PART A

CHAPTER I

Introduction

INTRODUCTION

Meaning and Scope of Geomorphology :

In its strictest sense the meaning of geomorphology as derived from its three Greek roots is a discourse on earth forms or the science of land forms and is concerned with the study of the form of the earth. In practice however, this simple definition is too all-embracing. The study of macro-features like shape of the earth body, form and origin of mountain systems, shape and distribution of continental land masses etc. belong to the domain of geodesy, geology and physics, whereas geomorphologists are mostly concerned with the study of small-scale landforms, such as drainage basins, areas of uniform rock-type, individual river valleys or the hill-side slopes of a small area.

It is thus clear that the study of the earth's surface forms (particularly of smaller dimensions) and of the processes that shape them, constitute the field of geomorphology. Geologists and geographers have long been collaborated to develop a field that is seldom confined to only one discipline. Geomorphology has at different times and in different countries had a different scope, and the contribution of geographers and geologists have complemented each other in varying patterns. Geologists are mainly concerned with the significance of rock structure and earth history for landscape evolution whereas

geographers emphasised mainly on the nature of surface forms and the relationship between forms and processes - and in recent years they have shown particular interest in assessing the role of man as a geomorphic agent and also in applying the knowledge of landform to the proper utilisation of land for man's benefit.

Sometimes the geomorphologists are reluctant to concentrate sufficiently on careful landscape description, and over-anxious to explain the origin of landforms about which insufficient basic information has been obtained. An example lies in the work of W.M. Davis, who made suggestions on the evolution of slope without detailed measurement of slope profiles in the field or actual study of the processes of weathering and transportation at work on slopes. His hypothesis is an example of deductive reasoning : he made certain assumptions (as regards tectonic movement and external process) and argued logically from there. If the assumptions are wrong, however, the hypothesis is also incorrect. Other similar examples of deductive approach are the work of Penck (1953) and Wood (1942) on slope development and Lawson's (1915) explanation of rock pediment.

Genetic Approaches :

One of the major aims of geomorphology is to explain how individual landforms, and more particularly landform

assemblages, have originated. However, most landforms are so complex and pose such a variety of problems that several genetic approaches may be taken up for their proper interpretation and explanation :

(a) Geomorphologists may be concerned with establishing fundamental relationships which exist between landform, structure and process.

(b) Others may approach landform study from a 'Historical' point of view, and demarcate the various stages of evolution which the landscape has passed through before attaining its present form. This is what may be called Davisian approach. The main objective of such approach is to identify, date and interpret planation surfaces developed in past 'cycles' and 'sub-cycles' of erosion. The idea is the basis of 'denudation chronology' or the history of erosion and development of landform. In work of this kind there is evidently much overlap with geology, for many of the surfaces preserved in the present landscape may date back to Pliocene, Miocene or even early Tertiary times. Another important aim of denudation chronology is to study the manner in which the drainage system of an area has gradually evolved. Through the identification of subsequent streams and the interpretation and dating of river captures, the original consequent pattern is reconstructed and the possibility of superimposition, antecedence etc. investigated.

The above method is highly speculative and controversial and hence, is subject to criticism by modern geomorphologists. First, the old surfaces are usually so modified by subsequent erosion that their original form and height cannot be easily interpreted. Secondly, the geological evidence needed to date the surface is often missing. As such, widely differing ages and different modes of origin may be suggested erroneously for a single surface.

Moreover, the denudation chronology approach succeeds in explaining directly only a very small proportion (not even exceeding about 10 per cent) of the existing land surface, mainly the fragments of former surfaces which have been dissected and almost totally destroyed in some cases by more recent erosion. Also the fragments may be visible in the field only to the very experienced observer.

(c) A third approach favoured by many modern geomorphologists, notably in the U.S.A., is that concerned with the investigation of the relationship between process and form. This involves in the first instance a careful analysis of weathering, erosion and deposition, both as regards their mechanism as well as rates of operation. Secondly, an attempt must be made to relate, in a causal way, individual processes and groups of processes with particular forms and assemblage of forms. For example, in the case of valley-side slopes one basic element may be attributed to the action of one process and another basic element to another

process. Thus a concavity of profile may be attributed to rainwash while a convexity to the action of soil creep.

There are many difficulties in the way of the Process-Form approach. Many of the processes act only intermittently (such as rain-wash and certain types of mass movement) whereas others act very slowly or almost imperceptibly (such as chemical weathering and soil creep). As such, patient and precise measurement and long-term continuous observation are needed for drawing a scientific conclusion.

Another fundamental problem is the difficulty in providing a causal relationship between a process and form. It is almost impossible to demonstrate conclusively that a particular process results in a particular form. Also it is difficult to isolate one process for study, since in nature it is usual for several processes such as chemical and mechanical weathering, soilcreep and other mass movements, concentrated and unconcentrated run-off etc., to act simultaneously on landform, and to be, to a greater or lesser extent, mutually interdependent. Even if one could relate one process to one form, say, soil creep to convexity of slope profile, it is not clear whether the process results in the form or vice versa.

Laboratory and Field Experiments :

In the study of processes, the geomorphologist is in some instances able to undertake experiments, both in the laboratory and in the field. Laboratory experiments are rendered largely invalid by problems of scale. It is obvious that, where practicable, field experiments are usually more satisfactory than those attempted in the laboratory. The opportunities are, however, very much limited, if only because of the large scale, or extremely slow speed of most geomorphological processes.

Recent Ideas :

In fact, Davisian geomorphology died a death of sterility several decades ago although it may be mentioned that a large number of Indian geomorphologists and quite a few in the western World still tend to concentrate their work on re-constructing the history of evolution of landform through successive stages and feel satisfied if successful in 'detecting' multiple planation surfaces even within a relatively small area. Thornbury himself has cautioned such geomorphologists by stating - " ... Topographic surfaces have many origins. .. Before interpreting any topographic surface as a peneplain the geologist should first take all possible precaution to make sure that the surface is not related to lithologic or structural control or a product of some other geomorphic process. If this is done, many fewer peneplains will be suggested" (1969, p.205). He has also pointed out "Lack

of a proper appreciation of the differential lowering of peneplain surfaces has been responsible for multiplication of alleged peneplains. When one notes eight or ten peneplains described in an area, as has been done, he will not only be skeptical of there being so many but will probably wonder if even one is present" (P. 186).

Productive researchers in geomorphology today have shied away from synthesis, while the majority of field workers are pragmatists - this is no doubt a good sign since it has served to a great extent to clear the air of confusion. In the mean time a surge of intensified field studies and experimentation in new techniques has been unimpeded by theoretical ballast. More refined mathematical and statistical concepts have been applied and found to be of increasing value.

Geomorphology : A Field Science :

Even after consideration of all the above facts one should keep in mind that geomorphology is basically a field science. One has to observe the landform and processes in the field and derive conclusions on the evolution of landform, particularly when micro-features are concerned, mainly on the basis of his observations in the field. Mathematical and statistical methods of analysis as well as laboratory methods are nothing but aids to draw such conclusions.

The Author's Approach :

Keeping in view the above facts and the limitations of different approaches and methods it may be said that

neither description nor explanation, neither form nor process, neither structure nor climate, neither the present nor the past, is by itself adequate or complete. Each deserves its proper place ; each is thought provoking in its own right.

In the light of the approaches which have so far been discussed, the author feels that these approaches can be 'fused' together when a particular geomorphological problem is being tackled. Thus, in order to study the geomorphology of an area, one should study first the lithology and structure ; then he should study the climate in order to understand the processes at work ; then satellite imageries may be consulted for an understanding of the macro-features of landform while aerial photographs and topographic maps may be studied and analysed for a more detailed study of landform. Various methods of morphometric analysis may be done in order to have a better understanding of the landform characteristics and finally, problem areas may be selected on the basis of the above study for detailed field work, mainly with the purpose of micro-geomorphological investigation and also for the study of the actual processes at work in the area concerned.

Finally, an approach to denudation chronology may be taken up on the basis of the field study of the geomorphic processes acting in the area. However, the processes which mould the landform are essentially destructive in nature and hence such study suffers badly from a shortage of field evidence.

As such, mathematical analysis has to be adopted in studying the characteristics of existing landform features as well as in reconstructing certain landform features which existed in the past.

In addition to the above, man's interaction with nature has to be studied and finally suggestions be made on the applied aspects i.e., how the knowledge derived from such studies could be utilised for man's benefit.

The present author therefore proposes to take up an area which may be considered a 'Geomorphic Unit' and adopt the relevant 'approaches' and 'methods' with a view to describe, analyse and interpret the Macro, meso and micro features of landform included in it, mainly with the help of geological, topographical and other maps including satellite imageries and aerial photographs, supplemented by detailed field work.

Selection of the Area for Study :

The need for accurate description of the geometry of landforms, mainly those of fluvial origin has been of prime importance in geomorphology, and one of the most important part of it has been the identification of the basic areal unit within which these data could be collected, organised and analysed. The conceptions of the nature and character of these units have been a product of the methodological approaches

to geomorphology and can be classified into three types :

The first approach depends on regional delimitation based mainly on structural geology as is done by Fenneman (1914).

The second approach aimed at the identification of the physiographic atoms (i.e., the facets of 'flats' and 'slopes' forming the intersecting surfaces characteristic of polycyclic landscapes) out of which the matter of regions is built (Wooldridge, 1932, pp. 30-33). This definition has later on been modified and extended to include segments of smoothly curved surface (Savigear, 1965) and to allow grouping of facets into landscape patterns. This approach has limited usefulness because of its genetic overtones and subjective character.

The third approach is based on the typical unitary feature of geometry as well as of process exibited by the drainage basin, as recognized by Davis (1899) and Playfair (Chorley et al 1964, pp. 61-63), illustrated by Horton (1945) and elaborated by Strahler (1964).

The present author, however, prefers to delimit the primary boundary of a geomorphic unit by following Fenneman although in a somewhat modified way. The main aspect of the area should be based on geological and geomorphological unity as depicted by the lithologic, structural and physiographic uniformity as well as by the sharpness

of the contrast of these elements with those of the surrounding areas. The sub-divisions of these units may, however, be based on drainage basin boundaries which are included in the area ; these sub-divisions are chosen mainly for the application of various methods of morphometric analysis of landform in order to collect quantitative information so that a vivid description of the landform is available, which may be used for the interpretation of its history of evolution as well. Examples of such geomorphic units are plenty in nature such as the Black Hills of western U.S.A. or the Massif Central of France. In India, however, there are several such areas like the Mysore Plateau, Manipur basin, Meghalaya Plateau or the Mayurbhanj Upland which stand in sharp contrast with the surrounding areas in lithology, structure and topography.

The Mayurbhanj Upland :

The choice of the geomorphic unit for the present study is the Mayurbhanj Upland of Orissa which was first visited by the author in 1962 when he was surprised by the abrupt rise of the hill country from the plains of Baripada on the east. The sudden change of the geologic character as well as the dense forest appeared in striking contrast with the surrounding. The first sight of the area impressed the author so much that he decided to take up the detailed

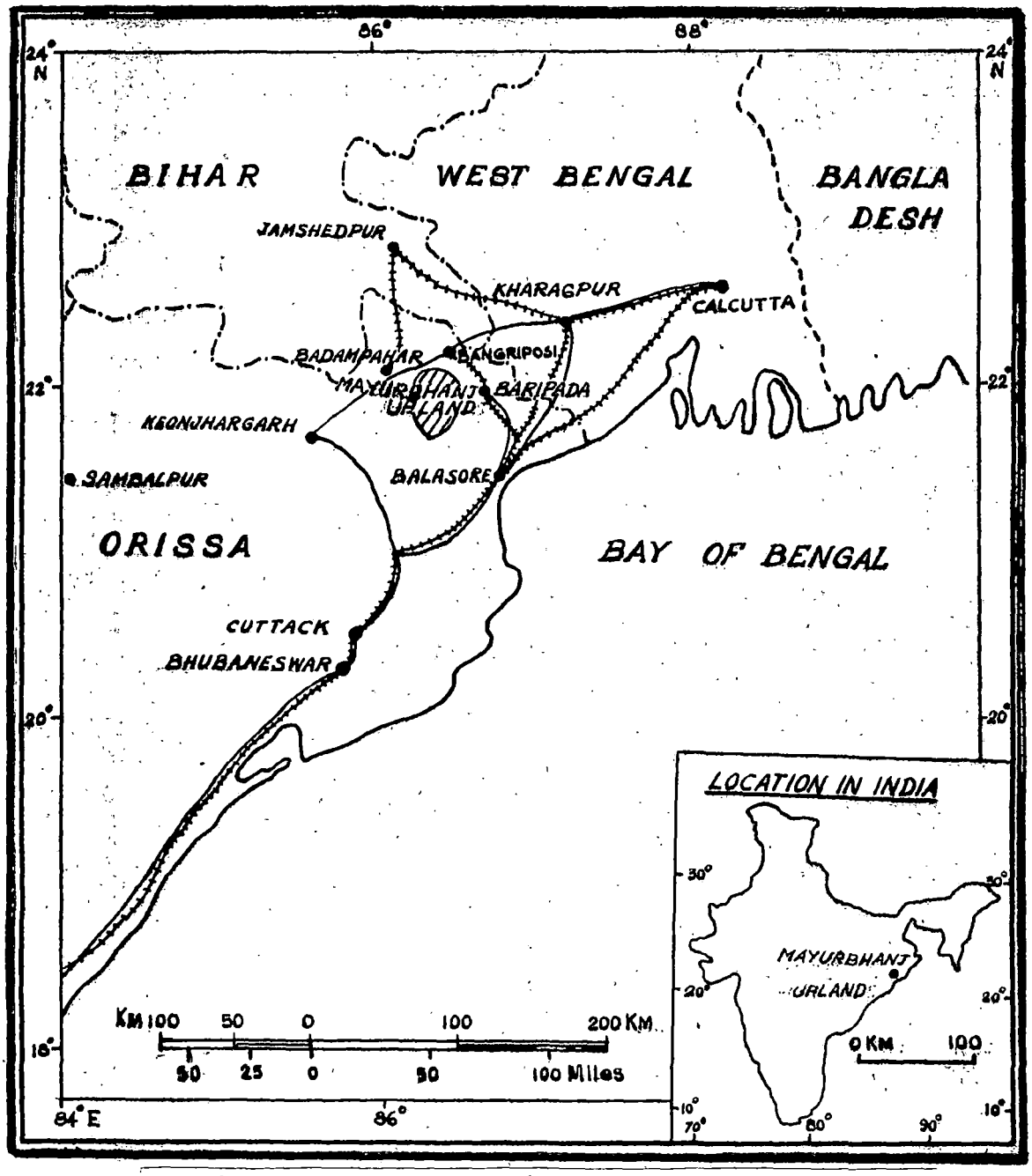
study of the area from the geomorphological point of view. During 1962-63 the author had the opportunity to do field work in the Massif Central of France under the guidance of Professeur Jean Tricart of Strasbourg who also encouraged him to study the geomorphology of the Mayurbhanj Upland which resembled very much the Massif Central of France in topography and geology. The study however, was not a continuous one ; only recently it has been taken up more seriously by the author for a Ph.D. degree.

The Mayurbhanj Upland : A Geomorphic Unit :

The Mayurbhanj Upland represents a compact physical, geological and obviously a geomorphological unit. The physical unity is apparent in its distinct boundary formed by the 450 metre contour line which separates it from the surrounding low-lying and gently undulating country side, especially in the east. The geological unity is prevalent in its synclinal basin structure made up of rocks mostly belonging to pre-Cambrian age. Such unity in structure and topography qualifies the area as a distinct geomorphic unit.

General Information :

Location : The area is located between latitudes $21^{\circ}10'$ N and $22^{\circ}40'$ N, and $86^{\circ}05'$ E and $86^{\circ}48'$ E. Administratively it belongs to the Mayurbhanj district of

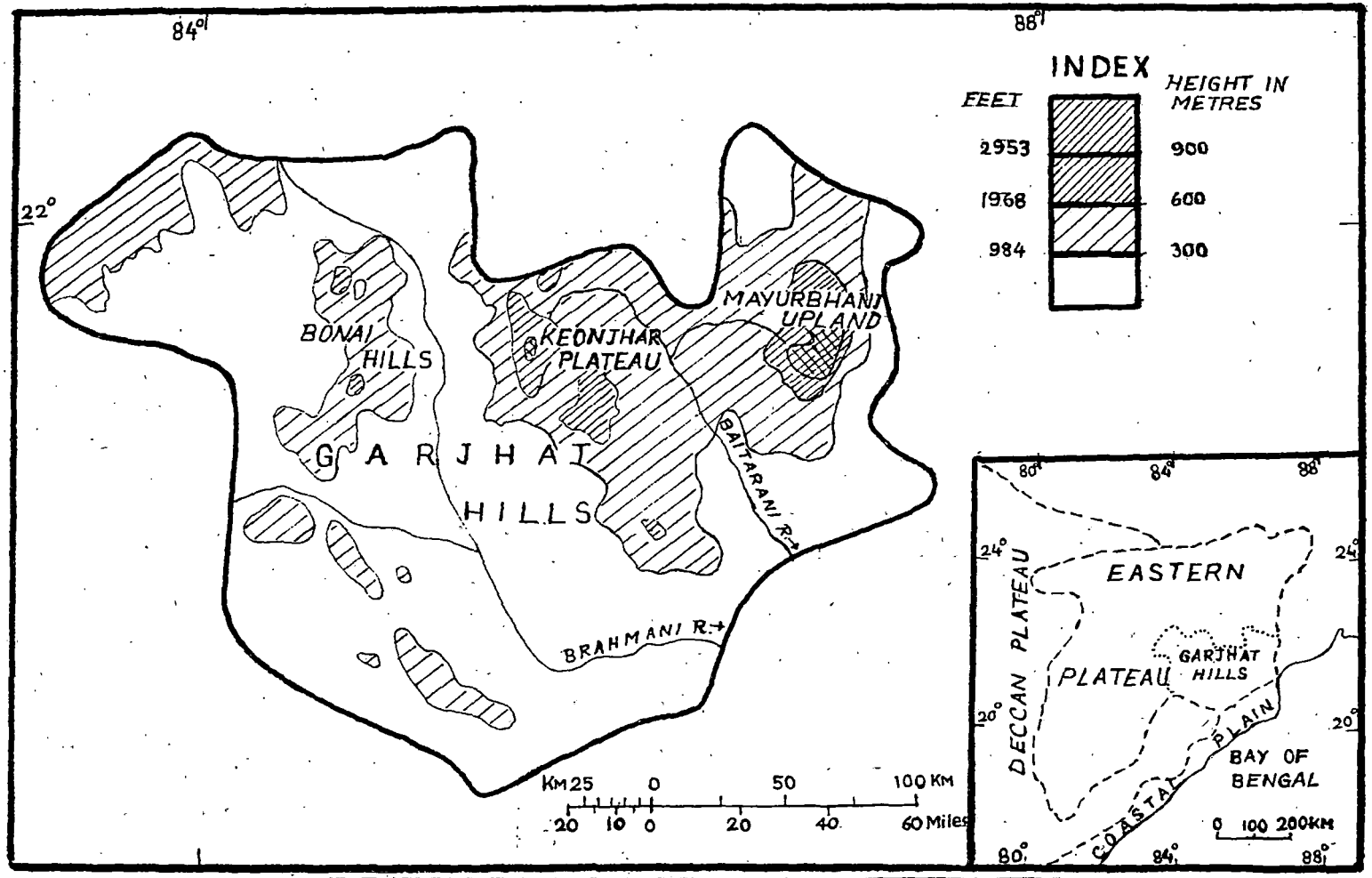


Location of the Mayurbhanj Upland in Eastern India

Orissa and lies in the northeastern part of the State adjoining the border of Bihar in the North and West Bengal in the northeast. The areal extent of the Upland is about 1000 sq. miles or 2590 sq. kilometres (Fig.01).

Accessibility : The nearest township is Jashipur on the western margin of the Upland which is located on the main road from Calcutta to Keonjhar at a distance of about 288 km from Calcutta. Baripada, the headquarter of the Mayurbhanj district, is located at a distance of about 75 km from Jashipur and lies on the eastern side of the Upland. The nearest important railway station is Balasore on the Southeastern Railway. Its distance from Calcutta is 312 km by railway and 91 km from Jashipur by road. Jashipur is the main entry-point to the Upland which remains virtually inaccessible to vehicles almost for about six months during the Summer because of bad road conditions which deteriorate with the on-set of the Monsoons. The best season for a visit to the area is during March-April when a cool, dry weather prevails in the interior of the Upland ; also during this time of the year the discharge of the streams is at the lowest and the roads and foot-tracks are least damaged.

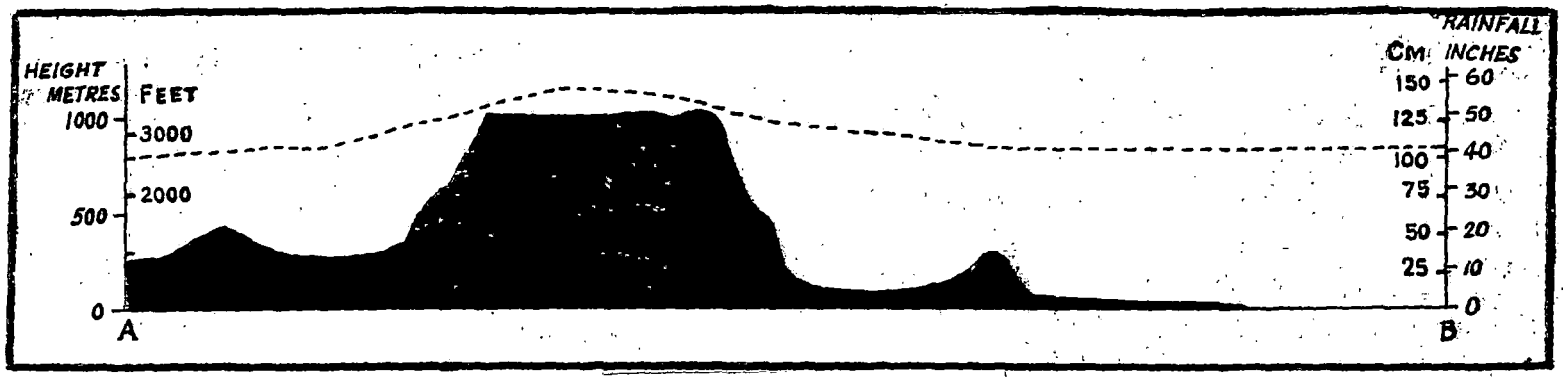
Physiography : Physiographically the area



Location of the Mayurbhanj Upland in Eastern Orissa

may be described as an Upland or plateau which has a flattish level surface at an elevation of about 3500 ft (1067 m) in the interior with highly dissected marginal areas. The flattish terrain in the interior is a gently rolling Upland with a few ridges of resistant rocks. The highest elevation is found in the south-central part of the Upland where the Meghasini Peak reaches a height of 3823 ft (1165 m). The central part of the area is drained by a number of streams of which the most important is the Burhabalang River. The streams originate in the interior of the Upland and diverge in all directions. Escarpments on the hill-sides and gorges and water-falls on the streams are common sites in the area.

Climate : Climatically the area belongs to the Tropical Savanna Type of Koppen and Sub-Humid Type of Thornthwaite. Summer Monsoons bring rain to the area during May to August mainly. There is no permanent meteorological station in the area and it is difficult to guess the actual amount of precipitation or the variation of temperature in the interior of the Upland. The interior remains cool even in the Summer because of the elevation. Nearby meteorological stations indicate that the monthly average temperature varies from 15^{o} to 31^{o}C while the total annual rainfall is about 127 cm.



Relief and Rainfall

Flora and Fauna : The area contains numerous varieties of plants and animals. The most important commercial timber is Sal (Shorea robusta). An undergrowth of Sabai grass is also found deep into the interior of the area. Elephants, tigers, deer, peacock, bear, and a large variety of other animals and birds along with poisonous snakes are found in abundance in the area.

Settlement : The area is very thinly populated mainly because of the less developed transport and communication, rugged terrain, dense forest, numerous ferocious animals and infertile soil. A few villages have developed in the alluvial flats of the Upland where people depend mainly on agriculture and collection of forest produce. Some important villages in the area are Gurguria in the Khairi valley, Similipalgarh in the Bakua valley, Khejuri in the Pitalisil valley and Kadalibari and Dudhiani in the Deo valley.

Status of Previous Work : Very little information on the geology of the Mayurbhanj Upland and its surrounding areas are available except from the publication of the International Geological Congress (1964) by Iyengar and Banerjee. Some scattered reference on geology of the surrounding area is found in the publications of Bose (1904),

Krishnan (1936) and Dunn and Dey (1942) but these do not give any information on the geology of the area concerned. So far as the geomorphology of the area is concerned, the only reference to the area may be had from the brief publication of the International Geographical Congress by Haque (1968). It was therefore not possible for the present author to collect information on various aspects of landform of the area from the existing literature. As such the author had to depend mainly on primary sources like Satellite Imageries, Topographical Maps, Aerial Photographs etc. for the collection of data on the subject concerned.

Objective of the Present Work : Certain characteristic features of the Mayurbhanj Upland attracted attention of the author when he visited the area for the first time. These are as follows :

(1) Sharp rise of the hill-country from the surrounding land which lies at a much lower elevation.

(2) More abrupt rise of the Upland on its eastern front.

(3) Extensive flattish terrain in the interior of the Upland.

(4) Abrupt rise of both linear and arcuate hill-ridges above the Upland.

(5) Circular pattern of drainage developed in the interior of the Upland.

(6) Almost vertical escarpment slopes along certain rivers and

(7) Straight segments with abrupt change in direction shown by a number of streams with strikingly parallel courses of streams in certain areas.

The above characteristics of the landform needs explanation and the success of an attempt for a proper explanation of the observed features depends to a great extent upon a precise description of the landform itself as well as of the lithology, structure and the geomorphic processes acting in the area. The main purpose of the present work is therefore to study in details the landform of the area along with lithology, structure and process which are the major controls of landform. With this view in mind the author adopted the following methodology for the present work :

Methodology :

1. Consultation of the existing literature : At first

a bibliography was prepared which included the existing literature on geomorphology and allied branches of geography such as climate, soil and natural vegetation as well as geology which have a direct impact on the landform of the area. Also it included the books and journals published in different parts of the world which dealt with the development of the surface features of the earth under similar environmental conditions. The above literatures were studied carefully and the relevant information collected. Techniques and methods adopted by geomorphologists in different countries for similar analysis were also studied carefully.

2. Collection and analysis of topographical maps :

The next step was collection and analysis of topographical maps prepared by the Survey of India. One inch to a mile (R.F. 1:63, 360) and 1:50,000 maps were the most suitable ones for the present study since more detailed maps were not available. In fact 'One Inch' maps were more useful for the analysis of the terrain since it gave a greater details of relief (60 ft or about 15 m) than the other one i.e. 1:50,000 map which gave an amplitude of 20 metres or 66 ft. Also 'Quarter Inch' (1:253,440) maps were consulted for the preparation of the outline of the area and the study of the shape and form of the region as a whole. Different

types of relief maps, slope maps, curves and diagrams representing the various characteristics of the landform were prepared by analysing the contour pattern of the topographical maps. Also selected drainage basins were delineated on the topographical maps and various morphometric techniques applied in order to collect necessary data for the analysis of the characteristics of the basins.

3. Collection and analysis of geological maps : The geological maps of the area were collected from the Geological Survey of India and the characteristics and distribution of various geological formations were studied carefully. Also the structural peculiarities and particularly the location and alignment of faults were noted. These characteristics were then compared with he topographic characteristics as depicted by the morphometric and other maps prepared from the topographic maps. An attempt was made to explain the terrain characteristics in terms of geological characteristics. Certain discrepancies were noted where the topographical features did not properly reflect the geological characteristics like lithology and structure. Those areas were then marked carefully for field verification.

4. Analysis of Satellite Imageries : Satellite imageries

covering the Mayurbhanj Upland and its surroundings were consulted for studying the geomorphological environment. This includes the major physiographic characteristics of the area as well as the characteristics of the landform and drainage of the surrounding areas which have some definite relationship with the area selected for the present study. Moreover, the geomorphic units of the study area, particularly its major divisions and their inter-relationships were depicted more prominently on Satellite Imageries than on more detailed large scale maps like topographical maps and aerial photographs.

5. Analysis of aerial photographs : Aerial photographs were consulted for studying the minor geomorphic features. The escarpments, ridges and valleys, hill-side slopes and even the smaller features like rills, gullies and badlands appeared prominently when viewed through the stereoscope. Also aerial photopairs helped the author to identify certain features of geologic importance like faults etc. as well as lithologic variations and thus the work appreciably reduced the necessity of field work in those areas.

6. Field work : (i) A traverse of the area was made in order to see the general layout of the hills, valleys and plains. The characteristics of the landform in general were observed.

(ii) Selected areas with topography-geology discrepancies were visited in order to understand the nature and cause of the discrepancy and the real reason for it was detected. In several cases it was detected that the available geological maps were lacking in details of geological variations and hence the discrepancies arose. Minor variations of geology such as occurrance of faults etc., which were not shown in the geological maps were then surveyed and plotted. Geomorphological study thus helped geological mapping of the area which supplemented the work of the Geological Survey of India.

(iii) Several instruments like chain and tape, Prismatic Compass, Esray Compass, Clinometer, Abney's Level and Dumpy's Level were used in some selected areas in order to study the micro-geomorphological characteristics of the area, particularly the location, extension and pattern of rills, gullies and badlands. These were mapped on a large scale and the nature and evolution of the badlands were studied. The same instruments were also used in the measurement of slopes along and across several hillocks including the crest-slope, middle slope and base slope as well as the plain lying in between the hills and the streams which drain the area.

(iv) Photographs of the landform features of geomorphic

significance such as hill slopes, gullies and badlands, outcrops of resistant rocks and water falls, were taken in order to give visual evidence of the variation of the geomorphic features.

7. Laboratory analysis : The soil samples and sediments collected from the field were studied in the laboratory. First, each sample was sieved and the amount by weight of different grain-size were measured. Each of the samples were then represented in diagrams to show their characteristics. The size and shape of the pebbles and granules were studied carefully in the laboratory with special reference to their petrographic characteristics. This analysis helped in understanding the physical characteristics of the samples.

8. Writing up of the thesis : On the basis of the above study the findings were then written in a systematic order in different parts and chapters which may be stated as follows :

The thesis contains four parts of which the first part i.e. Part A contains five chapters which give the background information on the area selected for study.

In the introductory chapter (Chapter - I) the concepts and trends in the broader aspects of geomorphology, basis for

the selection of the area, objectives and methods adopted are stated in brief. In Chapter - II a brief description of the climate, natural vegetation and soil is given since a background knowledge of the above elements of physical environment helps one to understand the character and intensity of the physical processes working in the area for sculpturing the landform. In Chapter III the general geology of the area is described. This particular factor appears to be the most important single item influencing the geomorphic characteristics of the area under investigation. Chapter IV gives the general description of the topographic characteristics of the area while Chapter V deals with the drainage characteristics which are directly related to the geologic characteristics.

Part B of the thesis deals with the collection and analysis of data from topographical maps, it contains two chapters viz. Chapter VI which gives the results of the quantitative analysis of landform of the area as a whole and Chapter VII deals with the morphometric analysis of selected drainage basins.

Part C contains three chapters viz. Chapter VIII which describes the results of analysis of the Satellite imageries and aerial photographs, Chapter IX gives the summary of

observation in the field while Chapter X describes the procedure for the preparation of geomorphological maps on macro as well as micro-scale. The map is based on the findings of the previous two chapters although some basic information have been borrowed from some other chapters, particularly from the chapter on geology.

Part D contains four chapters viz. Chapter XI on denudation chronology and XII on Physical divisions which result directly from the studies made in the previous chapters, while chapter XIII describes in brief the human aspect of the problem in relation to the geomorphological characteristics of the area and finally Chapter XIV gives the summary and conclusion drawn from the whole study.