatable term in socio-economic context that has been in common usage in an industry and encompass a wide spectrum of activities from the area of abundant mineral property to an end use of mineral products.

Among the bounties of nature, mineral resources are the foremost valuable treasure to the modern world marching ahead on the road of planning to achieve economic development growth. Off late this repository of natural wealth has been subjected to a vatual

plunder. In consequence, the local topography is losing its resiliency and regenerative capacity. Under mining the economic and cultural development have been extremely changed from time to time and thereby industries were in need of materials or resources coming up in the form of raw materials. Mining has, therefore, evolved gradually in response to availability of resource in a particular area. Thus, mining and its operational activities had led to the destruction of resource itself and the other productive natural resources such as, land, vegetation and water. There is also no doubt that mining ia a vital sector of the economy in our country, therefore, here we can examine in the study region where the extraction or mining of resources has been started during past few decades.

Mining in the region of West Khasi Hills has been one of the oldest especially in the case of sillimanite at Sonapahar. Therefore, the study contribute to some extent that geomorphology and mining interlink and interact and also interrelated with the present formation of landscape features of the area. Mining has evolved gradually in response to both availability and depletion of resources technical and technological progress, economics and dis-economics of scale. Since most of the mining areas in West Khasi Hills is located in much backward areas, the focus is on the regional development primarily through employment generation.

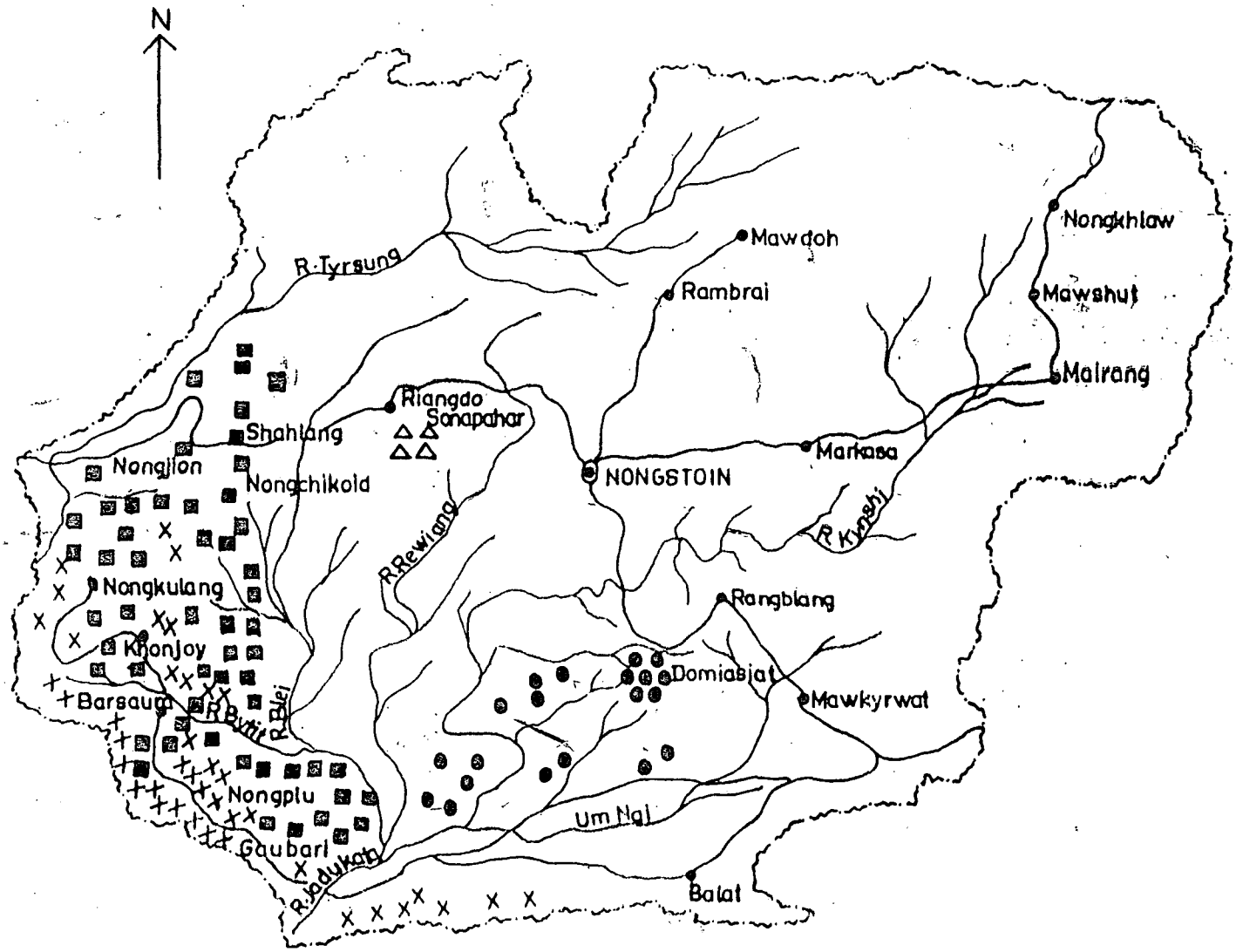
Geologically and geomorphologically as it has been mentioned in the earlier chapter the plateau region of West Khasi Hills is a

Part of the Shillong plateau and comprised of the gneissic complex. In short, it is the combination of hills and plateau, synclines and anticlines character. Hilly topography with deep gorges and gullies especially towards the southern side. As it is known to geologists, the region formed the ultimate net result of the geological structures of lithological processes, erosional and depositional processes, climate and drainage pattern. Within the three geomorphic provinces there is sedimentary rock types exposed include the basal conglomerate, quartzites, slate, calc chlorites, etc. it represents the lines of unconformity between the two formations of gneissic and quartzitic. The river and streams are small passing through a narrow ravines especially in the western part.

Considering the local geological structure and geomorphological provinces as mentioned the plateau as a whole is endowed with variety of mineral resources. Nature has enriched the plateau region into various mineral that are economically and commercially important. We would therefore, discuss some of the mineral resources of this plateau before we would give deeper attention to the natural resources and their mining operations that has been located in the plateau. Resources are of many significance that having link with the landscape characteristic of the plateau. These are some of the mineral resources and their area of location as shown in a map No.8.

Map NO. 8

WEST KHASI HILLS DISTRICT
MINERAL RESOURCES



REFERENCES

COAL	
LIMESTONE	X X X X
SILLIMANITE	△△△△
URANIUM	●●●●

MINERAL RESOURCES AND THEIR LOCATION :

In West Khasi Hills plateau region the mineral resources are of great importance. These have affected the distribution of population and the economic activities and the growth and distribution of settlement in the district. Even in the past, the occurrences and use of certain minerals were known to the local inhabitants which are evident by the existence of a few sites of old quarries and smelting centres. Coal, sillimanite and limestone are the chief minerals and the recent sandstone type uranium mineral are also found in the district. Other include clay, corandum, glass-sand, gold, iron ore and copper. Of these, only coal, sillimanite, uranium and limestone are the most important from economic point of view.

These minerals are associated mainly with the three important geological formations of the plateau. They are the Archaean, Gneissic complex, the Shillong series of rocks and the Cretaceous-Tertiary sediments. These formations are spread all through the region, the first two formations contain sillimanite and the third formation contains coal, limestone and uranium. Among these mineral resources of the district mining has been operated only in the exploitation of coal, sillimanite and uranium. Limestone deposits are plentiful in the area but so far it is yet to be extracted.

In the geomorphological context, these three important mineral resources are located in different provinces. In this we

would reveal the mineral locations in the plateau of West Khasi Hills district. Sillimanite is one of the famous mineral which is located in the northern zone of the geomorphological province of the region. It is one of the economic and commercial mineral in the country as a whole. It is also known that this sillimanite is the best quality in the world. It is also one of the oldest mine in the state which located at Sonapahar 45 kilometers from Nongstoin a district headquarter. Sillimanite is also found in the adjoining areas around the Sonapahar area such as Lalmati, etc.

The next mineral located all over the three provinces is coal. Coal is found mostly in the northern zone in the area of the East of Maheshkhola, Shahlang and adjoining areas. Coal is also found in central plateau in the area of Mawmarin, Nongmaweit areas. It is also richly found in the southern zone of the plateau in the area of Langrin. Langrin coal field is the most important located in Borsaura, Nongkulang, Khonjoy etc. There is plentiful coal reserves in the area of West Khasi Hills plateau region which is yet to be mined or extracted.

One of the most important mineral which is recently found by the Atomic Energy Department, Government of India is the Uranium, sandstone-type which is deposited in the southern province of the geomorphic division. Sandstone-type uranium is one of the latest mineral that is located at Domiasiat about 65 Kilometres southward direction from Nongstoin.

Besides these, limestone is one of the largest mineral deposits in the region. Limestone is exposed all along the roadsides from Ranikor to Borsaura area about 140 Km. from Nongstoin. These areas are seen to be the largest perhaps, but limestone in this region is not yet exploited. The location of limestone is seen all along the western border of the plateau region of West Khasi Hills district. Therefore, West Khasi Hills plateau region is endowed with variety of mineral resources. In due courses of time it is certainly true to mention that these minerals would be economically important.

MINERAL RESOURCES AND MINING OPERATIONS :

Considering the local geological and geomorphological setting, West Khasi Hills plateau region is one of the area having abundant mineral resources. As far as the field investigation is concerned, during the last few decades the area is really known to be rich in natural resources. Therefore, when the industries are in need of these mineral attaining as materials, ultimately widespread mineral deposit areas have come under the processes of mining programme. As it has been mentioned, mines are located in an area or region that constitutes abundant minerals. Considering the resources available, the region is therefore, associated with the mining programmes in exploitation as well as in extraction. Therefore, the region as a whole striking a wide spectrum to mining operation to all the abundant mineral resources.

The processes of mining therefore began its way to operate the minerals which is probably true to mention that its operational programme adversely affected the landforms of the regions, keeing in mind, when mining started direct and indirect impact results to the despoliation processes of local topography and landsurface is the first losing its resilency among all from the environmental point of view.

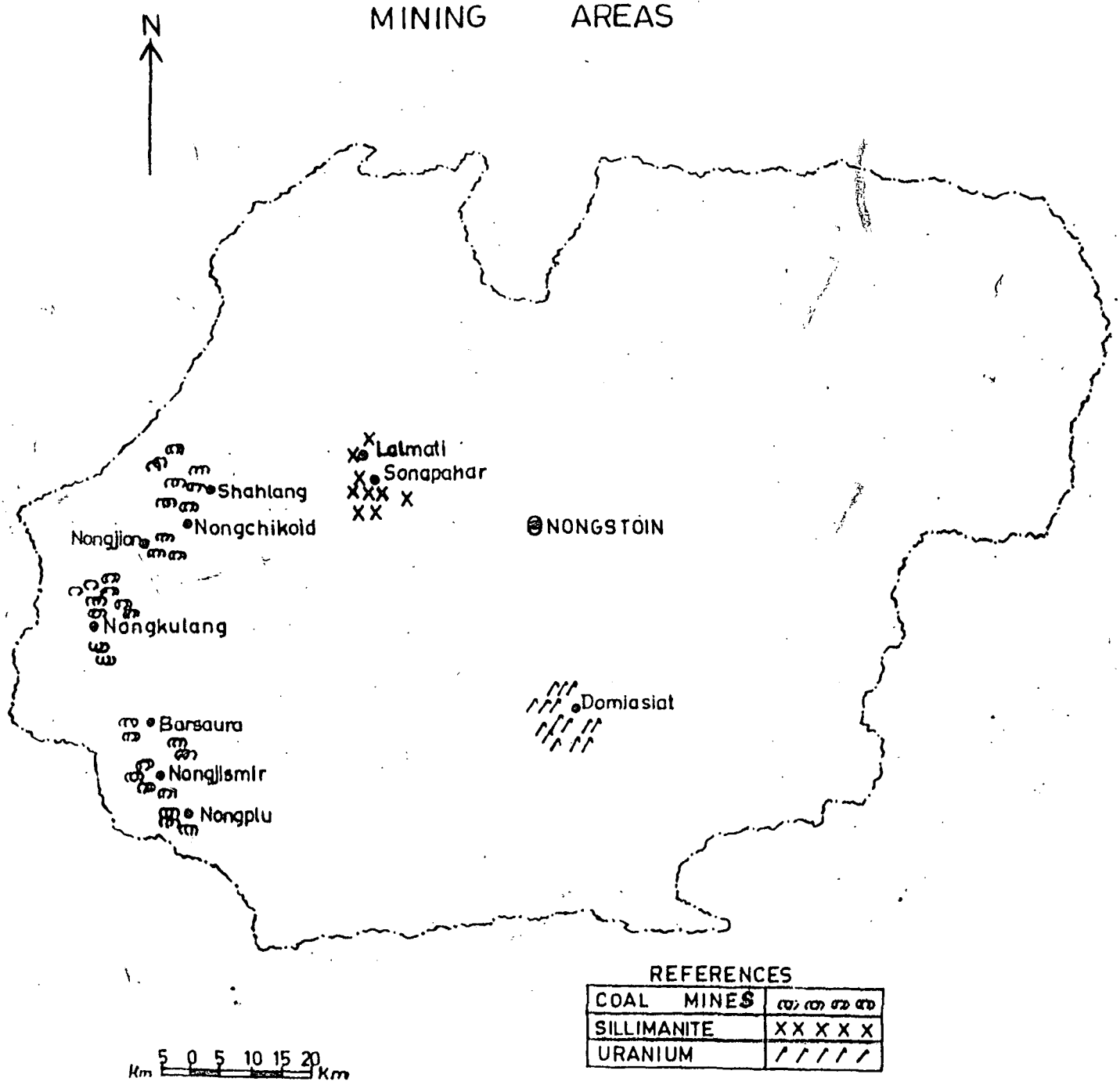
Among the bounty of mineral resources that nature has endowed the region, only a few of them are engaged in mining project. Some of these minerals are coal, sillimanite and the recent limestone-type uranium. In this context, we would now examine how far mining has affected the geomorphological setting of the area. Mining therefore, become one of the main problems that are associated with the geomorphic provinces or geomorphic history of the region. Therefore, we would go on a wide spectrum about the mining and their imprint on a topography of the area of West Khasi Hills plateau. This is shown in a map No. 9.

COAL MINING :

The Tertiary coal deposits of the region mostly belonging to the Eocene age, which are mostly deposit on the northern and southern geomorphic province. The main characteristics of coal obtained here are its low ash content, high volatile matter and also high calorific value, however, it suffers badly from its comparatively high sulphur content. The coal deposits are mostly those of sub-bituminuous in character. Due to the inconsistent nature of

Map NO 9

WEST KHASI HILLS DISTRICT
MINING AREAS



coal seams coupled with complicated geological structure in certain areas. It is rather difficult to ascertain the actual reserves of the coal deposits. The inferred reserves as estimated from time to time are however indicated under the description of each mine deposit.

The Langrin coal mine which is situated in the southmost extremity of the plateau region of West Khasi Hills and extend over a large area from Kynshiang (Jadukata) river in the east to Maheshkhola river in the west. The eastern extension of coalfield is upto Goabari and Borsaura. The Um Blei river and the tributary Um Bytit river flowing from west to east from the northern boundary of the coalfield. Exposures of coal are found further north near Nongjismir village in the Um Mawblei river section. Although, Maheshkhola river is the western boundary of coalfield, thereby coal mine extends further west and is exposed in the Pyndengru-Balphagram area and Shahlang coalfield.

The coal seams are found in Tura-sandstone of the lower to middle Eocene Age, which overlain by Siju limestone and Kopili shale. The most well exposed section is found in the area of Mawmarin, Um Nongchikoid stream section, other exposures of coal is also mainly found in the areas of east Khonjoy area of West Khasi Hills region. The reserves of coal around Borsaura and Wah Rangah stream, Nongplu and Nongjion of the region are also found.

The reserve of coal around Borsaura area is 2.26 million tonnes. In the area around Maheshkhola coal of 2 metres thickness is exposed in Nongshahlang area, where its reserve is estimated about 8 million tonnes. In the western part bordering with the area of Garo hills coal seams exposed continuously in the Um Bytit river section from south of Nongmen to Nongchikoid and also another exposure is found continuously from north to south in the western part of the Um Tongkut village. The reserves of coal in this area are estimated at 24.1 million tonnes. In Nongplu and Nongjion areas ranging in thickness from 0.80m to 01.55m are found within 35 metres of formation and its reserves of coal is estimated at 20 million tonnes. Coal exposed in Wah Rangah streams is estimated about 0.35 million tonnes. In the area of Nongmaharu thickness is exposed in the Um Mawblei section that estimated about 8 million tonnes. Near Nongjismir and Riangdem area another thickness seam of 0.50 metres. Both of the regions are situated in the northern geomorphic zone, it has reserve of about 1.40 million tonnes. The total reserves of these areas mentioned coal deposits come to 60.11 million tonnes.

During the period 1980s, extraction of coal was made from certain areas such as Borsaura, Nongjion, Maheshkola, Shallang, Nongplu, Goabari and Nongchikoid. Coal mines of these areas are extracted mostly by open cast method. This method in operation of coal mine in these areas have therefore, played a very significant role to the local geomorphic features of the area. The activities of mining in coal reserves has a drastic change in the surface landforms. In order to meet the rising demand of coal in the country, coal

deposits have been extracted. The effects on landforms is due to the method of operation. Most of the areas being put under mining of coal and with the growth of mining activities there is a wide spread of areas suffer from topographical degradation. Virgin forest have been cleared for mining purposes, deforestation and soil degradation have become the most common phenomena. Surface landforms, therefore have been disturbed as well as disfigured. Therefore, coal mining operation in West Khasi Hills plateau has created a vital impact on landforms and its surrounding geomorphological picture which includes countless despoliation of deforestation as well as surface damage owing to landslides, erosion and debris flow which occupy in reshaping of topographical depression especially in some of the mentioned areas.

Coal mines operation however put an imprint on landforms which also cause to various geomorphological degradation especially, the mining operations do not have any scientific programme in extractions of coal in the plateau region of West Khasi Hills district.It is, therefore, striking that coal mining of the area is one of the cause problem in disfiguration of the topography of the area.

SILLIMANITE MINING :

One of the best sillimanite deposits in the world is found in Sonapahar area of the northern zone of geomorphological province of West Khasi Hills plateau region. Sonapahar is about 45 Kilometres north from Nongstoin a district headquarter. Sillimanite

deposits are associated with corrandum, quartz sillimanite and schists. It also forms a broad band that can be traced discontinuously over the area. The sillimanite group of rocks occur as detached remnants over the older gneissic complex separated by angular unconformity.

The major sillimanite bodies are small to moderate sized lense, hardly exceeding 1 metre across with the exception of a few lenses in Lalmati which yield some 40,000 tonnes of sillimanite. Such lenses are found only in one or two other areas. The rest of the deposits are in the nature of float boulders. The largest massive sillimanite float boulders found so far are reported to weight 300 tonnes. The high allumina and silica contents of this deposits make this mineral a natural refractory material of great commercial value. It is also important to mention that London Warehouse in 1922 was an accidental discovery, when the corrandum mined from the area of West Khasi Hills was found and it was not quite hard. Although the sillimanite mines at Sonapahar have been operated since long time by various mining companies and agendies, it was a pity that no serious assessment of the available reserves of this valuable minerals were undertaken. Already about one and half lakh tonnes of the sillimanite has been mined so far. The production of sillimanite has been recorded at the mining office at Sonapahar. The annual production record shows only since 1980-81 to 1991-92. The production was recorded by the Bharat Sillimanite authority and they are as follows :

Table No. 4

ANNUAL SILLIMANITE PRODUCTION

Annual Production	Metric Tonnes
1980-81	4,258
1981-82	4,232
1982-83	3,838
1983-84	3,863
1984-85	3,782
1985-86	3,696
1986-87	3,648
1987-88	3,646
1988-89	3,643
1989-90	3,552
1990-91	2,075
1991-92	1,565

Source : Bharat Sillimanite Office, Sonapahar.

A time may not be far off when one has to think in terms of beneficiation of the sillimanite-quartz schists available in plentiful especially in Sonapahar and its surrounding. Some minor sillimanite occurance has been reported in Dapse-Tholegiri in Garo Hills.

From above annual productions, when one looks at Sonapahar immediately discerns a pity situation that the topography has been

Plate No. 1 Sillimanite Mining at Lalmati, Sonapahar

Plate No. 2 Hillslopes sillimanite mining areas at Nongkyn-A

Plate No. 3 Top soil eroded near Nongkyn-A

Plate No. 4 Hillslope being bulldozed near Janapih

very much disfigured and leaves the landforms into large volume of scarifications. The hills and plateaus have been very much disturbed due to the open cast method of Sillimanite mining.

The plateau and hill slopes are mined by the help of machines like bull-dozers and scrappers, slope failure and landslides are the common phenomena in the area. Major portion of the area in Sonapahar was thickly forest cover. These forest covers were felled for the mining of Sillimanite. Therefore, soil erosion is enhanced and increase with the heavy rainfall especially in summer season. Large amount of mine waste and boulders are removed and exposed which directly leads to geomorphological despoliation in these localities. The ultimate result is mascree of the steep slopes which was once having thick growth of beautiful trees and bamboos. The topography of the area is totally altered becoming unsuitable for any agriculture activities. Due to unscientific extraction of sillimanite, the local topography has been very much disturbed, as it is seen in the plate No. 1, 2, 3 and 4.

The activities of sillimanite mining in the area of Sonapahar revealed a drastic change in the surface of landforms. Top soil is washed away and the steep slopes of the area have more vigorous soil erosion. Large number of trees were cut off for mining purposes. Therefore, deforestation and geomorphological degradation are the main result in reshaping the landforms of the area around Sonapahar. Mining authorities so far have not taken any measure

about the developing of waste materials in the area. Although, production is gone down from time to time, but this depends perhaps on the requirement of sillimanite.

URANIUM :

This is one of the most important mineral found in the most southern zone of West Khasi Hills plateau region. It is one of the mineral that has been recently put under exploitation. Sandstone-type uranium deposits represent one of the ore types and constitute a major uranium resource of the whole country. A little account of sandstone-type uranium is known about its deposit that is found in Domiasiat area, 84 KM from Nongstoin a district headquarter. Sandstone-type uranium is located in the southern border of Central plateau and eastern extremity of southern zone.

Exploration of uranium in the Upper Cretaceous Mahadek sandstone along the southern fringe of the West Khasi Hills district which has led to the discovery of sandstone-type uranium deposit at Domiasiat. This deposit is largest of its type in India. Intensive exploration by the Atomic Mineral Division of the Department of Atomic Energy, Government of India to locate the occurance of uranium deposits which commenced during the seventies. Follow up the details in investigations including evaluation of drilling has led to the discovery of a major sandstone-type uranium deposit in the area of Domiasiat which is the largest so far known in the country.

In brief, geological structure of uranium at Domiasiat is the Upper Cretaceous Mahadek formation which are dominantly composed of gray immature clay bands. These directly overlie the Precambrian basement. During 1989-90, significant operation of drilling were put up at Phot-Kilung, Phot Rangam, Pyrnotbri and Phot Umla area. During this time, according to the Atomic Energy Division samples of vertical faces exposed along the bank and nala of Phot Kilung, Rangam and other localities gave encouraging and put a consistent result of this type of mineral. Petrographic and mineralogical studies have indicated that the host rock for uranium mineralization is an immature of feldspathic quarty arenite.

The rugged nature of terrain of the southern zone however was once thickly forested and elephant menace, together with lack of proper road, hampered a detailed follow up exploration of uranium in the area. The delineation of uranium at Domiasiat area by drilling operation so far affected a great change in the geomorphological characteristics of the area. Forest were cleared for roads and mining are the common phenomena. Top soil is exposed and extensive mine waste have been dumped. The stable profiles of slopes of the southern face of the plateau have been highly disturbed due to extraction of the deposit of sandstone-type uranium. At the environmental balanced, how far uranium would affects could not be measured in this study, since it is also the new mining started in the region.

In this area one can conclude that the local topography is highly disturbed especially due to road construction through out

the region. Large amount hof debris and soil has been washed away. Despoliation is high especially in the mining area. Thus local landforms have been very much disfigured in the surrounding of Domiasiat and its adjoining areas. Nevertheless, scenario of landforms have been hampered a great change.

Besides coal, sillimanite, sandstone-type uranium and limestone is also one of the mineral that is abundantly deposited in the plateau region of West Khasi Hills. Limestone is deposited in the most southern slope of the plateau. Regionally, it can be said that a fairly continuous belt running right from western end bordered with East Garo Hills and follow eastward to the part of Jaintia Hills. The limestone section is mostly found in the area of Ranikor, Nongkulang and Khonjoy. Unfortunately, no estimates of limestone reserves are available. Although, limestone deposit in West Khasi Hills is very thin in comparison to the East Khasi Hills.

Limestone of West Khasi Hills belong to the Sylhet limestone and occur below the coal bearing sandstone. It is worth noting that the quarring of limestone in the part of southern slope of West Khasi Hills is yet to start. No detail study has been carried out so far. Thus, limestone of West Khasi Hills remains as a natural resources of the district since no operation has started.

It is very difficult to make an accurate estimate of resourdes availability in the region.

DESPOLIATION OF THE AREA :

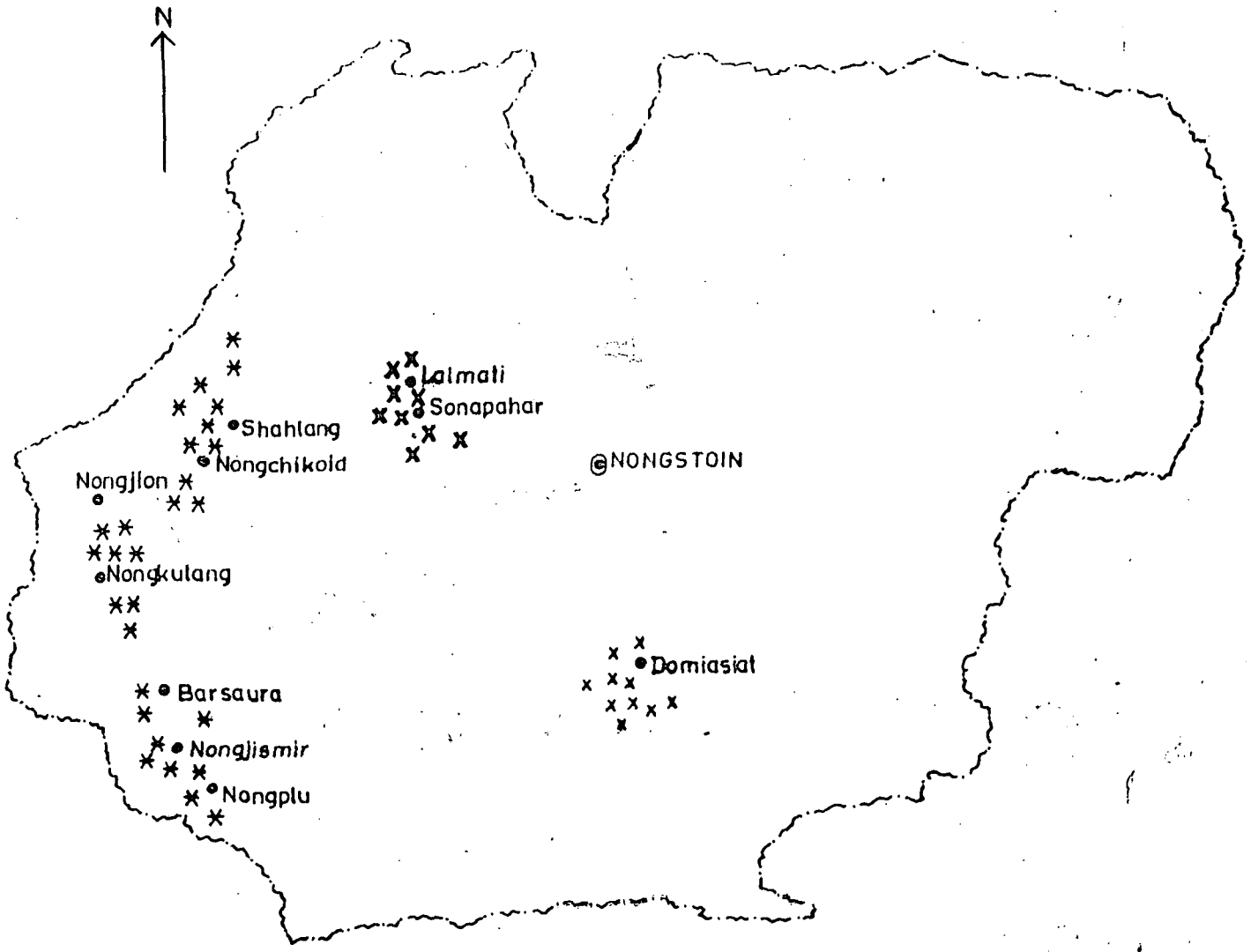
The plateau region of West Khasi Hills is the western part of Meghalaya that comprises the three geomorphological provinces as mentioned earlier. Mining activities have therefore brought a great change in the landforms of the area especially the mining areas. It denotes to land despoliation in the area, thus, the problem of despoliation in the area become very important as old as mining itself, though its severity and extent are relatively recent phenomena.

Literally, despoliation in the study area denotes spoiling of landscape features. All the human activities which cause despoliation, mining activities is the most destructive. It has affected the whole eco-systems, that is plants, soil and water. Mining despoliation in mining area of West Khasi Hills is only in the form of surface mining, i.e., open cast mining. The environment is in a great stress on global scale on account of ruthless exploitation of natural resource. Therefore, the area of despoliation is shown in a map No. 10.

The plateau region of West Khasi Hills district is bound to suffer from mining despoliation. But the magnitude of this problem have become alarming in last few years since mining operations started in the region. The present situation of the plateau is therefore is due to large scale mining operation that has affected the landscape topography.

Map NO.10

WEST KHASI HILLS DISTRICT
AREA OF DESPOLIATION



REFERENCES

Area of Very Severe Despoliation	XXXXX
Area of Severe Despoliation	*****
Area of Moderate Despoliation	x x x x x

PATTERN OF DESPOLIATION IN WEST KHASI HILLS MINING AREA :

The magnitude of mining despoliation is not uniform in the region of mining. It varies significantly from one locality to another and from one type of mining to the other depending upon the type of mining operation and as well as mineral deposits. On the basis of the despoliation in the area, three categories of despoliation have been identified and they are as follows :

1. Area of very severe despoliation
2. Area of severe despoliation, and
3. Area of moderate despoliation.

1. Area of very severe despoliation :- Of all the minerals of the plateau region, the most extensive deposits are those of coal and sillimanite. Again despoliation is great on the mining of sillimanite so far. Sillimanite is a very old enterprise in this region, it is also one of the oldest mining activity in the area. Sillimanite mining was started during the 1922. Similarly the area of sillimanite mining despoliation has spread not only in the past but it is also in the present past. Despoliation in sillimanite mine has a remarkably complicated character, primarily on account of what has been seen during the field investigation. It has been grouped into the area of a very severe despoliation which is unmatched in the region as a whole. The magnitude of surface despoliation on account of mining of sillimanite which has become a complex problem in disfiguring of local topography. In some areas of sillimanite mining

at Sonapahar. Severe despoliation mainly result from an expansion of mining areas and the adoptation of large scale open cast mining in recent years. The surrounding areas as a whole are passing through a phase of boom in mining activities. The increase of production is necessarily means increase in open cast and this resulted to large scale surface despoliation. More landsurface have been damaged and despoliated.

In the area of severe despoliation of the sillimanite mining at Sonapahar, plant life is highly affected, hill slopes and plateau being bulldozed and scrapped off huge amount of waste materials. A huge amount of debris is allowed to roll down the valley slopes that accelerating the process of erosion. Because of the rugged topography of the area, steep slopes and rugged terrain, the excavated material is easily role down the slopes. The top soil erosion is a very common phenomenon. The result is reshaping of the local topography generated a large volume of debris and disruption of surface water channels

It is also not only affected the configuration of landscape but also lead to total disruption of the ecological balance affecting the quality of air and water. Thus, landsurface have become very much despoliated. Sillimanite mining and their activities, become the most destructive by heavy open cast mining which has ripped apart the surface, mutilated the terrain and created artificial hills and ridges in most of the coal mining areas.

2. Area of severe despoliation :- The area of severe despoliation is found in coal mining areas, as coal mining in the area has just started in the recent years. Coal mining areas have been very much disturbed due to large scale deforestation. Severe despoliation are found in coal fields of Langrin, Nongchikoid, Nongplu, Nongjion, Borsaura and Nongkulang areas. Coal extraction results to scarification and ugly topographical features. Coal is extracted by the open cast method and as well as contour strip mining in which huge dumps of loose rubbles, boulders and stone pieces are made. These areas high affected the clearing of valuable trees of commercially important. As number of coal mines increased the forest cover is also indiscriminately reduced.

The problem is of deforestation and soil dagradation of local landsurfaces. These coal mining areas have brought their own localities into a great problem of severe despoliation which involves a drastic change in the topographical as well as scenery of the area. Soil erosion and landslides in coal mining are not new phenomena, but it has been occuring very commonly.

The rugged topography, uneven terrain and abrupt slope gravity are the characteristic features of the whole region, this has resulted to an accelerated soil degradation. The continuous coal mining in the region also resulted into permanent instability of most of the coal mines and its localities. The heavy rainfall have

also added to erosional hazards since the steep slopes are highly susceptible to erosion and landslides. Therefore coal mining of the plateau region of West Khasi Hills have become the severe area of despoliation.

Coal mining areas has adversely changed the topographical feature of the region, roads have been constructed throughout the mining areas, large amount of plants have been cut off for the mining which directly lead to land despoliation. Therefore, local topographical features have been very much disfigured and disturbed which play a very significant role to the study of regional geomorphology. Aesthetic damage due to disfiguration of landscape adversely affected the recreational value of the region as a whole. Thus, landforms have been very much reshaped to a very large scale especially in some of these areas. In Borsaura, very much soil degradation is caused due to coal mining, that has ultimately lead to a severe despoliation of land.

The sunsidence of landsurfaces over the mines of many places is the result of unscientific practices. A relatively slow process extending over decades, the subsidence eventually leads to a land despoliation. The soil likewise contain minerals that on weathering are in a crushed state, the weathering and production of pollutants takes place at a much faster rate.

3. Areas of Modsrate Despoliation : The area of modsrate despoliation are localised in occurance and associated with either sharp mining or manual quarrying. Sandstone-type uranium

mining are the good examples of the areas of moderate despoliation. The despoliation is caused mainly by drilling method. Sandstone-type uranium is mined by vertical drilling method, where huge amount of solid waste are being desposed. Surface landforms become despoliated mostly on the part of the surrounding mining face. This area of the sandstone-type uranium constituted constant disfiguration of surface with the clearing of vegetational cover. Most of the area of uranium are covered with thick forest and due to this mining, flora of the area is removed which ultimately leads to top soil degradation. The processes of uranium mining revealed a drastic despoliation of the top soil which is being pushed down slope created into erosional acceleration. Ugly topography has seen at Domiasiat where big boulders were removed on account of the mining. Huge amount of soil is washed especially by rain water. Streams are also the agent of soil and debris degradation.

Despoliation is moderate in this area because of either sharp mining or modest scale of semimechanised. Much localised despoliation has resulted from mining and quarrying of mineral waste. Thus, mining despoliation is going on unabated throughout the plateau region of West Khasi Hills district especially the sandstone-type uranium mining. Intensification of uranium mining has further expanded the areas of moderate despoliation. The construction of roads over an uneven and rugged topography of Domiasiat which involves blasting of huge boulders. Road construction spread headward througout the areas, hence, soil and vegetational

cover is highly disturbed in most of the area of uranium mining of the plateau region.

Despoliation is a regional problem, it occurs whenver minerals and rocks are extracted on account of mining. Consequently, public concern for restoration is bound to emerge sooner or later. While some take a notice of the problems at an early stages, other realised the urgency of restoration when despoliation begins to affect social and economic vitality and as well topography and environmental balance. But, the problem of mining despoliation in this particular region of West Khasi Hills seams yet to put any restoration programme. It has bean yet scientifically studied and therefore most of the mining areas and areas of despoliation have become a complicated problems revealing a dramatic and drastic despoliations especially on land and plant life. However, large area of the mining may involves in a geographical context and extent, its land resource is neither infinite nor putting even a sample recoverable processes. On the other hand landforms are gradually being reduced and even diminished with the growth of mining activities and its unscientific project. Considering the unscientific mining the whole geomorphological picture has not only changed but also left a negative heritage to the present generation.

Thus, because none of the despoliated areas has been reclaimed nor regenerating its own loss of vegetations and soil

as well as other environmental degradation. Therefore the plateau region of West Khasi Hills district is yet very much important and these mining areas play a vital role which affect geomorphological character to countless amount and the quantum of despoliation can not be in any estimations.

Therefore, the use of technology in mining is directly or indirectly related to the geomorphic characteristic which includes the intensity of work and energy in mining processes. It would be useful to take a look at the technology used in mining which revealed a great change in the landsurfaces and landform formations. Considering the geomorphic regions of West Khasi Hills the above natural resources available revealed a vital problems in the geomorphology of the region.

The magnitude and significance of the above mentioned interactions on geomorphology of the region depends mainly on the scale and concentration of minerals where mining programme is in a conjunction with the topography of the area. Therefore, mining processes viewed in the context of local geomorphology into a drastic changes in land, air and water. It is a grim of reality that the process of mining is interacts with the landform features in such a remote areas like West Khasi Hills plateau which has affected a vast tracts of landforms in the region.

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MINING ACTIVITIES AND ITS IMPACT ON LANDFORMS

Throughout the history of mankind, mining has been playing its significant role all over the world, so much that various periods have been known by the names of minerals dominating the scene during the periods. One can see the presence of mining activities in ancient times and till the modern times it has been playing its significant role at several places. A mine is therefore understood as a processes of excavating the earth surface for the purpose of extracting useful minerals, such a mine could be established on the surface of the earth where abundant minerals are found. Therefore, mining and its processes of extracting the minerals of the earth constitutes mainly to the benefit of mankind. It is very important to be noted that whenever there is mining there is also an impact or effects on environmental landforms.[1]

Mineral commodities are therefore produced either by open cast or underground mining and both these methods of operations produce adverse topographical impacts. The magnitudes and significance of the above mentioned methods of mining effects the landforms, and it either depends mainly on the types of mine, scale and concentration of its operational activities.[2]

The impact and effects on local landscape involved before the commencement of the operation. It is also worth-noting that most of the impact and effects involved firstly to the forest resources existing in the area of operations and secondly on the types of soil structure and its topography of the particular area or region, thirdly adverse effects produced by the mining operations involved in the surrounding areas of a region and many related problems become very significant.

The process of extraction of mineral resources and its use in various ways, generates a wide range of topographical changes which sometimes having far reaching consequences, while these changes have evoked formulation of national policies for their proper conservation, little has been done in our country to ensure rehabilitation of the land effected by mining activities. In this context, the plateau region of West Khasi Hills district has become one of the area having adverse impact by mining operation on landforms. The plateau region of West Khasi Hills would therefore assess our view in the context of its local topography. In this region more land is present under the stress of mining activities of various kinds.

Much larger area is disturbed by activities associated with mining. In the case of West Khasi Hills district, the recovery of mineral as mentioned in the earlier chapter as those of

coal, sillimanite and recent uranium mines that have largely affected the local topography of the region as a whole.

The recovery of minerals and construction materials requires removal of vegetational cover with underlying soil mantle and excavating overlying rock masses which more commonly exceed the volume of material sought. Keeping in mind, therefore, the result is reshaping of the topography which generate a great volume of debris (waste) and disruption of surface and even ground water circulation. It is important to be noted that the area of Langrin coal mine, sillimanite mine at Sonapahar as well as Domiasiat mine of uranium are taking into consideration and adverse impact due to activities. The network of road construction to service the mining operations is further aggravates serious problem of topographical features. So severe is the problems of land damaged by mining activities in West Khasi Hills district. The problem also striking ahead is because the area is involved by the method of surface mining which manifest sheet and gully erosion, landslides and rocks fall in mining areas.

In West Khasi Hills plateau region, mining is practiced by the open cast method constitute one of the most intensively operating disturbances to the natural setting and physical environment. The magnitude of the geomorphological impact created by mining can be judged from an example of coal mine at Langrin and

Shahlang and other areas. Assuming the depth of the overburden in the open cast mines, the disposal of debris would be of great impact on landforms. As the demands for mineral grow, the area of mining would expand at a faster rate threatening increasingly larger areas of landscape with sacrification, debris dumps, soil degradation, with widening circle of deforestation and distress perhaps to the population affected as sillimanite at Sonapahar and the recent uranium at Domiasiat which is located at the southern slopes of the plateau of West Khasi Hills.

At Sonapahar sillimanite mine, open cast mining have been practiced and this process constitutes the overburden stripped away to recover the minerals by using bulldozers, scrappers or manual operations which is called as "Contour strip mining". These activities have much larger affected to the local topography. These activities involved removal of the top soil and proceeding along the hill slopes or hillsides, so that the cut after another is made and a series of benches were formed. The inside wall range in few metres high but generally within 10 to 12 metres. On the other hand, debris is dumped on the slopes and the net result is

very ugly disfiguration of the landscape. Sillimanite mine open casting operations in the plateau and hills of Sonapahar area affect the rich top soil and soil is together scrapped off and pushed downslope. The sliding of mining recovery cause a great volume of debris and great damage to the vegetational cover. Ugly scarification and drastic reshaping of landscape and serious destruction of vegetation have occured in the hills overlooking the Sonapahar area. Similarly in the case of Langrin coal mine and Nongchikoid drastic change on landforms may cause due to the open casting operation of coal.

Indiscriminate mining of this kind includes landslides and aggravates erosion as witness in a stream called Umbayu at Sonapahar area. A study is carried out in mining of sillimanite that the rate of erosion in strip mining was of a great significance. It is observed that in some relatively flat terrain areas strip mining is involved or involving cutting of trenches has resulted in extensive deforestation, destruction of soil, lowering of water level and as well as pollution of surface water. Large amount of the debris flow would certainly disrupt the circulation of the surface as well as ground water, reduction of chan-

nel capacity of some streams promoting to erosion in others and causing much water pollution in the region.)

In the case of coal mining, Langrin coalfield is located in the western extremity of the West Khasi Hills plateau and it extends over a large area from Kynshiang (Jadukata) river in the eastern part and Maheshkhola river in the western edge of the plateau. Extraction of coal denudes natural reserves and in its process takes its tall of both the environment and the people engaged in mining of coal deposits. The impact on landform is of great significance, that the surrounding areas are highly affected to the soil degradation, giving rise to pressure and conflicts. Coal mines whether it is only an open cast, degradations cause although most of the mines are not very deep mines. A number of them especially in Nongchikoid and Umpyrtha areas coal extraction runs to a considerate depth. However, coal mining and their activities has had a profound impact on the landscape in these regions. It certainly caused or contributed to the processes of deforestation in the surrounding area as well as deprodation of soil and its fertility. Wide spread of land collapse and prevalance of underground landslides are very common.

Most of the coal bearing areas of West Khasi Hills district were densely forested even untill a few years back. Yet, with the growth of coal mining forested areas have been cleared to set up coal mines. These mines precipitated to the cutting down of natural vegetation in several ways. As number of mines increased, vegetations was indiscriminately cleared to make way for mining and settlement. In the area under study it has also been noticed that the extraction of coal meant that it has to be transported from the pitheads to the road side, this also causes great impact on landforms in the construction of roads in transporting activities of the materials.

The excavation of coal mines in the plateau region of West Khasi Hills district brought about a drastic change in topographical features, it is also noticed a sequence of climatic changes and much more important in soil epesion. Coal seams have certain consequences for the surface where retention of moisture by top soil which was severely impaired decreasing the landsurface. Subsidence of landforms in the area of coal mines is not new but have been commonly that gave way to topographical degradation. The losses which all are occuring on account of continuous degradation

of the land resources are of staggering dimension and constitute one of the important threats to our progress. Mining activities have created many scars on the landform resulting in the geomorphological degradation. This problem is more and it has become very acute in the area of West Khasi Hills district, this is because of surface mining that is being well practiced.

Similarly in the case of uranium at the southern part Domiasiat areas, where drilling method is carried out through the entire areas. The mine being located in the plateau and hills which are of great geomorphological problem that are likely to be very common therefore, great impact of mining activities in the form of disturbances of land surface due to the pits of mineral drillings, removal of vegetation and top soil is very common. Due to the extraction of uranium in due course, soil is washed or role down to the hill slopes during rainy season. The stability of slopes in some cases may be disturbed and results to landslides. Land damage by the activities therefore claims to be of such order that disturbing the local topography of the region.

Generally, in the plateau region of West Khasi Hills the most common open cast mining activities play a major role

causing to above processes. The adverse impact on these existing topography causes much land degradation which has become one of the most intensively operating disturbances to the natural setting and physical environment. The reduction of land due to mining operations undertake a serious problems of disfiguration on landscape and even reduced the vegetational cover. Even when the mining activities operate in a rocky area such as coal at Borsaura, serious problems caused to the topography of the area. In both the cases, the common features in mining areas as disposal of surface materials, mine waste, low grade product such as sililimanite poses grater impact in reducing landform or landscape features of the area. In these mining areas, mine waste which spreads all over the mining faces change in the landsurface and stream course is a very common phenomena, which may cause a drastic change in drainage pattern. Because of the very nature of mining practiced in the area of West Khasi Hills land is disfigured, vegetation is cleared by human beings.

Surface mining and underground extraction of minerals causes landforms scarification by lowering the surface and breakage of the rock strata above the extraction area. Subsidence of ground level in a low lying areas or region may give rise to severe

drainage problems. These development or cracks and scarificated face in strata creates drainage problems. The changes in slope and the water retaining capacity of land greatly affects its potentiality of topographical features.

The indiscriminate and unscientific method of mining operations leave its imprint in the geodynamically sensitive areas of West Khasi Hills plateau region. It has been great disturbances which caused serious geomorphology problems as well as environmental problems in this sector of the area. The various aspects of the area and its topographical degradation as observed during field work has therefore been described some of the facts as below :

1. DEFORESTATION : Prior to the mining activities the vegetational cover is removed from the mining sites, accelerating erosion and massmovement is a continuous process in the area. The scree which is allowed to slide down the hill slopes near Sonapahar, Riangdem, Langrin, Mawmarin and Nongchikoid coalfields harming and hampering the growth of trees and shrubs as well as grasses. Large number of trees have been damaged due to mining and accumulation of extracted materials drastically influenced

the ground flora and at places completely manished the growth of vegetation like grasses, herbs, masses and lichens. The roads that are connecting the mine sites and the main transport road are extremely dusty at all the time. The dust particles blown in the atmosphere ultimately settle on the tree leaves and grass causing severe physiological disorders. Keeping in mind, the various aspects of mining activities cause a great impact on deforestation. Trees are felled down for mine purposes and forests are cleared due to the construction usage of mining needs. This is ultimately making a scars on the flora of the region since most of the mining areas are located in the thickly vegetational region of the district. And this is found in the plate No. 5 and 6.

2. MASS-MOVEMENT AND SILTATION : In the operation and process of excavation of minerals, huge amount of debris is allowed to role down towards the valley slopes, aceelerating erosion activities especially in an areas of heavy rainfall such as the plateau of West Khasi Hills. The scree originating from Sonapahar sillimanite mine is swept away by Um Riangdo, Um Blei and Umbayu streams. During last 20 years more than 4 metres thick sediments

Plate No. 5 Sillimanite boulders (Open cast mining of Sillimanite at Sonapahar)

Plate No. 6 Deforestation along river stream, coal mining near Shahlang

load has roll down and deposited in these streams which resulting in widening of channel, flooding of low lying areas and low lying cultivated field and accelerating bank erosion. The flash floods of the areas have completely destroyed the cultivated field especially of Umblei stream. Off such a mass movement and siltation, that allowed to roll down the slopes triggering land subsidence and landslides.[3] The increase of mass movement and reactivating towards the erosion processes. So far as soil resources are concerned, the mining area in West Khasi Hills it would be the fact that the valley comprises both denudation and depositional soil.

It is also worth noting in the areas of coal deposits that mining has resulted into the soil denudation and soil deposition. Top soil of the mining areas is removed and allowed to spread and flow down to the valley slopes. Debris flow is therefore a common phenomena where huge amount of waste is deposited in the slopes or valleys. It is a process of erosional acceleration especially in some coal mines of the district. The heavy rainfall in the summer season pave the way to huge amount of soil and debris to move and silted in the slopes of the plateau, as it is seen in the plate No. 7 and 8.

Plate No. 7 Heavy landslide due to coal mining at Riangdem

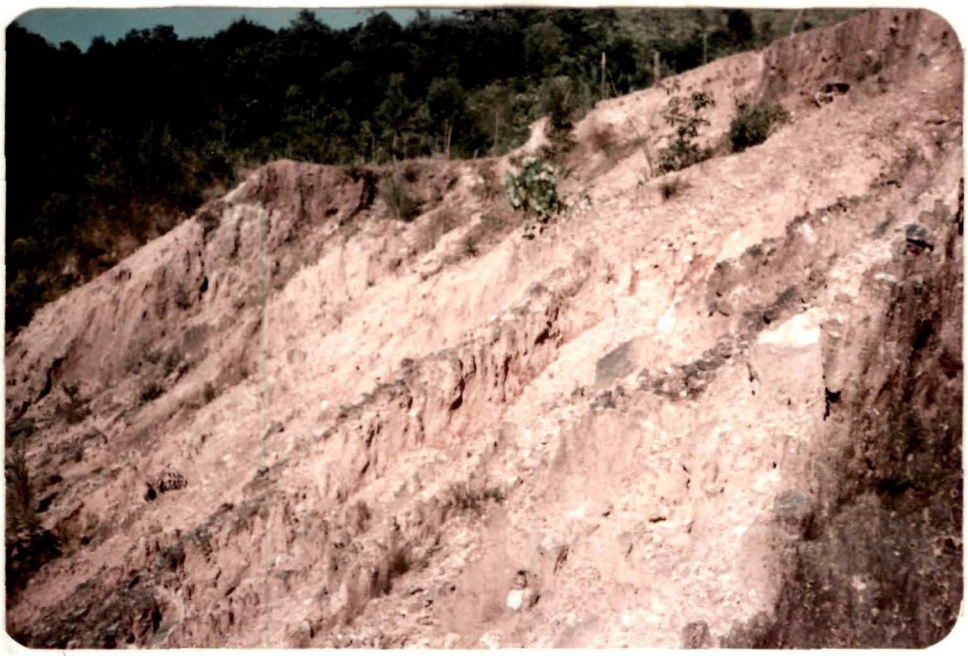

Plate No. 8 Soil degradation due to sillimanite extraction

3. GEOHYDROLOGICAL DISORDER : The mining activities have largely affected the local surface drainage as well as the ground water conditions in most of the drainage system of the plateau region of West Khasi Hills district. Siltation of debris flow in the streams have completely changed the hydrological balance. These mines in West Khasi Hills such as coal and Sillimanite and a drilling method of recent uranium are playing a great role in the hydrological balance. Coal and sillimanite open cast method in general their excavation result in lowering of water table. This is a common phenomena. The excavation has created some flat areas with dangers of water seepage which may trigger off the slides of the debris dumped down slopes along the slope or steep sided areas especially in mining of sillimanite at Sonapahar. Sometimes streams have diverted their course due to mine extraction. River streams are bulldozed and scrapped off therefore water resulted in the diversion of their actual course. This has resulted to a hydrological imbalances in the areas as *seen in the plate No. 9 and 10.*

Subsidence of ground in much of the low lying areas give rise to severe drainage problems. The change in slope and

Plate No. 9 A river stream being bulldozed due to sillimanite mining

Plate No. 10 Deforestation and soil degradation near Riangdo

in the water retaining capacity of the land greatly affects its agricultural potentiality. Therefore, mining operations affects the hydrological balance in several ways.that caused much drainage disorder in most of the areas.

Therefore, mining activities as it has been found in the West Khasi Hills plateau region played a very significant role in reshaping the geomorphological features of the area. In summing up the looses which are all occuring in the area, due to mining in West Khasi Hills district. Mining has ultimately taken its toll to account a great impact on landform formation. The disfiguration has really taken an imprint on topographical landforms. It is a great story of continuous degradation of land resources which are of staggering dimensions perhaps it is true which constitute one of the important threats to our regional geomorphological features. The cause of impact of mining activities damage the mineral resources and created many scars of landforms of hills and plateau of West Khasi Hills. The problem of mining activities and their impact on landforms resulted a geomorphological degradation.

It would therefore be desirable to realise the importance of modern mining activities and impact on landforms at the regional, national and global level but not at the cost of topographical degradation. It would be important to improve some of the landscape properties of sub soil and to provide soil conservation measures in order to solve the wash off from mines and to check the impact of mining activities on landforms. West Khasi Hills has been endowed with natural beauty and natural bounty. With the passage of time, there has been an increasing damage to topography.

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CHAPTER - V

MINING ACTIVITIES AND EFFECT ON REGIONAL GEOMORPHOLOGICAL ECO SYSTEM OF THE STUDY AREA

Environment as one understands is the status of various factors which contribute towards the healthy living, the nature of land, air, water and other factors. Irregular or improper hand ling of any one of these attributes upsets the equillibrium and imbalance in the eco-system. Though in general these elements have been damaged or disturbed over the years, the cummulative effect of these has created a persetible change in the conditions around us. There are many causes for disturbance of these natural factors and in this context the upsetting the environmental eco-system has been that of the mining activities in their mineral operations. Metals and minerals have been a part of human needs from time immemorial but the recent upsurge in population and the needs for raw materials have been the cause of increase in exploi-tations of minerals. These minerals become in our modern times as a host of such commodities needed for a large number of uses in any developed and developing countries. Therefore, it has led to conflict in exploitation of minerals which is one of the reason in our study of West Khasi Hills district and its mining areas which directly or indirectly resulted into the environmental degra-dation.

West Khasi Hills district plateau region is very sacred and important not merely for its aesthetic value but because it is the fount of life for the entire state of Meghalaya. It has large vareity of minerals which are very viable. The region comprises of valuable minerals like coal, Sillimanite, uranium and others like limestone quartz. Nature has generously endowed the area of West Khasi Hills plateau region with varied types of resources, and mining has become one of the great significant. Natural calamities and ecological hazards such as floods, landslips, siltation of river beds, soil erosion, changing course of rivers change in hydrologic and climatic regime etc. causing untold hardship and miseries not only on the hills and plateau areas, but also in the river valleys and low lying areas.

Mining and its impact on regional geomorphology is known to us very well and modern activities that have developed in the areas of West Khasi Hills plateau region. Extracting of minerals denudes natural reserves and in the process takes its toll of both the environment and topography of the area. Its impact on the regional geomorphology and environmental ecosystem therefore environment includes ecology as well as the relation

between social groups which governs access to the utilisation of resources of the earth.

Mining is a devastating operation that not only destroys the natural eco-system particularly if it is surface mining as in the case of West Khasi Hills. The associated problems of spoiling landsurfaces, deforestation, waste disposal, water pollution, air pollution, land collapse are of course marked and perhaps to be expected in mining operation. But little attention has also deals with the environmental eco-system that re-acts directly or indirectly due to the mining.

Substantial contributions have been made by the geologists in perceptions as a part of hazard research which was initially confined to natural hazard. Porter[1] has enlarged the scope of hazard perception research by introducing environmental hazard as a recognition of the human and social contribution to the existence of hazards. Intensive search by the Geological Survey of India for the presence of economic mineral occurances in West Khasi Hills has revealed the presence of several minerals and sillimanite is one of the most important. Therefore in the study area perhaps it is true that mining activities are carried out unsystematically and irrationally that these would affect the

ecological balance of the atmosphere.

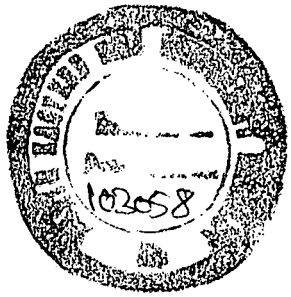
These mining activities reduces or destructs the biological potential of the land which ultimately leads to disturb the otherwise balanced eco-systems, thereby creating by mining wastes.

In remote areas such as West Khasi Hills plateau region it is important to be stated that resource management activities are inadequate knowledge of environment which leads to an extreme hazarducus cenditions.While reviewing the environmental degradation in West Khasi Hills, it shows that these plateau is in itself prove to natural hazards which become more damaging by mining activities in exploitation of minerals.

From this point of view, when one looks at West Khasi Hills district mining areas immediately discerns the grave situation of both natural and technological hazards in this area. The slope failure and land sliding has been very common phenomena in this region and the unstable rocks like slate and shale accompanied with highly jointed quartzites and sandstone are being most

susceptible to large scale erosion causing several damages. Soil erosion is also enhanced by various natural activities such as high rainfall which is one of the most essential in this area, landslides, slopy terrain has been very much affected by deforestation.

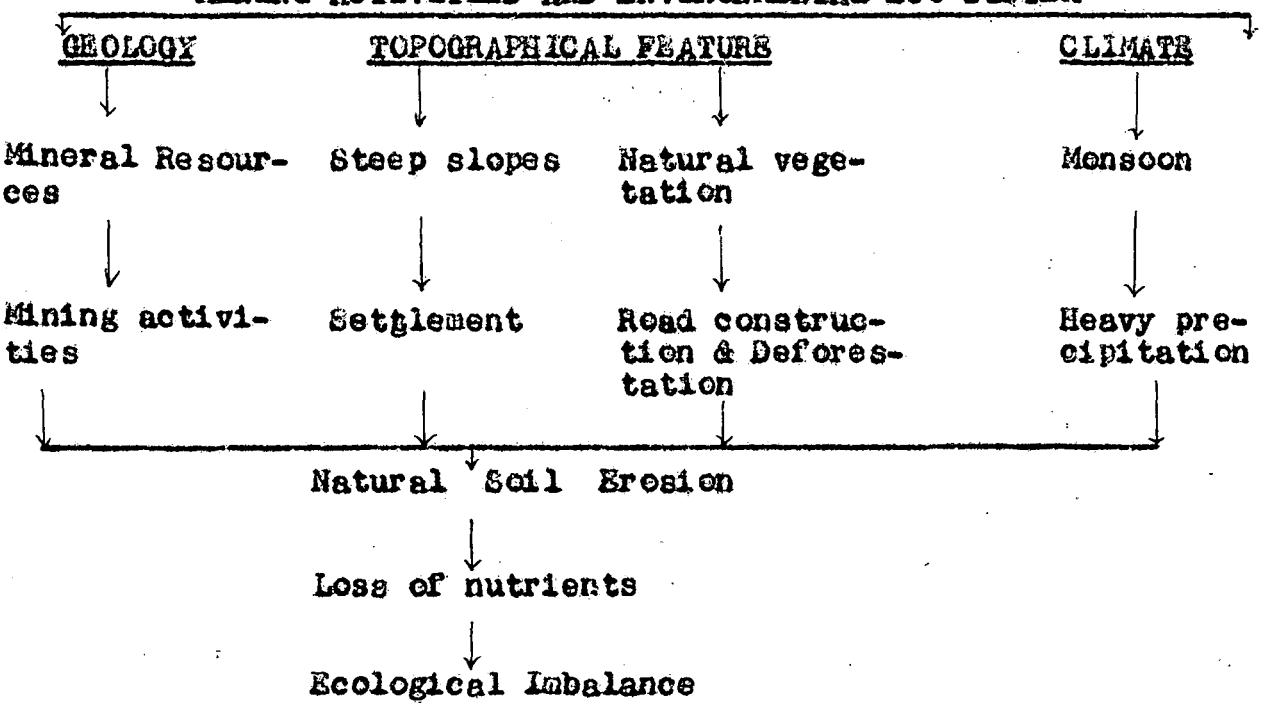
In general the various geomorphological and environmental problems have steamed the study from the over-exploitation or unscientific exploitation of natural resources. In this process, ecological balance has been upset and the very resources are being degraded or depleted beyond sustainable limit. The conservation of such resources or to exploit them in a scientific manner is therefore a basic important aspect of management of the environment. Among the natural resources exploitations or extraction, is one of the most important which requires scientific exploitation for the preservation of the surrounding environment. Especially in a hilly track like Meghalaya plateau as a whole, where geological structure is quite old as well as unstable. It is also important, therefore, to preserve the environment. Un scientific mining has caused deforestation and soil degradation. Construction of roads and development of settlement etc. has also



affected environment. The model present in the following figure explains the effect of mining activities on landforms and environmental eco-system.

Table No. 5

MINING ACTIVITIES AND ENVIRONMENTAL ECO-SYSTEM



If we examine some of the notable landslides and deforestation areas of West Khasi Hills, the result reveals that most of them are located in an around the mining areas. The result brings out a very important point that the Piedmont areas consisting of terrace materials are quite stable and usually not affected by mining activities. The field observations carried out

establish that most of landslides and disfiguration of landforms and slope failures in West Khasi Hills district is caused due to mining operations. The heavy rainfall within the region also imbalance the environmental and topographical ecology. Mostly in a plateau region, structures is unstable, consisting mainly of phyllites, schists, gneissic, etc. reveals a great imbalance to the environmental degradation.[2]

In West Khasi Hills plateau region mining is practiced by open cast method. Mining in West Khasi Hills constitute one of the most intensively operating process. Disturbances to the natural setting, physical environment and indirectly to the social environment. Open cast mining activity invariably leaves its imprint on the biotic system including air, water and land. In process of majmr open cast mining system like the sillimanite mines at Sonapahar, there is bound to be scar on the face of the region, on one side and creation of mini mountain on the other, affecting its physical environment.

There is apprehension among environmentalists that mining activities will affect the ecological balance especially

in this highly fragile territory of the state as a whole. Mining covers an insignificant portion of the total land surface as compared to the damage caused by haphazard destruction of forest. Truely speaking, the mass poverty and the greed of a few are responsible for creating the ecological imbalance. Mining activities may, therefore, cause inconvenience but it must be borned in mind that they generate employment opportunities for many and alleviate the suffering of the people in West Khasi Hill which is one of the remote areas in Meghalaya.

ECOLOGICAL FACTOR IN RELATION TO LANDFORMS :

The extraction of mineral resources in the plateau region of West Khasi Hills by means of surface mining or the open casting is one of the major mining activity. Miners removed the minerals and mine waste that disturbed especially in the coal mine areas. Ultimate result is massacree of the steep slopes which was once thronge with prolific growth of beautiful trees. After mining these areas on road sides and steep slopes become devoid of vegetation cover. The topography of the area is totally altered becoming unsuitable for any human activities. Due to this reason, the ecology of the surrounding areas has changed.

For the plant growth on the bare exposed hillslopes, the overburden should be free of large rock pieces. It should contain a high percentage of soil particles and adequate mineral nutrients to support the plant growth. Protection and preservation of steep slopes susceptible to frequent landslips during rains is in need to be endorsed by a very right thinking miners these unscientific mining affected largely to the ecosystem of the plant growth. The disposal of overburden has naturally changed the slope, vegetational cover and even hydrological conditions in the mining areas of the West Khasi Hills which has caused anxiety among the settlers of the area. Rugged topography on one side and uneven and abrupt slope gravity are the characteristic features of the whole region. These mining activities continue likely to cause permanent instability to the region.

The mining areas of West Khasi Hills plateau are badly denuded by the surface mining operations, such as construction of temporary unmetalled road, the transport vehicles keep on plying and cause constant damage to the top soil and natural vegetation which are affecting the eco-system of the plateau adversely. It constantly resulted to the loss of vegetation and top soil and its fertility. Decrease

in water table and accelerate soil erosion and landslips or landslides. The mining of coal and sillimanite are most unscientific in operation.

Therefore, the hills and plateaus of West Khasi Hills are quarried indiscriminately without any measure to present the ecological balance. The quarries in the case of sillimanite do not take any care of preservation of vegetations and especially the soil erosion, which generally cause to a serious problems to the environmental eco-system.

DEFORESTATION :

Before mining was taken up the plateau of West Khasi Hills especially the area around Sonapahar and Langrin was thickly forested but with the advent and increase of mining and mine colonies as well as population deforestation took place. Large number of trees and bamboos were felled for mine use. Mining activities are therefore resulted the whole area in reshaping the landsurface and despoliation of natural vegetation which created ugly sacrification and leave the area into barren conditions. It should also be borned in mind that

mining areas are located in most thickly forested areas this would directly or indirectly disturbed the conditions of ecology. There is a great loss of timber and fuel resources where forest has to be cleared. Destruction of forest is more evident in the area where open cast mining is taking place. Prior to mining activities, vegetation cover is removed from the mining site, with the increase in mining forest cover is therefore cleared.

Deforestation in the plateau area of mining in the region of West Khasi Hills has not only brought about soil erosion, but the main drastic change is the climatic condition which resulted a constant change in the environmental ecological context. This large scale deforestation in the district has rendered the sensitive areas into many climatic hazards and calamities of droughts. It has also rendered particularly to soil degradation in the area. Therefore, mining operation created a great despoliation in the ecological balance of the area.

SOIL DEGRADATION :

Out of all the adverse environmental impact the effect of mining activities is mainly associated with open cast mining is the

most serious problem which has brought a great change in the land surface. Again, open cast mining activities in the region have created a dramatic changes in landscape. Mine waste becomes overburden quite substantial as compared to the volume of mine extracted.[3] Soil degradation is the most common phenomena especially in West Khasi Hills plateau region, because of heavy rainfall during rainy season. Whenever top soil is removed for mining purposes it is easily washed away by rain water.

Most of the rich top soil is scarpped off and pushed down slope by rain water. This sometimes, loose waste matetial becomes debris flow which descend down into the valley and spread over. In this process mining waste in the area would further tend to occupy large tract of land which resulted in making the agricultural land infertile. It is therefore, cause serious soil degradation when rich top soil is exposed and washed away by rain water especially in the steep slopes of most of the area. This is therefore would directly leads to the problem of beauty as well as usefulness of landscape topography. Mining activities and mineral beneficiation operations on landforms have caused environmental degradations due to lack of anti-degradational equipment and above all due to the ignorance or negligence for the environmental protection.

WATER POLLUTION :

The processes of extracting minerals from the underground rocks and effects adversely the water table in several ways. In the study of West Khasi Hills plateau region one of the main environmental problems is the mining operation that are associated with water ecological context. The problem and processes of overburden of mine waste disposal has caused severe environmental disturbances to the use of water. The dumps and piles of soilid waste have disturbed the drainage and the waste water usually not re-cycled as it let loose in water courses giving rise to problem connected with injurious effects on habitations, livestock and surface or ground water.

AIR POLLUTION :

Air pollution is defined as the presence in atmosphere of substances which adversely affect the living organisms or their habitats. Air pollution from the operation of mining comes in two forms of sources : Point and Non-point sources.

Point source of air pollutions are caused especially in open cast mining or even in drilling system.

The non-point source of air pollutions are from blasting, dust gases, haulage over internal and external roads construction and general dust blow from mining face.

In an environmental topography of the mining areas natural circumstances exists in soil and weathering, biological reaction and even of the parrent rocks and with these mining should however, conserved the adverse effect of the whole ecology. Environmental damage would affects the ecology to an unacceptable degree and with these there is however need basically the scientific mining operations.

The mining authority would therefore assess the environmental degradation and ecological impact and made a balance between the set up activities in the state of operations. Mining operators should always take step of consideration the best possibilities in environmental context that its issues would alongside for mining project in order to balance the ecosystem of an area.

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CHAPTER - VI

SUMMARY AND CONCLUSIONS

In the context of local geomorphology, mining has caused a drastic change in the surface landforms. In West Khasi Hills plateau especially the area around Sonapahar, large scale mining of sillimanite has been going on since last 50 years. Therefore, the area has been very much affected due to long continuation of mining operations which have altered the natural landscape of the region as a whole. In the same manner coal mining is going on a very rapid scale of production in this area. Keeping in mind the pertinent problems of such activities in this region have played a very important role in the regional landscape.

Out of all the adverse environmental conditions associated with the open cast mining, naturally all surface mining produce dramatic changes in the landscape. Mining in conclusion implies rejection of waste and the very process of selection may produce damages and undesirable effect on landforms. In short, it would contain inevitably the seed of environmental pollution unchecked to balance the ecological conditions.

It would be apparent from the above studies that mining and their activities reduce or destroy the biological potentiality

of land and finally disturb the balance eco-system. If no ameliorative measures to rehabilitate the land either alongwith mining activities or on cessation of mining, a state of entropy will reach and will be handling most unproductive land to future generation.

Since the existing physical conditions in mining areas are acute and nothing tangible has so far been done to improve it, cautious steps should be taken by the Government before starting the mining operations in the region of West Khasi Hills district. Side by side, the future mining operation should be carried out in a scientific and planned manner, so that waste materials do not run down the streams. Especially in the area of heavy rainfall like West Khasi Hills plateau region. Certain amount of soil conservation to stabilise the existing landslips in the area is very necessary in order to check the soil erosion. Moreover, sillimanite and coal seems of appreciable thickness and length may only be extracted leaving aside the disjointed and fragmentary inferior varieties which induce haphazard activities in the area.

Very little has been done to know the applicability of the known techniques in our country and evolve new techniques to

restore the mine spoils or mine despoliation areas. But it may be clearly mentioned here that the above suggestion cannot formulate the general guidelines, because of varied physical and biological factors such as climate, soil and topography, etc.

The geomorphological and environmental consideration must therefore be worked out in detail before any mining activities is undertaken in this geo-dynamic sensitive and ecologically fragile belt of West Khasi Hills district. It is very difficult to make an accurate estimate of future availability of mineral deposits. Thus, certain pertinent conclusions can still be drawn for a number of important minerals their exploration should however be in a scientific and planned manner. Environmental management should thus form an important part of all schemes mainly with a view to reclaim such land including mining dumps and spoiled sites which should be put under afforestation programmes so that there is adequate plant cover for protection of land surface from the erosion. This is only the single way of enhancing the beauty and usefulness of landscape.

Soil and slope stabilisation is the major pertinent problem in mining operation, where erosion control is one of the

most expensive recurring costs in the rehabilitation of mined land and requires special efforts to minimise its effects. Thus, despoliation is a global problem, it occurs wherever minerals and rocks are exploited. Consequently, public concern for restoration is bound to emerge in the area of West Khasi Hills district. The mining despoliation in our state and particularly that of the plateau region of West Khasi Hills has not been scientifically studied as yet.

The despoliated areas of the region would continue to become more complex by landslides and new mining activities which became larger and larger in extent. The despoliation would not disappear from the region on its own because the impact of mining cannot be transferred to other areas. Moreover, large region may be in geographical extent, its land resources is neither indifinite nor simple recoverable. Effective measures of land despoliation or restoration or land reclamation can neither envisaged nor suggest an implemented unless our attitude to mining changes drastically. The change should focusses primarily on the following points :

1. Even today there are people who believe that there is more money in destroying the environment rather than in conserving it. Mining, however, should be regarded not as a temporary anti-

environment destructive activities but as an industry that provides an opportunities for creative manipulation of our landscape.

2. Treatment of areas despoliated by ming should be in a progressive and continuous manner. It is wrong to think that tidying up is something that is done when a job is finished. If this attitude is taken up in the case of mining, the result is that the effects of mining will accumulate creating an increasing long term environmental degradation loss of land surface.

3. Lastly, appropriate legislation should be made for restoration reclamation of despoliated areas by development authorities and mine owners themselves.

Although, much remains to be done for winning back the impact and despoliated areas due to mining. In this respect a sign of optimism is noticed in the following unanimous resolution of the mining activities. It is an imperative that in order to ensure sustained development of the mining operation, maintenance of environmental ecology and optimum utilisation of land in India, land reclamation strategies should be integrated into the planning design, development and operation of mining projects on scientific lines, by the governments and the industries.

The physical alteration and conspicuous in surface landform had played a vital role in this study. In conclusion, the solid waste and mine dumps around large mines or mining areas in the district result into man-made hills being add to the topography. These artificial hills being unconsolidated and loose that are subjected to large sliding and easily erodable choking surface drainage and despoil fertile land downslope. Unlike transport of land flux by natural erosion and even by agricultural practices where floating sediments directly finds its way into the ultimate sink of deposition. Therefore, the environmental impact by natural erosion only in geological time that form agricultural source may be within a century. The siltation impact of mining activities appears in the area of West Khasi Hills ultimately changed to a large extent of topographical landscape.

Thus, West Khasi Hills plateau region need an immediate attentions for the maintenance of eco-system and the conservation of soil and vegetational cover. It is a need to the local people of the region in raising their voice for scientific mining operation for the protection of these hills and plateau. But at present, the basic need is to prevent the denuded hills from erosion and

landslides. Consequently the vegetational cover should be put into various schemes of afforestations within the areas.

Characteristics of geomorphological entity of West Khasi Hills plateau although is significant for its natural resources particularly the minerals and forests. The exploitation programmes for these has however, observed to influence adversely the eco-system of the region.

REMEDIAL MEASURES

Some of the suggestions would be in need to this study as far as landscape and the effect of mining is concerned, that we would now be in a prerequisites for the protection of local landform topographical degradations. Therefore, the suggestions in this study are as follows :-

1. A programme like environmental awareness should be longed scientifically in exploitation of minerals, especially in the region of hills and plateau like West Khasi Hills district.

2. Open casting method should however be stopped unless protection of soil waste is made.

3. Mine waste should be suitably disposed off.

4. Metalled roads for transportation services should be well planned or constructed as an approach roads to mining areas.

5. Afforestation programmes especially in the mining areas should be taken up vigorously.

6. Reclaimation of land and conservation of soil should be speeded up and the area should be terraced in order to avoid slope failures.

7. Gully erosion should be checked by erecting the check dams, retaining walls, etc.

8. Toe-wall along the foot of the slopes should be erected to check further soil erosion and siltation of rivers and streams.

9. Premeable barrier should be made to make run-off smooth and retain the debris siltation pits also should be well constructed.

Henceforth, it can be concluded that there is a very close relationship between the geomorphology and mining. There is an impact of mining activities on a very large scale on the surface landforms of the area. Mining activities, therefore, leads to various topographical degradations in most of the area of mining in West Khasi Hills district. It also leads to form large scale deforestations, soil erosion, etc. due to the indiscriminate mining in the study area of the region.

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

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