

GEOMORPHOLOGICAL STUDY OF WEATHERING PROCESS IN MAMA BHAGNE PAHAR, BIRBHUM DISTRICT, WEST BENGAL

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Abstract

Granite landscape are characterized by the presence of sharply defined residual hills rising abruptly from the surrounding plain. It's average elevation from sea level is 77 metre of 252 feet Mama Bhagne pahar is a rock formation near Dubrajpur town in the Indian state of West Bengal, the balancing of the rocks are so surprising that it is a famous landmark in West Bengal. In Mama Bhagne Pahar region weathering process is very active. This research is characterizes the weathering of natural building stone using an field observation and instrumental methods. Weathering is the disintegration, decomposition and breakdown earth material in situ, differences in weathering from place to place thus play a key role I defining the character of a landscape. A distinct boundary between unweathered and weathered rock that moves downward as weathering proceeds is known as weathering front.

Key Words: Mama Bhagne Pahar, Granite landscape, Weathering, Weathering Front, Disintegration

INTRODUCTION: The study area (Mama Bhagne Pahar) is characterised by both physical or mechanical weathering and chemical with bio-chemical weathering probe area. It is the extreme eastern part of the chotanagpur plateau region where the granite is gray and composed of glassy quartz pink, gray feldspar and black mica. Granite landscape are characterized by the presence of sharply defined residual hills rising abruptly from the surrounding plain. In this paper an attempt has also been made to abuse the geomorphic features with different weathering process like mechanical weathering, chemical weathering and biological weathering. Weathering is the change of ground materials under influence of the Earth atmosphere, hydrosphere, cryosphere, biosphere, and by nuclear radiation , mostly causing hard ground to become soft ground. (Hack, 2019). Weathering being part of geomorphic processes is the disintegration and decomposition of rocks and minerals on the earth's surface as a result of physical and chemical action. Weathering is a diverse process that has implications for a wide range of earth and surface processes . (Shalkowski et al., 2009). The surface relief of any land is not permanent on the earth. Every block of rock is subjected to modifications. Over a period of geological time, these surface blocks and rocks break down into smaller and finer pieces. (Balasubramanian, 2016). The effect of weathering on rocks may be reflected by changes in index properties such as dry density, void ratio, clay content and P- wave velocity. Because these properties of rocks have geotechnical significance , it is

important for geotechnical engineers to assess the weatherability of rocks and to quantitatively classify weathered rocks. (Heidari et al., 2013). The base cations and phosphorus that are essential for forest growth can be re-cycled from organic residues through microbial decomposition but if they are lost through removal of organic material the only way they can be replaced is by weathering of rocks and minerals.

OBJECTIVE OF THIS STUDY: Objective of any study lead the organized systematic guideline of the theme and provide substantial degree of momentum to attain the reality. The major objectives of this study can be expressed by the following means—

- (1) To trace out the morphological evolution of weathering process in Mama Bhagne Pahar region.
- (2) To identify major and minor geomorphic features of study area.
- (3) To identify clear boundary between unfeathered and weathered rocks , which is called weathering front.
- (4) To analyse the character of the terrain and the spatial distribution of different types of weathering in relation to landscape setting.

METHODOLOGY: The study is based on the following steps-

- (1) Pre-field work: At the outset location of the area which is geographically known as the tor topography or granitic dom topography was identified in the map and the area was demarcated . A literature survey was done from the published works.Observed the different types of mechanical weathering like, Exfoliation, Block Disintegration, Granular Disintegration , Boulder Cleaving, different mechanical biological weathering.
- (2) Field work: Identification of different types of weathering in the field observation methods and instrumental methods.
- (3) Post-field work: After completing my field work the final maps, charts and final writing has been prepared. Geomorphic processes in this region have been analyze in this paper.

WEATHERING IN MAMA BHAGNE PAHAR REGION: The process of disintegration and decomposition of rocks insitu is generally called weathering. It means weathering is a static process. According to C.D. Collier (1969) –“Weathering is the breakdown and alteration of minerals near the earth's surface to products that are more in equilibrium with newly imposed physio-chemical conditions”. The same types of weathering do not happen in all environments. The nature and magnitude of weathering differs from place to place and region to region. The controlling factors of weathering are climate, particle size, mineral composition and structure of rocks, exposure, nature of slope or gravity, floral effects, time and pollution etc. Thus weathering processes or simply weathering are divided on the basis of weathering agents, into 3 major types—

Three major types of weathering

1. Physical or mechanical weathering	2. Chemical weathering	3. Biological weathering
(a) Block disintegration due to temperature	(a) Oxidation	(a) Plant weathering
(b) Granular disintegration due to temperature	(b) Carbonation	(b) Animal weathering
(c) Block disintegration due to frost	(C) Solution	(C) Biochemical weathering
(d) Exfoliation or onion weathering due to temperature and wind	(d) Hydration	(d) Anthropogenic weathering
	(e) Chelation	
	(f) Hydrolysis	

In this study area Mama Bhagne Pahar region weathering prone area like physical weathering, chemical weathering and biological weathering. Insolation weathering is a type of physical weathering which involves repeated heating and cooling of rock over daily cycles, progressively breaking apart the grains of rock. In the natural environment, temperature and moisture are very important parameters in stone degradation. Process of mechanical weathering is related to diurnal insolation are largely unexplored. Recent studies demonstrated that rocks in a range of environment exhibit preferentially oriented cracks that are hypothesized to form as rocks are heated and collecting the sun's daily transit across the sky.

1. EXFOLIATION: When the top layer of rocks open from the bottom layer due to temperature variation, it is called an exfoliation. Exfoliation happens in places where there is a very big difference in temperature between the night and day. During the day the heat causes the outer layers of the rocks to expand. At night the cold temperature causes the outer layers of the rocks to get smaller and they contract.

- **Origin:** Because rock is a poor conductor of heat, the upper layer of rock expands with intense heat during the day and shrinks at night. But there is no contraction or expansion at the bottom of the rock. The result is a thermal slope from the inside of the rock layer to the outside. Due to the continuous expansion of the outer part, the upper part of the rock layer protrudes like an onion peel.
- **Characteristics:** The main characteristics are-

(1) The granitic batholiths, which are exposed above the ground surface, are being continuously affected by exfoliation weathering.

(2) Differential heating of outer and lower shells of a rock mass causes flaking.

(3) This weathering usually occurs in rocks composed of homogeneous minerals.

(4) As a result of this weathering , parent rock becomes somewhat domed.



Plate-1: Exfoliation: Exfoliation is the process by which the outer layer of rocks slowly peel away due to pressure changes

2.BLOCK DISINTEGRATION:

- **Origin:** Because rock is a poor conductor of heat, the upper layer of rock expands with intense heat during the day and shrinks at night. But there is no contraction or expansion at the bottom of the rock. As a result of unequal compression and compression innumerable vertical and parallel cracks are formed and large boulders fall off.
- **Characteristics:** If the temperature of granite rocks is increased by 65.5°C ,the rock expands by 2.54 cm per 30.48 metre distance.

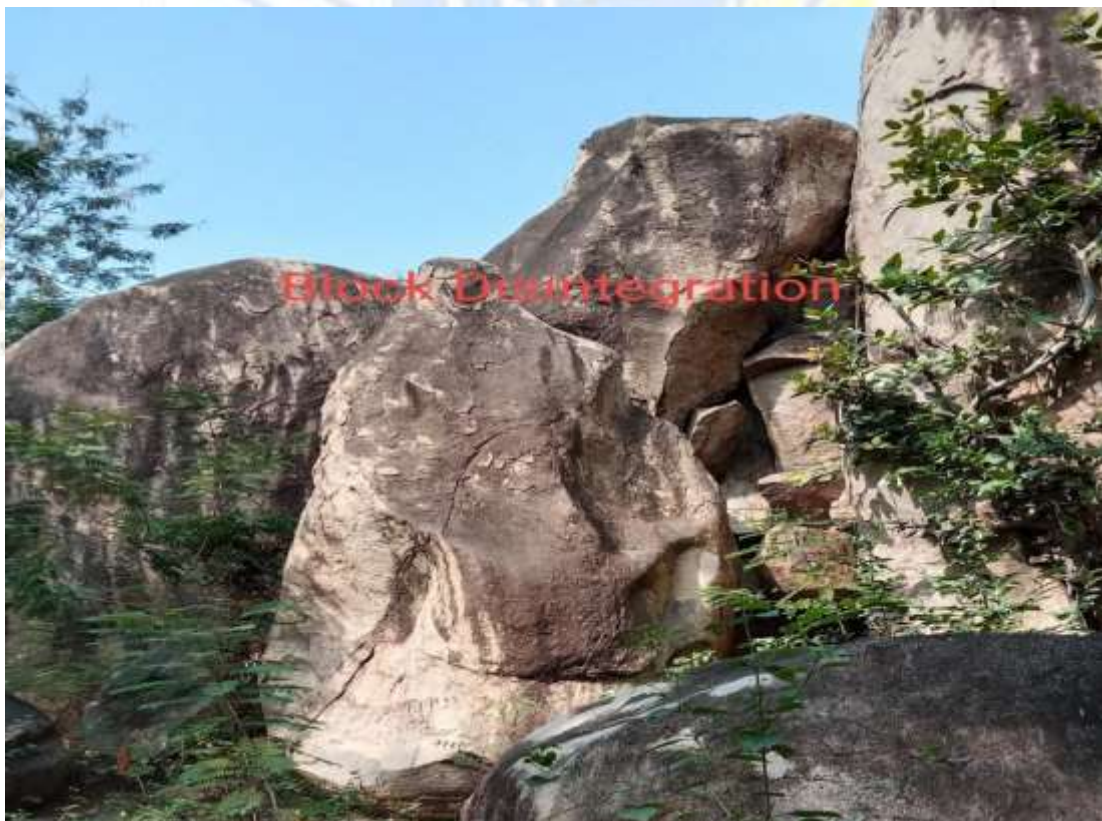


Plate-2: Block disintegration: A form of weathering where the grains of a rock become loosened and fall out due to repeated heating and cooling as a result of temperature changes.

3.GRANULAR DISINTEGRATION:

- **Origin:** Rocks are composed of a combination of different minerals and the properties, nature and colour of the minerals are different. As a result, minerals in the rock expand at different rates during the heat of the sun during the day and contract at different rates during the night. As a result of unequal contraction and expansion the rock erupts and becomes tiny rock.

4.BOULDER CLEAVING: Boulder cleaving refers to breaking and splitting of boulders of granites and basalts and complex boulders due to thermal expansion. In case where the follicles are slightly penetrated into the fine grained rock layer and the rest are exposed, in that case the protruding part of the grained rock is much more compressed and extended than the protruding part. This causes the rock to break along the junction of exposed and buried parts.

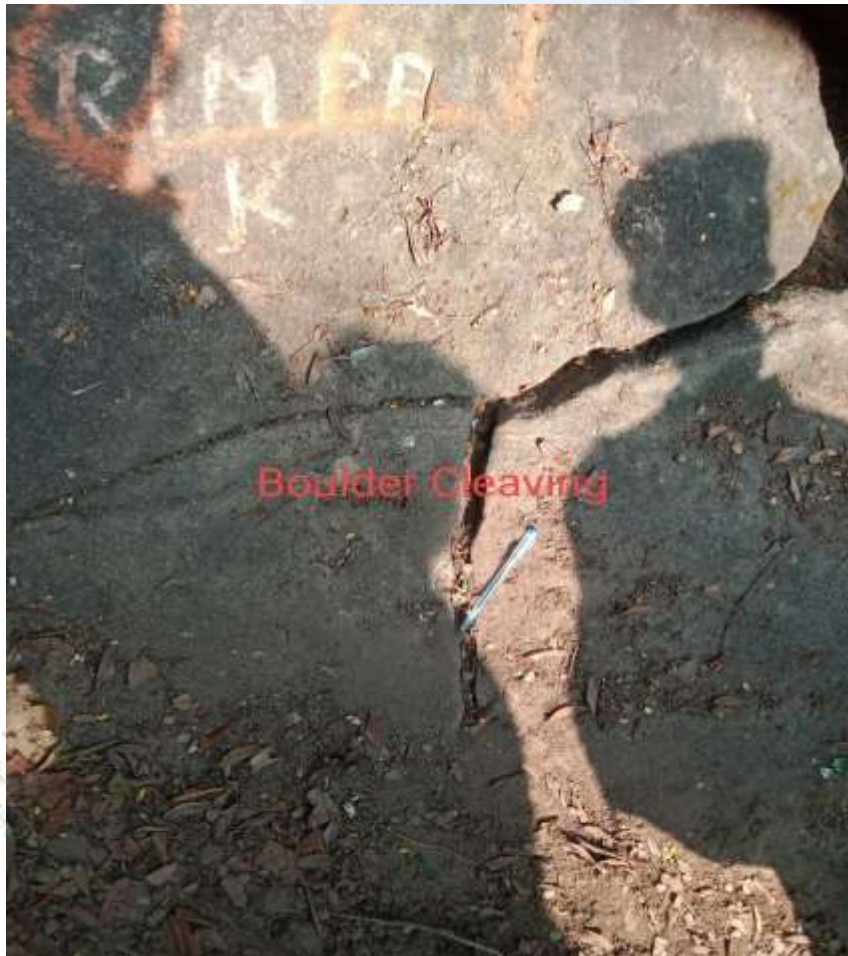


Plate-3: Boulder cleaving: Breaking and splitting of Boulder of granites due to thermal expansion

Table-2: Mass weathering grades used by engineers

Grade	Class	Description
VI	Residual soil	Soil with characteristics horizon development
V	Completely Weathered	All rock material is decomposed to soil but the original rock texture or fabric is largely preserved.
IV	Highly weathered	Rock is discoloured throughout , more than half of the rock material is decomposed, discoloured rock is present as blocks or rounded cornerstones.
III	Moderately weathered	Less than half of the rock is decomposed or disintegrated . Fresh rock fragments are present as blocks or corestones which fit together.
II	Slightly weathered	Rock may be slightly discoloured , especially along joints, rock is not much weaker than when fresh
I	Fresh rock	Parent rock showing little or no sign of discolouration.

In most accumulations of weathering products it is possible to recognize varying degree of alteration ranging from nearly fresh rock to completely altered material. It should be noted that the surface soil, rich in plant roots and humus is not included in the classification as it owes it's characteristics as much to plants and/or human interference as it does to weathering processes within the regolith. In a particular profile not all grades may be present, thus a profile may pass from fresh rock grade I, into moderately weathered grade III, and then into an agricultural soil.

1. WEATHERING FRONT: The weathering front is the interface between intact or unweathered bedrock and the weathered rock, saprolite, regolith or soil above it's. The concept of a clear boundary between unweathered and weathered rock, that moves generally downward as weathering proceeds – the weathering front .



Plate-4: Weathering Front: Weathering front is the interface between unweathered bedrock and the weathered rock.

GEOLOGICAL SETTING OF THIS STUDY AREA: Mama Bhagne Pahar is the extreme eastern part of the chotanagpur plateau where the granite is gray and composed of glassy quartz pink, gray feldspar and black mica. Dubrajpur group(Mahadeva series) -the relationship between the rocks of Dubrajpur and Barakar groups, are sometimes obscure , but the lower beds show signs of disturbance to a greater extent than the upper beds. Cases of overlap are also numerous which indicate that an interval in which denudation was active elapsed between the two periods. In the absence of good series of fossils either in the typical Mahadevas or Dubrajpur rocks, lithological resemblance and physical relations to other known rock groups are used to correlate them together. The evidence afforded by these two characteristics, is in favour of the view, that the rocks belonging to the Dubrajpur group represent locally in the Rajmahal hills , the upper panchet or lower Mahadevas of other parts of India.

EVOLUTION OF DOMES AND TORS: The most obvious morphological features which denote a dome are their domical form with summit convexity, steep slopes consisting of bare rocks and a clear differentiation from the surrounding terrain. These features are often associated with curvilinear joint patterns leading to the formation of sheets. It is because of these characteristics that this particular type of inselberg is also known as 'exfoliation domes' (Thomas M.F., 1974, p.173). There is great variety in the morphology adopted by the domes and tors. They may be composed of one solid, virtually unjointed , rock mass standing in isolation above the adjacent slopes. They manifest curvilinear fracture pattern. They are also known as Bornhardt (Willis, 1934). The term 'Glockenberg' meaning a bell shaped hill is an equivalent (Jibon, 2006, p.85) . Another type manifests orthogonal fracture pattern and referred as castle Koppies. A third type consists of jointed and broken dome. They are also referred as Boulder inselbergs and boulder strewn inselberg (Migon, 2006), nubbin and knoll. In Mama Bhagne Pahar region two types of forms can be noticed. The following section deals with the morphological analysis of individual domes and the associated features derived from the disintegration of domes in Mama Bhagne Pahar region.

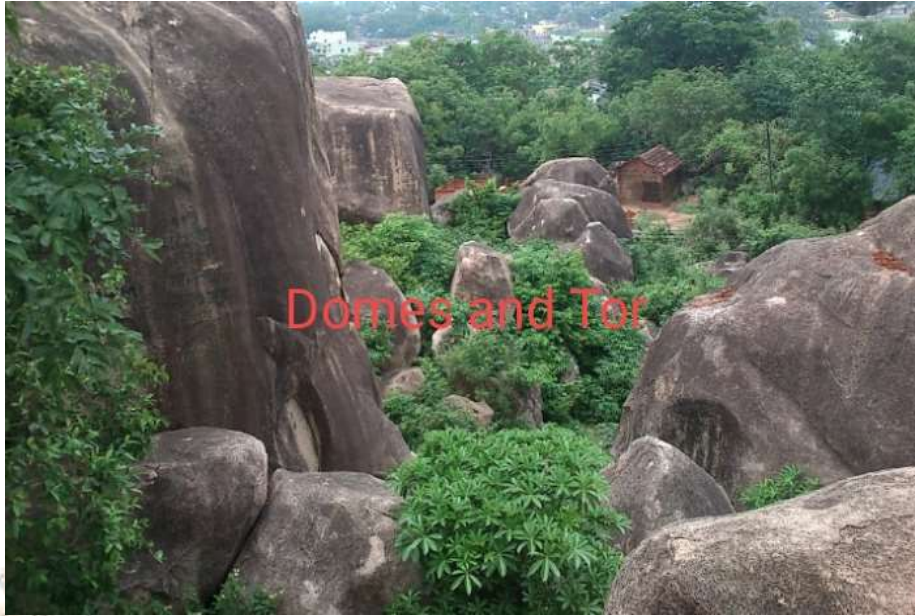


Plate-5: Domes and tors: Most joints have angular intersection but weathering attack occurs on all faces of a joint block so that sharp corners are gradually rounded by weathering. Even sharply irregular blocks are gradually rounded within the figure.

BIOLOGICAL WEATHERING: Biological weathering is the weakening and subsequent disintegration of rock by plants, animals and microbes. This type of weathering occurs in different ways like---

1. In the Mama Bhagne pahar region, growing plant roots can exert stress or pressure on rock. Although the process is physical, the pressure is exerted by a biological process (i.e. growing roots).
2. Biological processes can also produce chemical weathering in this study area, for example, when plant roots or microorganisms produce organic acids which help to dissolve minerals.
3. In the Mama Bhagne region, microbial activity breaks down rock minerals by altering the rock's chemical composition, thus making it more susceptible to weathering.



Plate-6: Bio-mechanical weathering: Cracks are widened by root penetration and consequent root pressure. Weathering of rocks by vegetation takes place in physical weathering.



4. In Mama Bhagne region animals like birds forage for seeds and earthworms, they create holes and erode the upper surface of the soil, thus contributes to weathering.

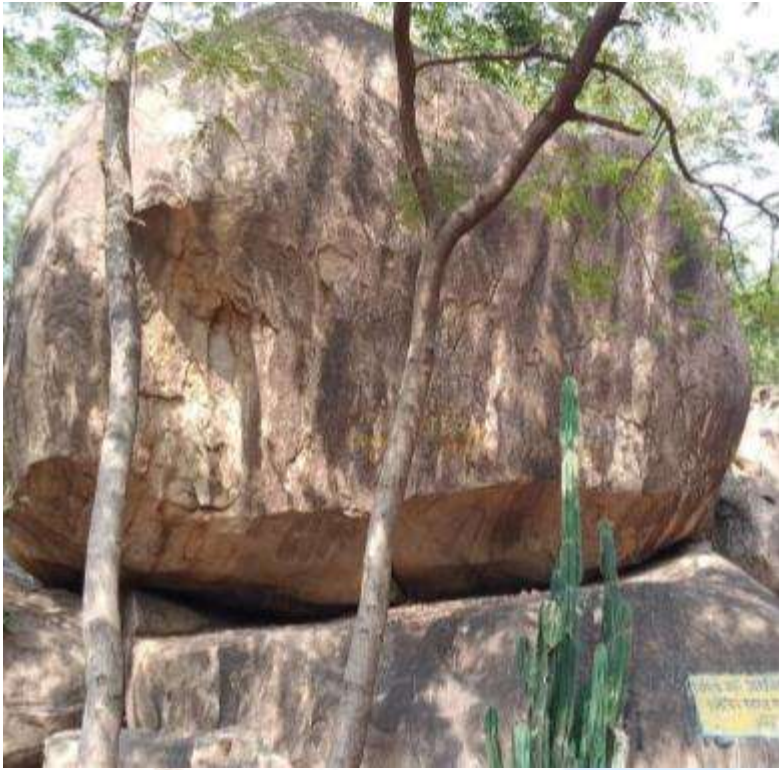

WEATHERING AND SOIL FORMATION: Regolith, a region of loose unconsolidated rock and dust that sits atop a layer of bedrock. On Earth, regolith also includes soil, which is a biologically active medium and a key component in plant growth. Soil is formed as a natural body out of weathered material. There is tremendous interest in understanding the process that controls the interaction between minerals and aqueous solution in the weathering mantle (i.e. regolith cover). Topography has a marked effect on the rate of weathering and also on the nature of weathered product as discussed above which in turn control the thickness of the weathering mantle. According to geomorphologist or soil science, soil is a three-dimensional body at the Earth's surface which supports plants and is generally produced out of alteration of weathered material so that a distinct layering of its mineral and organic components appears. Such layering is called soil horizons.



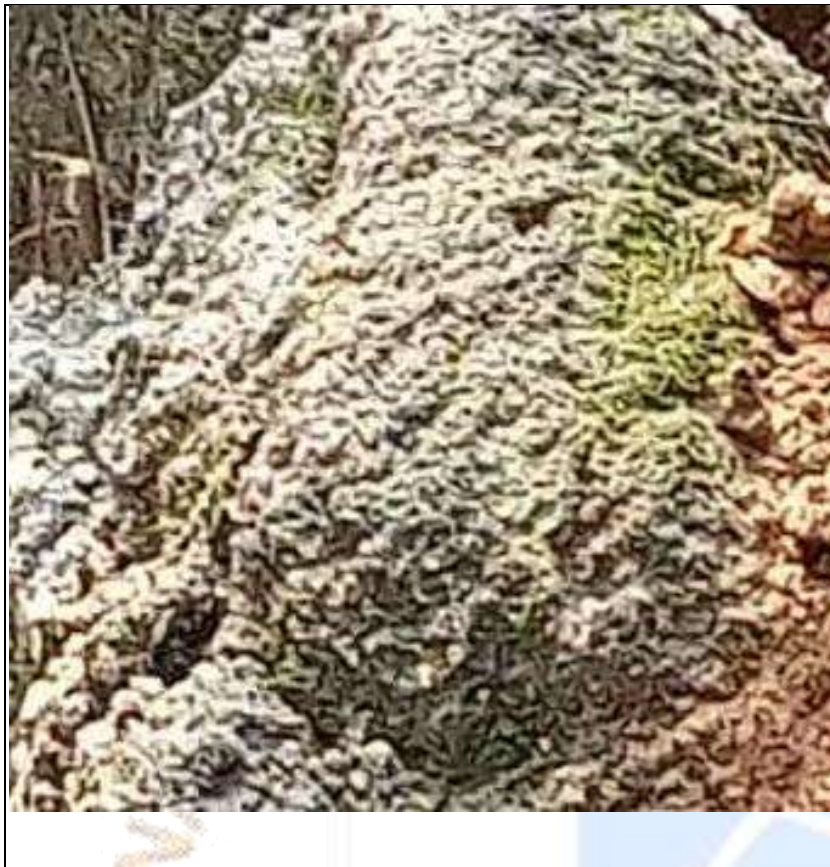
Plate-7: Regolith and soil formation

MAJOR DISCUSSION AND FINDINGS:

Weathering /landforms	Name	Description
	<p>Boulder cleaving</p>	<p>Boulder cleaving caused by insolation weathering due to thermal expansion of the outer heated layer of the Boulder during sunnydays.</p>
	<p>Weathering front</p>	<p>The interface between unfeathered bedrock and weathereed rock, saprolite,regolith or soil above it.</p>

	<p>Spalling This spalling Length-6.7 metre Breadth-1.1 metre</p>	<p>The process of spelling ,which is a weathering process refers to the development of platy rock fragments in the rock due to unloading of super incumbent load.</p>
	<p>Tors and Domes</p>	<p>A tor or castle Koppies or kopje is a large, free-standing rock outcrop that rises abruptly from the surrounding smooth and gentle slopes of a rounded hill summit or ridge crest.</p>

	<p>Regolith and soil formation</p>	<p>Formation of regolith by breaking down of the bed rock . The addition of organic matter through the decomposition of plant and animals tissue and reorganization of these components by soil formation.</p>
	<p>Bio-mechanical weathering</p>	<p>Plant also break up rocks. If a plant roots grow into cracks in a rock then they may make the crack wider.Over time this may cause the rock to break apart.</p>

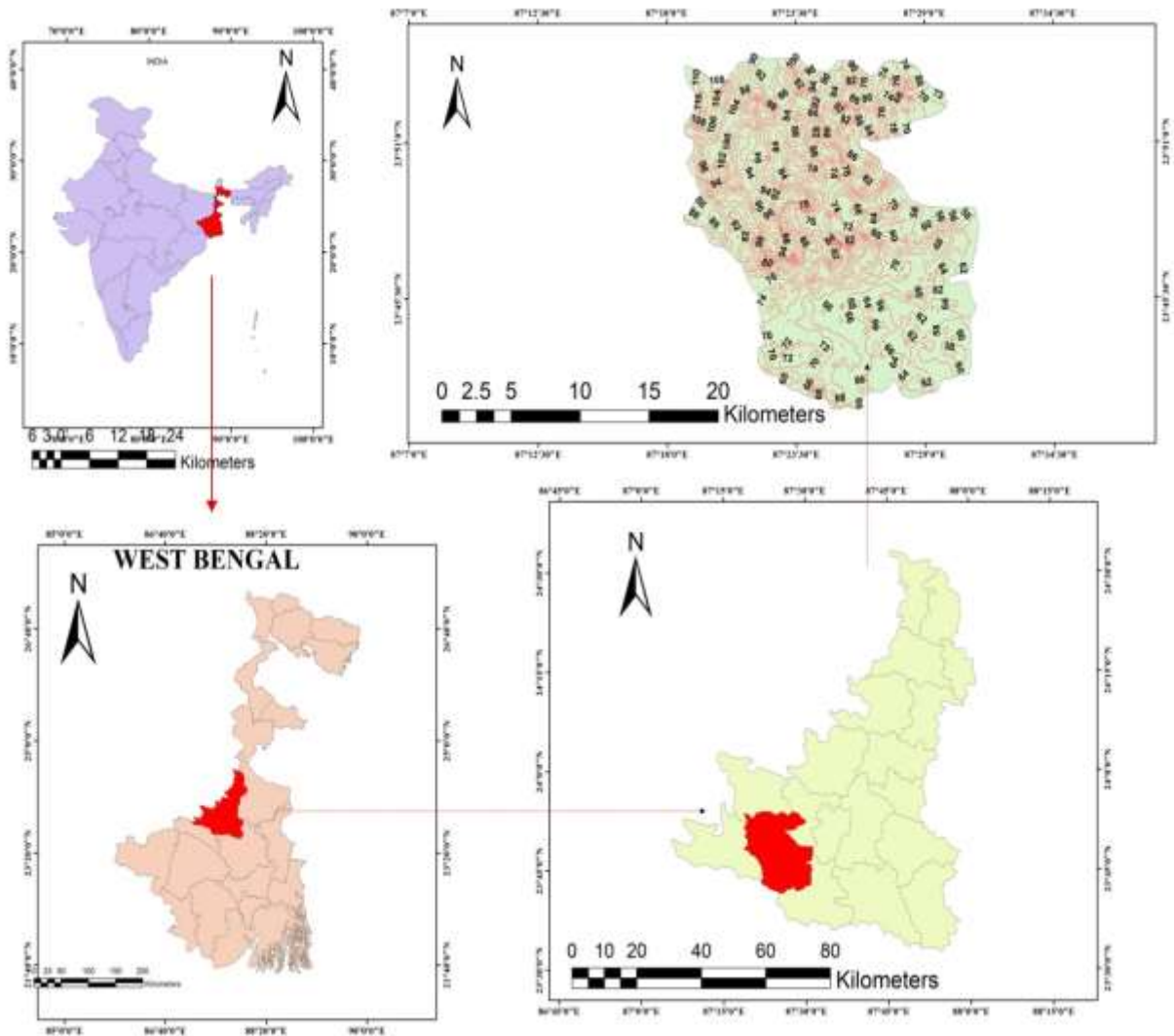


<p>Bio-chemical weathering and chelation</p>	<p>Decomposition and disintegration of rocks due to organic materials of both flora and fauna. A complex set of different biochemical processes such as cation root exchange, chelation, solution by root exudates and production of different kinds of organic acids.</p>
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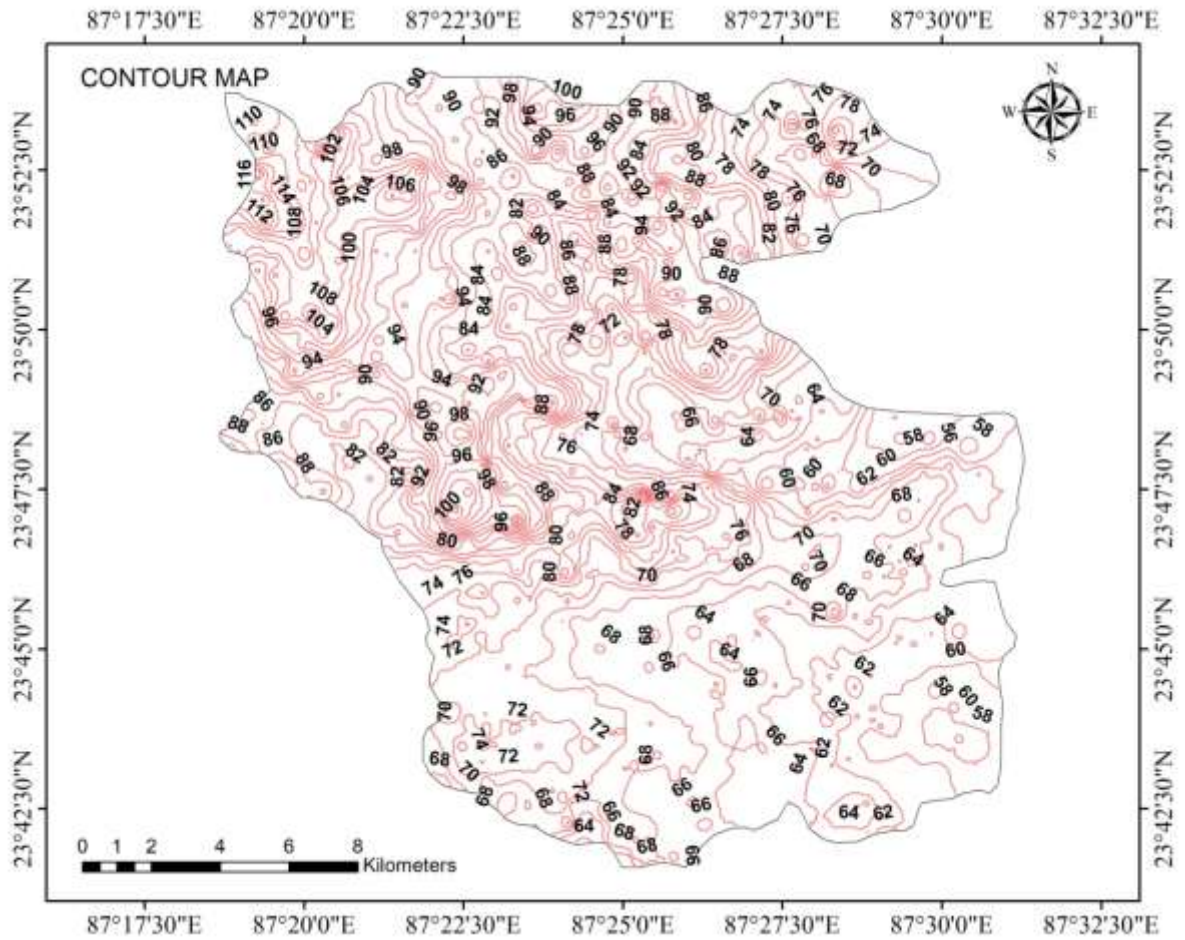
CONCLUSIONS: The leached layer of the transitional zone is finally exfoliated from the hydrated zone to be a member of the exfoliated zone. A distinct boundary between unweathered and weathered rock that moves downward as weathering proceeds -the weathering front-is explicitly or implicitly part of landscape evolution concepts of etchplanation, triple planation, dynamic denudation and weathering and supply limited landscape.

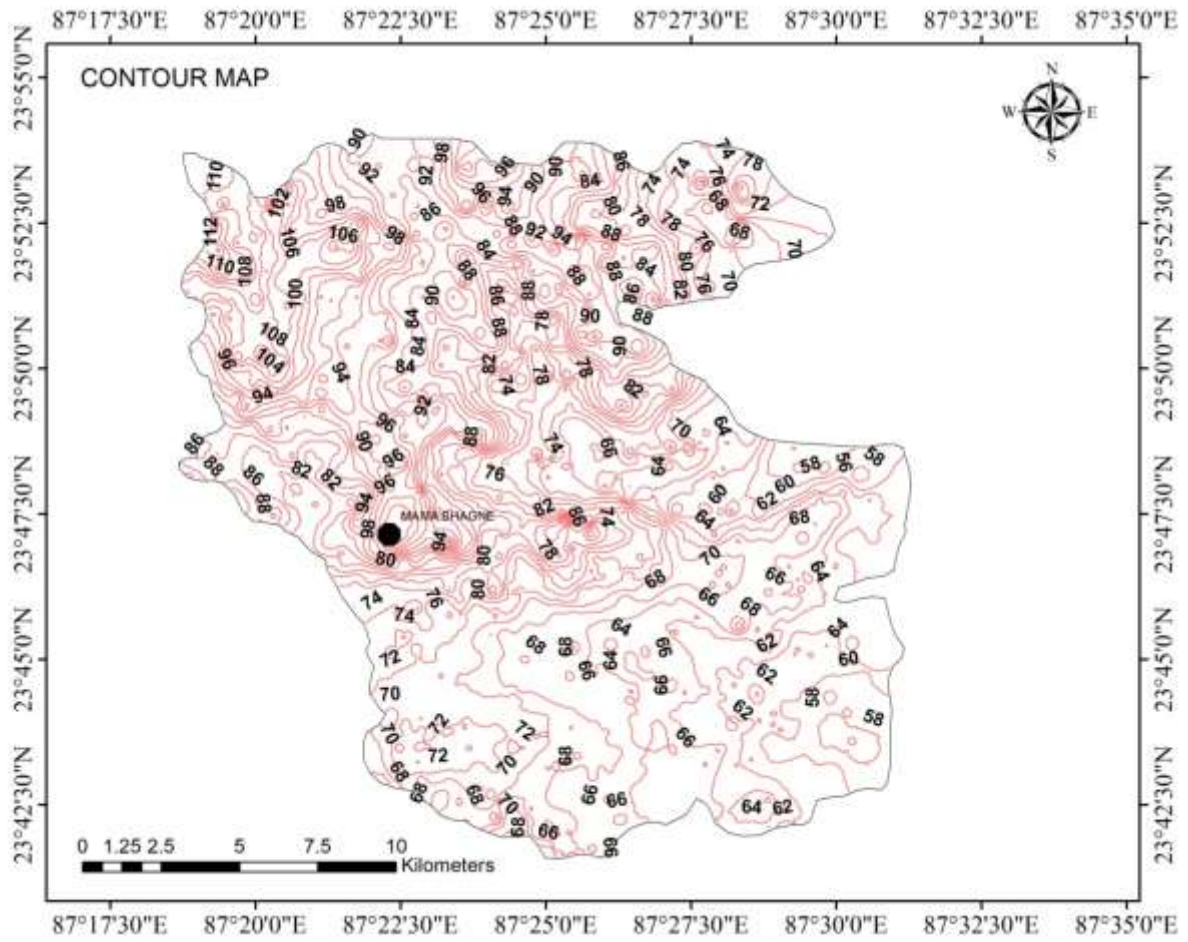
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Term (intact rock)	Description		Term (rock mass)	Description	grade
Fresh	No visible sign of weathering / alteration of the rock material.		Fresh	No visible sign of rock material weathering. Perhaps slight discoloration on major discontinuity surfaces.	0
Discolored	The color of the origin fresh rock material is changed and is evidence of weathering/alteration .		Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces.	1
Disintegrated	The rock material is broken up by physical weathering , so that bonding between gains is lost and the rock is weathered / altered towards the condition of a soil in which the original material febric is still intact.		Moderately weathered	Less than half the rock material is decomposed or disintegrated.	2
Decomposed	The rock material is weathered by the physical alteration of		Highly weathered	Ore than half of the rock material is	3

	the mineral grains to the condition of a soil in which the original material fabric is still intact.			decomposed or disintegrated.	
			Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.	4
			Residual soil	All rock material is converted to soil . The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.	5

Table: Weathering description and characterization of intact rock and rock mass (ISO 14689- 120170)