

# **AN OUTLINE OF INDIAN GEOMORPHOLOGY**

(A Study in Regional Geomorphology of Singhbhum)

**DEBIDUTTA P. P. SATPATHI**

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## PREFACE

It has been very recently realised that geomorphic studies have more than their scientific and academic values. There are few aspects of economic, human life which are not affected by geomorphology. Slope determines field patterns, the problems of irrigations, the characteristics of soils, the pattern of agriculture, the lines of communication and transport, the development of forests, the preservation of the environment, industrial locations, mining, power development, etc. Thus, geomorphology has come to be realised as one of the foundations of human economy and environment.

By its geomorphic characteristics Chotanagpur is a representative of a much larger unit i.e., Peninsular upland. South of the Gangetic plain Singhbhum is geographically a representative section of Chotanagpur and a larger unit of Peninsular India. The representative aspect is contained in the geological evolution, lithological base, tectonic characteristics, geomorphic history and evolution, slope characteristics, drainage evolution and patterns and thickness and characteristics of the Pleistocene and Holocene sedimentary cover.

All these above aspects of Singhbhum have been studied intensively with the help of suitable maps, diagrams, photographs and relevant quantitative analysis. The important geomorphic regional units have been delineated on the basis of the systematic analysis and their dominant geomorphic characteristics have been discussed.

Detailed geomorphic study of Singhbhum is particularly significant because it is related to the highly mineralised, potentially industrial and ethnically important region of India.

As such this book is expected to be welcome by students of geomorphology, geology and soil conservation and environment preservation. It is also expected to be an important source in research methodology for geomorphic investigations.

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I express deep gratitude to Dr. E. Ahmad, Professor and Head of the Department of Geography, Ranchi University, Ranchi, whose deep knowledge of the subject of Geography has been a constant source of inspiration to me.

I am in a special debt to Dr. Marton Pécsi of the Hungarian Academy of Sciences who took the trouble of sending almost all the important geomorphological papers published in his country either written by himself or in association with other authors or written by other prominent geomorphologists of that country.

I am also thankful to Prof. Lesjek Starkel of Poland who kindly sent some morphological papers contributed by himself and some geomorphological maps of Poland which depict a new trend in geomorphological mapping.

Among the Indian geologists and geographers I am highly indebted to Dr. S.N. Sarkar, Director, Dhanbad School of Mines, Dhanbad, who has done most intensive work on Singhbhum Geology after J.A. Dunn and who has been a pioneer in the geochronological study of the stratigraphic sequences, tectonic history and orogenic cycles of the region.

I am in a special obligation to Dr. A.K. Saha, Professor of Geology, Presidency College, Calcutta for sending almost all his papers on Singhbhum Geology. I am also highly indebted to Dr. K.M. Naha, Dr. D. Niyogi and Dr. D.S. Bhattacharjee of the Department of Geophysics, I.I.T., Kharagpur, who took troubles to send their papers on the Geomorphology and Geology of Singhbhum. I am also greatly obliged to Prof. M. Pathak, Reader, Magadh University, Gaya, Bihar for his occasional suggestions. I cannot forget the dedicated work of my students—Sri A.K. Sinha, Sri M. Prajapati, Sri A. Prakash and Sri N. Sundi who helped me a great deal in cartographical work of the thesis.

Author

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## CHAPTER I

# Introduction

Geomorphology is a relatively new branch of Physical Geography. Because of this newness there is a lot of flexibility and even vagueness in this discipline. As an illustration we can see the writers on climatic or climatogenetic geomorphology denying or undermining one another. No doubt there are some respectable works, like Fenneman's *Physiography of the United States* or Wooldridge's and Morgan's 'An Outline of Geomorphology' or Jhonson's 'Shore line Processes' or Fairbridge's *Encyclopedias, etc.*, but in quite a good deal of geomorphic literature there is considerable lack of uniformity and coordination both on the philosophical as well as on the practical stage. One can easily sieve out incongruities out of the modern geomorphic literature both of Indian and foreign origin.

It would, however, be unfair to be discouraged by such drawbacks and not to tackle geomorphology of the Indian sub-continent and its regions. The present study is concerned with the district of Singhbhum which has been the scene of detailed geological works of such renowned scientists as L. L. Fermor, H. C. Jones and J. A. Dunn, *etc.* The present writer belongs to this district and benefits by his long association with the region.

The scheme of work will be apparent from the list of contents :

(1) The first chapter deals with the stratigraphy of this area. No doubt the development of the geological succession of rocks is one of the fundamentals of geomorphic characteristics of the area. All the viewpoints from the venerable days of the early masters of the G.S.I. to the latest approaches have been discussed.

(2) The second chapter examines the structural characteristics and dispositions of the rocks. Those characteristics are no less significant than the lithology of the formations.

(3) The structural characteristics are the result of the tectonic events. The area under study was particularly marked by tectonic disturbances especially during the Pre-Cambrian times and later on during the Tertiary and later periods. The former movements were violent and large scale leaving strong structural marks on

the area in the form of anticlinoria and synclinoria, shears, thrusts, and magmatic intrusions, *etc.* The tectonics of the Tertiary and later times are responsible for the composite-level topography or erosion surfaces and titled areas, *etc.*

(4) The building of the past geography of an area is of immense interest to a physical geographer. This becomes of added importance to one who tries to elucidate the geomorphic development of a region.

(5) Geochronology is a relatively new field ; but it is an important basic tool in dependable scientific arrangement of lithological, tectonic and geomorphic features of an area. The writer could not ignore these aspect in his detailed geomorphic study of this important mineralogical district of India.

(6) Then we enter the main field of geomorphology in the chapter on drainage which is a detailed study of the subject pertaining to this district. The author has examined drainage from all the latest points of view and techniques giving particular emphasis to the quantitative aspects and their cartographic representation.

(7) Of equally detailed nature is the chapter on morphometric analysis. Here too all the latest important techniques and methods have been applied to present the geomorphic elements and their different facets, with the help of statistical analysis, cartographic presentations and geomorphic interpretations.

(8) The next important geomorphic chapter deals with slopes. In view of the fact that to many of the modern geomorphologists, the geomorphology of an area is basically related to the nature of evolution of slopes, this chapter is of unusual significance.

(9) Although few surfaces are wholly erosion surfaces in view of some localized and even small scale depositions, erosion surfaces are the terms which may be correctly applied to Singhbhum owing to the predominance of erosional processes and considerable altitude of the region with respect to the local or regional or grand base level.

(10) Despite oppositions the cycle concept is fairly appreciable in most areas and it is very helpful in orderly comprehension and interpretation of geomorphology.

(11) Of specific importance is the subject of gully erosion in the district. Although the cause is not exactly known, it is one of the most important aspects of Holocene Geomorphology of the area.

(12) The next chapter deals with the important but controversial aspect of climatic and climatogenetic geomorphology as



applied to this region. The occurrence of pediment like surfaces along with a thick cover of sediments considerably support the idea that many of the erosional surfaces are not active but dead erosion surfaces. There are, however, substances in the other viewpoints also.

(13) The last chapter is culmination of the whole study where an attempt has been made to delimit the area into geomorphic regions of the different levels. This means not only an integration of the entire stratigraphic, structural, tectonic, palaeogeographic, geochronological, morphometric, erosional and climatic backgrounds of the area, but also the development of geomorphic framework in which the future investigations of different geomorphic scales can be undertaken.

(14) Apart from the author belonging to the area, he has visited different parts of the district in connection with the field study. Such field work has enabled him to observe the features noted by earlier workers, new features noted by himself and their interpretations as far as possible. The photographs and the local colour in the text are also the result of field observations.

*Nomenclature* : There are some local or regional names of some morphological phenomena. Within this region there is a difference of nomenclature between the western and the eastern parts.

In the western part 'Buru' means hill, hillock or ridge. But in the east for hills or hillocks the terms like 'pahar', 'parbat' and 'dungri' are used. In the western part the hills are specified by terms like 'Jilling Buru' which means long hill and 'Marang Buru' which means big or large or high hill.

The words 'Gara' or 'Lor' are used for rivers and streams in the west whereas in the east the words like 'Nadi' and 'Jhor' are in vogue. This difference of nomenclature is due to the cultural, ethnic and linguistic differences of the two regions. The terminology in the western part is dominated by the 'Ho' languages. "The name Singhbhum, that is, the land of Singhs is most probably derived from the patronymic of the Rajas of Porahat to whom the north of the district was once subject" (D. G. Singhbhum, 1958, p.2).

*Working Plan* : Any geomorphological work consists of four component activities—the collection and study of all relevant literature pertaining to the subject, preparation of maps and field investigations, and finally the interpretations.

The literature on geomorphology has become a "no man's land"

being claimed equally by Geology and Geography. This enlarges the compass of literature. As the author is not well versed in French and German languages, he had to miss a great deal of geomorphological works by the eminent continental geographers published in continental languages e.g. some papers of Paul Macar (Belgium) Julius Budel (West Germany), Fournier (France), Tricart (France), Baulig (France), Bekker (France), Corbel (Germany) and Louis (Germany), etc. Colour has been used only in one map (Geolithological map). In the other maps black and white has been used. The maps are based on the information available in existing maps, literature and from field study.

In a geomorphological study there is no escape from field investigations. The author visited the field in different seasons, made field inquiries and observation, took photographs, and made some observations. All the photographs are taken by the author himself. He has also collected some rock samples from the important regions of study.

*Previous Works :* Prior to this no geomorphological work of this region was attempted by any worker. Some physiographic notes of course appeared along with this geological works done by the eminent geologists.

Although the first available report on Singhbhum appeared in 1840, the comprehensive work on the geology of Singhbhum came out in 1881 (The Geology of Singhbhum and Manbhum by V. Ball, Mem. G.S.I., V. 18, Pt.s). This work was followed by several stray papers on different aspects of the geology of the region, until Sir L. L. Fermor made some solid contributions to the geology of this region. Fermor's works (1919, 1921, 1936) were followed by the works of H. C. Jones (1922, 1927 and 1934). In the mean time Dr. J. A. Dunn started doing some intensive work on the geology of Singhbhum. His works (1929, 1934, 1935, 1937, 1940 and 1941) were entirely based on field investigations. He made some corrections on the earlier works and contributed a great deal to the stratigraphy, structure, and petrology of the region. He made a detailed geological mapping of the region which had not been done by any other worker before. In every geological memoir he has attempted to give a physiographic description of the region. His findings on Singhbhum geology were supposed to be final until 1962 when Dr. S. N. Sarkar and Dr. A. K. Saha made some alterations in Dunn's stratigraphic sequence basing their arguments on geochronological data.

Besides these the works of J.M. Maclaren (1904), E. F. O. Murray (1921, 1923, 1940), F.G. Percival (1931 and 1940), L. A. N. Iyer (1932), C. Mahadevan (1924) also cannot be overlooked.

The District Gazetteer of this region appeared twice; the first by L. S. S. O. Malley (1910) and last by P.C. Roy Choudhury (1958). A brief physiography of the region appears in both the volumes.

The first geomorphological work of Chotanagpur of which this region is an integral part appeared in 1956 (Geomorphological Evolution of the Highlands of Chotanagpur and its Adjoining Areas in Bihar, by Dr. R. P. Singh).

In 1965 appeared the monumental work on the Geography of Bihar by Dr. E. Ahmad. Although he could devote little space to this region, whatever he has written about the morphology of this region, is thought-provoking.

*Delimitation Of The Area* : The region has a latitudinal extent of about  $1^{\circ}$  ( $22^{\circ}0'N$  to  $23^{\circ}0'N$ ) and longitudinal extent of  $2^{\circ}$  ( $85^{\circ}E$  to  $87^{\circ}0'E$ ). In the north this region is separated from the Ranchi plateau by the scarp region mainly of the Dalma volcanics, in the south it is separated from the Keonjhar district of Orissa by the Baitarani river for a great distance. In the west no natural boundary seems to separate this region from the Ranchi plateau and the Gangpur region of Orissa. To the south of Dhalbhum the region is separated from the Mayurbhanj district of Orissa by a natural scarp. In the south-eastern extremity the Subarnarekha river separates the region from the Mayurbhanj region. In the north-east especially to the north of the Dalma ridge and to the east no natural boundary is present to separate the region from the Ranchi plateau, the Manbhum plain and the lateritic Midnapore plain of West Bengal. This region contains the three incomplete drainage basins—the Subarnarekha, the Brahmani and the Baitarani. The region has an area of 5192 sq. miles or 13291. 52 sq. Kms.

## CHAPTER II

# Stratigraphical Background of Morphology

In the geomorphological study of a particular region, the knowledge of its geology is most essential. The genesis of the present day landscape has largely to be sought in the geology of the region. Therefore, perhaps Charles Lapworth appropriately asserted that geomorphology is the child both of Geology and Geography and the separation of either parent from the offspring would be to the detriment of the whole family. "Geology is in fact made up of a countless number of geographies, horizontally stratified in relation to the vertical time line; geography is therefore, only one day's issue of the world journal whose complete file constitutes geology."<sup>1</sup>

Geology of Singhbhum is bewildering in complexity. From the Archaean to the recent alluvium all formations with their striking individuality are present here. The Dalma volcanic hill rises to more than 3000' in the north of the district. A narrow, elongated shear zone which contains some important minerals like copper, nickel, uranium, and molybdenum extends E—W through the heart of the district. In this shear-zone the rocks are severely overfolded sometimes their identities being deceptively obliterated. Contrary to this, in certain areas the beds have preserved the original forms of the rocks such the unmetamorphosed conglomerates, sandstones and shales of the Kolhan series in South Singhbhum. Due to the amalgamation of such heterogenous features within a single region, Singhbhum has been aptly called the 'veritable museum of Indian Geology'.

Though the first study of the geology of Singhbhum was carried out more than a century ago, the comprehensive work intended to classify the rocks in sequence was made in 1922 (Rec. Geol. Surv. Ind., Vol. 54) by H. C. Jones. This pioneer effort was succeeded by a large number of publications by Dunn (1929, 1934, 1935, 1937, 1940 and 1941), Percival (1931 and 1940), Iyer (1932), Jones (1934), Krishnan (1935) and Dunn and Dey (1942). During the last 30 years or so numerous papers on the structural, petrological, stratigraphic and oregeologic problems of Singhbhum have appear-

ed in different journals and magazines. But there is no gainsaying the fact that Dunn's and Jones's investigations, which were carried out amidst inhospitable climate, underdeveloped communication and difficult terrain and which delineated the major stratigraphic units, gave a solid basis for all the subsequent investigations taken up in recent years.

*Stratigraphy* is the study of strata, their occurrence, lithological character, fossil content, succession and mutual relations and their classification with a view to arranging them in chronological order. Also it usually includes a consideration of those palaeo-geographical conditions that may explain the facts.<sup>2</sup>

The stratigraphy of Singhbhum has undergone a great change from H. C. Jones (1922) to Dunn and Dey (1942) and lastly to Sarkar and Saha (1962). Jones gave the following sequence of lithological units on the basis of extensive field investigations in South Singhbhum.

TABLE 1  
Stratigraphy of South Singhbhum (After Jones)

	Newer Dolerite
	Granite
	Ultrabasic rocks
	Basic lavas
Iron-ore series	Upper Shales
(Newer Dharwar)	Banded haematite-quartzites
	Lower shales
	Purple and grey limestones (local)
	Basal conglomerate and sandstone
...	Unconformity
	...

(Older Dharwar) Older Metamorphics—quartzites, quartz mica, hornblende and chlorite—schists.

Besides this basal conglomerate Jones could recognise "other conglomerates which he regarded as 'intraformational' in the upper part of the Iron-ore series."<sup>3</sup>

South Singhbhum and the adjoining areas resurveyed by Dunn (1929, 1937, 1940) and Dunn and Dey (1942) who gave a new interpretation of their stratigraphy. Dunn made the following corrections on Jones' succession :

1. The Older Metamorphic Series is not a separate series but is a part of the Iron-ore series consisting of certain banded jaspers and hornblende schists, the metamorphic rocks are the metamorpho-

sed parts of the Iron-ore series.

2. The basal-conglomerate is not at the base of the Iron-ore series but it belongs to a much higher series. It is the basal rock of a younger system characterized as 'Kolhan series' by Dunn. There is a distinct unconformity at the base of the Kolhan series separating it from the rocks belonging to the Iron-ore series.

3. Jones has always considered granites intrusive into the Iron-ore series as younger than the basal-conglomerate but Dunn did not find support of this idea from field evidence and therefore he has remarked that the Kolhan series rests unconformably on the Singhbhum Granite which means that the basal-conglomerate is younger than the Singhbhum Granite.

Percival<sup>4</sup> and Spencer<sup>5</sup> were also extremely critical about Jones' interpretation of 'intraformational conglomerates'. Percival remarked that while he had not seen any other rocks overlying the conglomerate of Deo Nadi, he has seen shales and limestones at that place. However, as these two authors did not provide any map their interpretations were not taken up seriously.

Dunn and Dey (1942) divided the Iron-ore series into two groups—the Chaibasa stage and the Iron-ore series in east and north Singhbhum. The Chaibasa stage, whose position according to those authors is unequivocal in the stratigraphy of Singhbhum, "is the oldest group of rocks and occupies the core of the anticlinorium followed by Iron-Ore stage rocks to the north in normal sequence."<sup>6</sup> The thrust zone, however, intervenes these two series to the south of the anticlinorium. But to the north and south of the shear or thrust zone these two beds are easily discernible. However, for all practical purposes the stratigraphic succession of Singhbhum given by Dunn and Dey (Table II) was holding good and was accepted by all the geologists interested in the geology of Singhbhum. But recently Sarkar and Saha (1959, 1962, 1963, 1964a, 1964b and 1967) have made a revision of the stratigraphy of Singhbhum (Table III) on the basis of structural interpretation of some areas and age data from different places. They postulated three orogenic cycles in Singhbhum, namely—the Older Metamorphic orogeny (3035 million years), the Iron-ore orogeny (2000 million years) and the Singhbhum orogeny (905-934 million years). The following are the chief characteristics of the new order of sequence :

1. The revival of the Older Metamorphics on which base the rocks of the Iron-ore series were supposed to have been deposited. But they have not given any geological evidence to justify this



revival.

2. The other important change noted in this succession is having the Iron-ore stage north of the thrust-zone and equating it with the lower Dhanjori group of rocks. According to these authors there is a striking lithological difference between the Iron-Ore series rocks north and south of the thrust zone. Sedimentary facies change is supposed to be the cause of the lithological difference by Basumallick (1963) and Sen (1963).

3. Thirdly, in Sarkar and Saha's succession sandstones and conglomerates are seen at the base of the Iron-Ore series south of the Copper Belt thrust-zone.

4. Fourthly, Chaibasa stage which has been emphatically stressed by Dunn and Dey (1942) to be the lowest bed in stratigraphical position has been given a much higher place by Sarkar and Saha (1962), thereby proving it to be much younger than the Iron-Ore series.

5. Fifthly, they have introduced a new series namely Singhbhum series which includes Dhalbhum stage (Sarkar and Saha, 1962) corresponding to the Iron-Ore stage and Chaibasa stage of Dunn.

TABLE II  
Stratigraphic Succession in Singhbhum & Adjacent Areas  
Dunn & Dey (1942)<sup>7</sup>

<i>North &amp; East Singhbhum</i>		<i>South Singhbhum &amp; South Dhalbhum</i>
(North of Copper Belt Thrust Zone)		(South of Copper Belt Thrust Zone)
Soda granite and granophyre		Kolhan series Unconformity Soda granite, granophyre and Biotite granite Singhbhum May be pre-Granite Dhanjori Diorite
Dalma lavas		Dhanjori group Lava Quartzite-conglomerates
	Overlap	Unconformity
Iron-ore stage	Phyllite  Quartzite, often	Phyllite and tuff with arkose conglomerate and quartzite



*North & East Singhbhum**South Singhbhum & South Dhalbhum*

Iron ore Series	hematite	Iron- ore Stage	Banded hematite-quartzite
	Phyllite, calcareous rocks with tuffs and basic igneous rocks		Phyllite, tuff and basic igneous rocks.
	Micaschist, hornblende schist, quartzite-granulite, quartzite schist ; tuffs where less metamorphosed		Basic lava.
Chai- basa Stage			

TABLE III

**Revised Correlation of the Pre-Cambrians of Singhbhum and  
Adjoining Areas (Sarkar and Saha)<sup>8</sup>**

<i>South of Copper Belt Thrust Zone</i>		<i>North of Copper Belt Thrust Zone</i>
Newer Dolerite		Newer Dolerite
Ultrabasic bodies (mainly with Singhbhum Granite)		Ultrabasic sills and dykes
Granophyre, Biotite Granite		Soda granite, granophyre,
		Chakradharpur Granite-Gneiss
Gabbro—anorthosite		
Ultrabasics of Jojohatu		
<i>Singhbhum orogeny</i> (905-934 mil- lion years)		<i>Singhbhum orogeny</i>
Dhanjori lava		Dalma lava
Quartzite—conglomerate	...	Overlap ...
Kolhan series (1584 million years)	Singhbhum Series	Dhalbhum stage
		(Iron-ore stage of Dun)
<i>Unconformity</i>		Chaibasa stage
Singhbhum Granite		
Iron-Ore Orogeny (c. 2000 million years)		