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RESEARCH PAPER

Large-scale geomorphological mapping and geological evolution of granite tors in the semi-arid climate of Precambrian Chota Nagpur Plateau, India

Biswajit Bera[1] · Soumik Saha[1] · Sumana Bhattacharjee[2] · Sisir Chatterjee[3] · Mahua Chatterjee[4] · Nairita Sengupta[5] · Supriya Ghosh[1] · Arijit Ghosh[1] · Sudipa Sarkar[1] · Enamul Haque[6] · Bilwamangal Mandal[1] · Madhumita Khan[1] · Anchita Mahato[1] · Sourav Kumar[1] · Monoj Kumar Bauri[1] · Safik Ansary[1] · Kusum Bauri[1] · Mehbub Ansary[1] · Mahabir Sing Babu[1]

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Abstract
Isolated bedrock outliers amid regolith-covered slopes are named tors that become an object of interest in many geological and long-term landscape evolution studies. These landform features are developed within a wide range of lithology, although granite and gneisses are the common rocks for the development of tors. However, this paper represents a comprehensive method for large-scale mapping of tor and its associated geomorphic conditions of two tor sites near Turi and Seraikela in the Chota Nagpur Plateau Region of Jharkhand. Detailed documentation has been prepared (in terms of geomorphological and geological properties) of the tor sites to know the comprehensive overview (bedrock properties and micro and macro geological features) of the tor regions. The entire study consists of three different stages including the preparation of a digital spatial dataset, field visit, in-situ geomorphological mapping and cartographic symbolization. A total of 29 mapping features have been identified and these are used in this study for a simple 2-dimensional representation of tor morphology and interpreting the controlling factors of tors and its evolutionary pathway. It is also observed that the massif part is characterized by a high Schmidt hammer rebound value (Sometimes, rebound value exceeds 50), whereas, the jointed and fractured part shows a low rebound value. The primary joint direction is SE-NW at the Turi site and approximately E-W at the Seraikela site. Based on this kind of detailed mapping one can extract the information regarding the geological pathway, weathering of rock surface, internal morphological differentiation, and orientations of discontinuities of the tor region.

Keywords Tor · Chota Nagpur Plateau · Schmidt hammer · Rebound value · Geomorphological mapping

Introduction

Tors are the conspicuous rock multitudes that are significantly raised overhead the surrounding regional ground surfaces. Tors are the localized bedrock outcrops within the regolith or soil-covered slopes, associated with strangely shaped

Biswajit Bera and Soumik Saha have contributed equally to this study.

✉ Biswajit Bera
biswajitbera007@gmail.com

[1] Department of Geography, Advanced Geomorphology and Hydrology Laboratory, Sidho-Kanho-Birsha University, Ranchi Road, P.O. Purulia Sainik School, Purulia 723104, India

[2] Department of Geography, Jogesh Chandra Chaudhuri College (Under University of Calcutta), 30, Prince Anwar Shah Road, Kolkata 700 033, India

[3] Department of Geography, Raidighi College (Under University of Calcutta), Raidighi, West Bengal, India

[4] Department of Geography, Lady Brabourne College (Under University of Calcutta), Beniapukur, Kolkata 700017, India

[5] Department of Geography, Diamond Harbour Women's University, Sarisha 743368, India

[6] Department of Geography, Netaji Subhas Ashram Mahavidyalaya, Suisa, Purulia, West Bengal (Under Sidho-Kanho-Birsha University), Lagda, West Bengal, India

up to a height of 20–30 m (Michniewicz et al. 2020). Generally, tors may develop in different rock types but are most commonly associated with granitic platforms (Migoń 2006). The widespread use of the term 'Tor' within the geological literature can be traced back to the seminal paper of Linton (1955). He mentioned the term 'Tor' from 'Turris' (the Latin word) which means 'Tower' (Selby 1972). Linton also defined the landform tor as 'a residual landmass of bedrock that noticeably uplifted than the surrounding rock platform and present form (isolated by steep rock faces) is due to the result of differential weathering and erosion (Linton 1955). An alternative definition of tor was given by Selby (1972). He defined tor as 'an isolated rock mass that ranges from 3 to 50 m from the rock platform'. Usually, tors are a monolithic geological feature but distinct with several stacks on a rock platform, sometimes, separated by joints and detached as pillows. Tors have a trend to form as a group in certain areas particularly, in plateau areas or uplands (Gunnell et al. 2013), and this kind of grouping pattern of tors is also linked with bedrock type, discontinuities, and intensity of weathering of the area. Formation of tor encompasses weathering rate and different weathering processes amidst the regolith-covered sloppy area (Michniewicz et al. 2020). Tors generally develop where the joint spaces are wide and the rocks are large with a high degree of crystalline formation (a high degree of crystalline rocks can resist the erosional agents then the surrounding surfaces and the resulting exposed rock is known as tors) (Gibbons 1981), where the minerals such as K-feldspar (Gibbons 1981; Pye 1986) and biotite (Eggler et al. 1969) are more ample within the bedrock. However, tors originated through differential subsurface weathering processes along the weak zone, followed by the exclusion of weathering products by the denudational processes (Meinecke 1957; Wilhelmy 1977).

Most of the tor-related papers are interrelated with photograph analysis, idealized sections analysis, idealized features analysis and the making of schematic diagrams of the concerned region, but a few studies attempted large-scale geomorphological mapping on tor morphology (Grab et al. 2011; Rypl et al. 2014; Michniewicz et al. 2020). Thomas (1967) presented a detailed large-scale geomorphological map of the granitic dome with a special focus on the geomorphology of the exposed bedrock surfaces and the structural properties of the region. He also mapped and compared the morphological features with slope inclination to show the evolutionary pathway. Dyke (1976) also represented a large-scale schematic map to show the outcrops in detail. He also mapped the weathering materials and the solifluction movement to show the general slope of the area. Grab et al. (2011) also mapped a sandstone landform in Golden Gate National Park, South Africa and they have also used 28 symbols with a contour interval of 100 m. Detailed outline of granite outcrops connected with periglacial hillslope morphology which was studied at Bodmin Moor upland (SW England) (Evans et al. 2017). Debates among the protagonists of the development process of tor epitomized from the late 1950s (Linton 1955; King 1958; Cunningham 1965). Now, researchers are more focused on the emergence of tors from the bedrock rather than the sequential evolution. Gunnell et al. (2013) have also used the cosmogenic isotope method to demonstrate the sequential development of low tors (less than 5 m), and they identified that it may take approximately 100,000 years time interval from their emergence to decay. Previously, different concepts of tor formation were used in Britain (Linton 1955) and Germany (Meinecke 1957), subsequently, these methods were applied to other landscapes in Europe and various corners of the globe on a regional scale (Martini 1969; Bartošíková 1973; Jahn 1974). Linton (1955) also recognized that many tors are located noticeably in a state of collapse associated with individual pillows those sliced vertically (Linton 1955). Tors are commonly comprised of residual undisturbed cores and stacks (Gunnell et al. 2013).

Tors are the distinctive granitic landforms on the Manbhum-Singhbhum Plateau of the Chota Nagpur Region. Dome top tors, ground tors, and valley side tors are the important types of tors in this region. The denudation process across the joint surfaces undermines the rock's stability and causes it to slide, rotational fall, and topple. However, it is believed that detailed large-scale mapping of tor can understand the magnitude of geological control and its degradation pathway. Therefore, in this paper, we present a cartographic approach to map bedrock outcrop distribution and characteristics. A detailed map of the tor area will support the spatial analysis of the entire tor region, and ultimately the spatial distribution pattern of tors. In addition, the use of different symbolization processes can help to identify the geological and morphological differences among them. This kind of tor analysis and mapping studies also helps us for the crucial understanding of the morphological evolution, and geological characteristics of the landscape. Tor mapping becomes a tool for the simple representation of landscape development. Precise mapping of tors can enhance the proper understanding of physical properties and associated microforms. Therefore, a cartographic approach has been taken here as a primary objective to accurately analyze the distribution of tor landforms using remote sensing applications and combined with ground mapping and analysis during and after fieldwork.

Study area

Chota Nagpur Plateau is located in the eastern part of India and it covers most parts of Jharkhand, the western part of West Bengal, and some parts of Bihar, Chhattisgarh and Odissa. This region is recognized as India's oldest

Precambrian terrain (Ball 1881; Dunn 1929), and known as the Singhbhum Protocontinent that consists of three significant litho-tectonic blocks (Singhbhum Granite Complex in the south, the Chota Nagpur Gneissic Complex in the North and the North Singhbhum Fold Belt in the middle) (Saha 1994; Saha et al. 1988). Palamu, Ranchi, Manbhum-Singhbhum and Hazaribagh Plateaus are the main part of the Chota Nagpur Region. Ranchi Plateau covers the highest areal extension along with a 700 m average elevation. The investigated tor regions (near Turi in East Singhbhum District (tor 1 (22.660587 86.171149)) and near Seraikela Town of Seraikela-Kharsawan District (tor 2 (22.690572 85.914404))) stand under the Manbhum-Singhbhum Plateau Region (Fig. 1).

Geological and geomorphological characteristics of the Manbhum-Singhbhum Plateau

This plateau section is situated in the eastern part of the Ranchi plateau. The signatures of volcanic outbursts are imprinted through intrusive dykes and sills (Singh 1977). Some important elevated regions of the Manbhum-Singhbhum Plateau are Dalma Hill (906 m), Ajodhya Hill (698 m), Bansa Hill (305 m), Biharinath Hill (451 m), Susunia Hill (425 m), Panchkot Hill (492 m) etc. (Ghosh et al. 2023). The Manbhum-Singhbhum Plateau of the Chota Nagpur region is the part of Singhbhum Granitic Complex and the eastern segment of the North Singhbhum Fold Belt (Roy and Purohit 2018; Ghosh and Bera 2023). This Plateau is subdivided into (i) the western highland region (ii) the central Plateau region (iii) the Dalma highland region (iv) the Dhanjori region, and (v) Subarnarekha Plain region. Western highland is characterized by the rocks of Dharwarian and Cuddapah formations whereas granite-gneissic rocks are mainly confined in the Central highland region. The central part is occupied by the Gamharia highlands and Haldipokhar lower plateau which has less variability of Pre-Tertiary dolerite dykes. Huge numbers of tors are situated above Arkasani granophyre deposits along the road section of Jamshedpur to Haldipokhar. Another important section

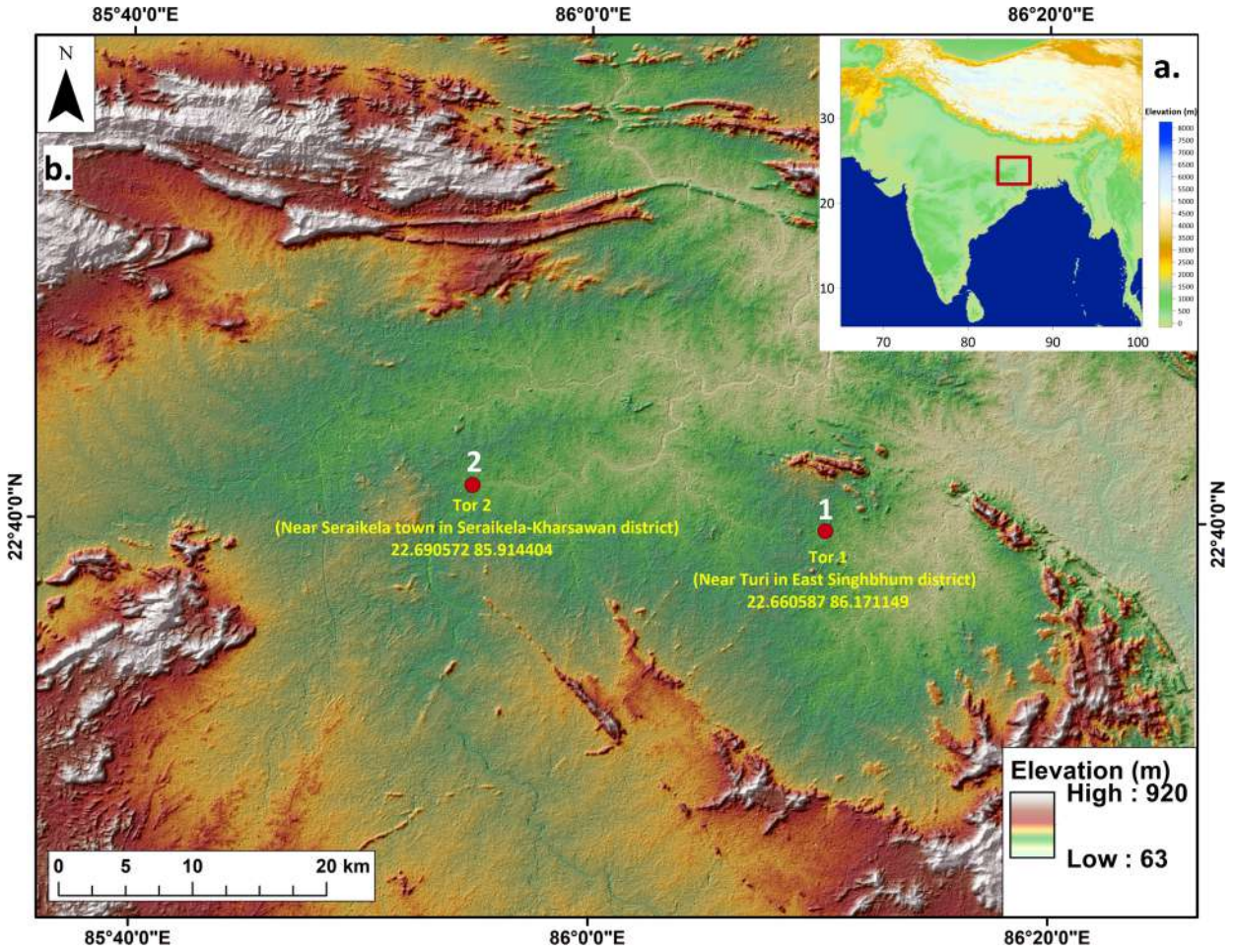


Fig. 1 **a** Location of Chota Nagpur Plateau within India; **b** Variation of relief in the Plateau Region and locations of the selected tor sites; 1. Near Turi in the East Singhbhum District (tor 1); 2. Near Seraikela Town of Seraikela-Kharsawan District (tor 2)

of the Manbhum-Singhbhum Plateau is the Dalma highland which is mainly formed by the invulnerable basaltic lava deposition. Dhanjori formation covers late Paleoproterozoic rocks (Fig. 2a) and the rivers of this portion are loaded with fragments of debris (Acharyya et al. 2010). Conglomerate, phyllites, and lavas are characterized by Dalma and Dhanjori highlands. Furthermore, the Archean deposit (mainly Dharwarian deposits) was uninvolved from the crystalline batholitic structure through denudation and ultimately developed tor landform (Ghosh and Bera 2023). Subarnarekha plain is composed of an iron-ore series overlain by Tertiary grits, gravels and recent alluvium.

Many tors stand as ground tor, valley side tor and hilltop or dome top tor in the Manbhum-Singhbhum Plateau region. The South-west and western parts of the Manbhum-Singhbhum Plateau consist of the lower Bonai group although the western part (near Manoharpur) is occupied by the Gangpur group (Fig. 3). The main characteristics of Bonai formations are dominated by the Archaean Iron ore group of rocks with basic volcanic lava (Mohakul and Bhutia 2015). The southern section (near Chaibasa to Raruan) of the Manbhum-Singhbhum Plateau appears under the Chota Nagpur granitic gneissic complex. In the middle portion of the Manbhum-Singhbhum Plateau, the left bank of river Subarnarekha encompasses the Dalma group of formations (Roy and Purohit 2018). On the right bank, the opposite side of Ghatshila Town contains the Dhanjori group of formations (Fig. 3). The southeastern section (near the Similipal region) encloses Similipal lava and it is encircled by numerous rocks of Similipal formation. Correspondingly, the Subarnarekha Plains of the Manbhum-Singhbhum Plateau hold iron ore series with recent alluvium (Singh 2014).

Tors near Turi in East Singhbnum District (tor 1) under the Manbhum-Singhbhum Plateau Region

Various isolated granitic tors have been exposed near Turi (22° 39′ N and 86° 10′ E) as ground and dome top tors. The contour

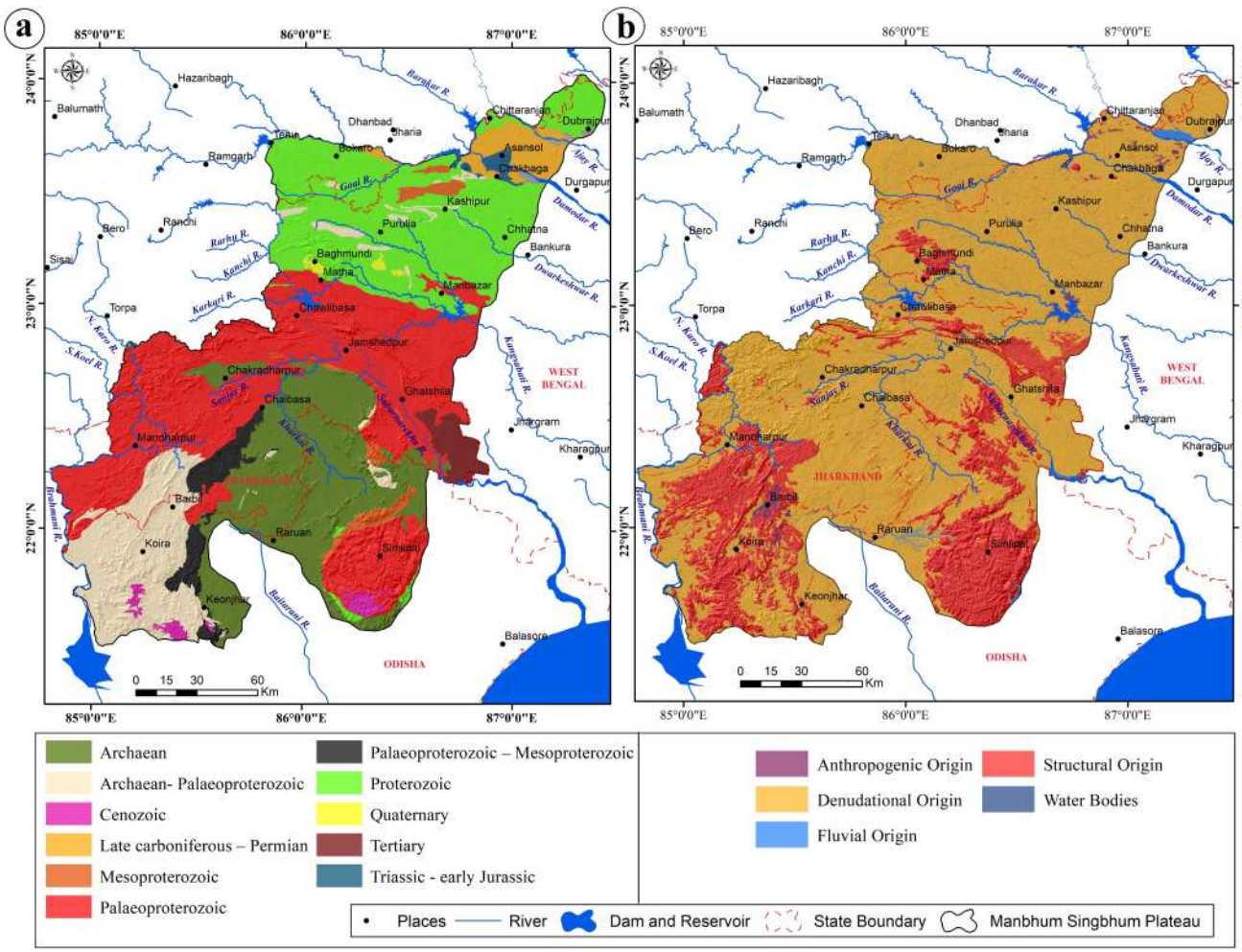


Fig. 2 **a** Geological age of formation of the Manbhum-Singhbhum Plateau; **b** Types of origin of Manbhum-Singhbhum Plateau according to (Geological Survey of India 2022)

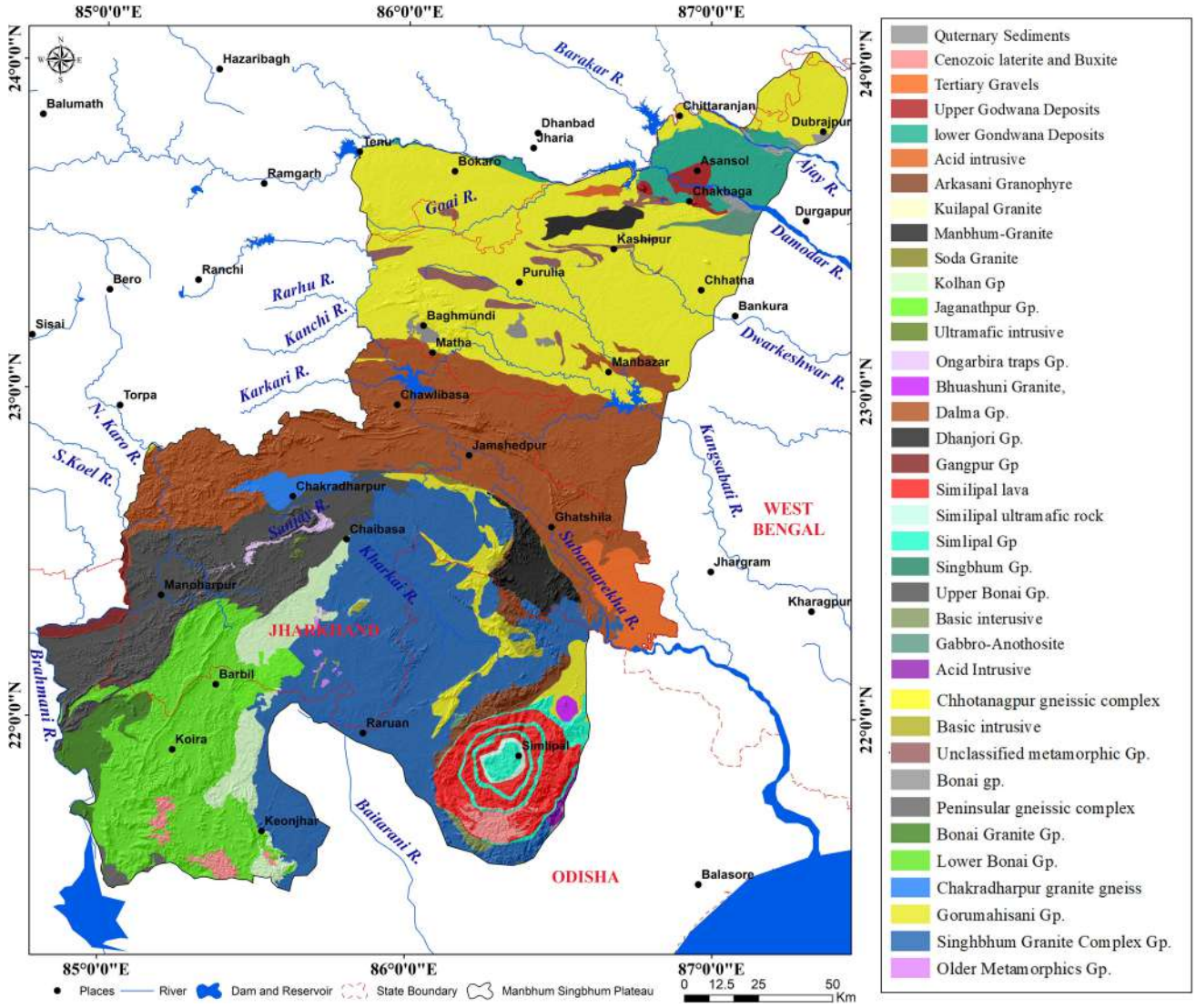


Fig. 3 Simplified geological map of Manbhum-Singhbhum Plateau (Geological Survey of India 2022)

ranges from 172 to 190 m and the maximum height of tor in this area does not exceed 10 m. The tors of the Turi site are associated with compact rock walls and massive structures but sometimes high density of joints and fractures within the rock masses accelerate a high magnitude of weathering and erosion. The entire region is characterized by loose boulders near rock platforms and also ground tors. Different micro-relief and geological features such as weathering pits, tafoni, aplite veins, quartz veins, closed depression etc. have been exposed at the proximity of Turi site tors in the Manbhum-Singhbhum Plateau Region.

Tors near Seraikela Town in Seraikela-Kharsawan District (tor 2) under Manbhum-Singhbhum Plateau Region

Multiple tors near Seraikela town (22° 41′ N and 85° 54′ E) stand as ground or dome top tors and contour varies from 171 to 176 m. The entire region is characterized by a series of tors, inselbergs, and huge in-situ rock blocks and boulders. The geological features in this region are highly diversified and associated with high towers, rock walls, boulder clusters, dome-shaped rock platforms etc.

Materials and methods

The methodological procedure of this study has been categorized into three successive steps. Firstly, it includes the selection of the study area and pre-processing of satellite images. Secondly, it is associated with field visits and geomorphological mapping. This stage is very challenging for the identification of micro features because micro features cannot be identified based on remote sensing analysis. Some areas in the studied section cannot be accessible due to several difficulties, so, the respective sketches also are created over the base map along with suitable photographs of the concerning features during the field. We have also made a detailed note of the region and its surroundings at the same time. And finally, cartographic symbolization has been done. Some problems have been faced during cartographic symbolization and legend systems because of topographic and geologic variations. Different types of elevation data sets including ALOS-PALSAR digital elevation model data, GPS elevation data, and high-resolution Google Earth data set have been used (the mean elevation error is less than 0.3 m). The accuracy of elevation data is theoretically high to represent the general elevation profile within the selected tor sites. A large-scale map of the tor has been prepared (1:750 to 1:1000) for the convenience of identification of various microgeomorphic features. The contours are generated from the elevation data in the GIS platform and a very narrow contour interval has been chosen (1 or 2 m) to demarcate the precise location of studied objects during the extensive field mapping. Numerous field trips have been conducted from January 2023 to March 2024 for comprehensive geomorphological mapping of the selected sites. Special attention was given to the micro features within the steep slope sides. A particular location of the tor feature has been identified over the base map and supplemented with photographs of the concerned feature. Post-mapping phase was done in Arc-GIS 10.3 software and the final graphical maps were enhanced using Grapher 14 and Adobe Photoshop CS6 software. Practically, there is no hard and fast rule for the establishment of cartographic symbolization for such kind of large-scale detail tor mapping studies. The scientific paper of Michniewicz et al. (2020) was followed during the symbolization process. The proposed symbols within this study help to distinguish the qualitative expressions of the objects or features within the region. All symbols have been designed on a grey scale (including black and white elements).

Rock strength measurement and analysis of geological features

The rock strength of isolated hills of sample tors and their surroundings at two sites was measured by Schmidt hammer. We took three Schmidt hammer rebound values from each point to improve the accuracy level and ultimately mean value was obtained. Rock strength rebound value ≥ 50 represents strong rocks and it was recommended by Selby (1980). A map of relative rock strength around the sample tors at different sites was prepared to identify the weathered status of the hills. The relative rock strength maps of different tor sites and their surroundings were prepared on Surfer 14 software. Schmidt hammer rebound value replicates an internal amalgamation of rock properties (including strength, elastic modulus, rock hardness, density, and surface smoothness) (Katz et al. 2000). The discontinuity within the rock mass has been analyzed. This type of analysis is always necessary for characterizing and designing rock masses. The attitude and magnitude of joints have been manually measured using a Brunton compass. Geological hammer has also been used to identify the weathering status of the tor sites.

Results and discussion

Analysis of the used legend system

A total of 29 symbols have been used in the legend system that significantly shows the features and appropriate slope microform characteristics within the studied region (Fig. 4). The used symbols follow their areal, linear and point forms. The areal elements are also reflected in the area extension of large outcrops including rock platforms, pulpits, towers etc. The graphical symbols also provide the density of the debris and rock cover in this area. Several linear aspects (micro and macro elements) including slope break, ravine, path, bedrock step etc. show various morphological elongations. For the identification of smaller mineralogical components and lithological diversity, we have used different point features. However, this kind of symbol system does not identify the real condition of the tor morphology because in certain cases generalization methods are used. Sometimes, the assemblage of different microforms cannot be mapped separately due to scaling problems, and then the generalization methods have been applied.

Occurrence and development of Tors

In this scientific research, an attempt has been made to understand the variability and occurrence of the tors at the selected sites (Figs. 5 and 6). The large granitic tor near Turi (tor 1) also consists of two Tor clusters (eastern rock platform and western hill region). The large tors found mainly over the western part and the entire regions have faced different intensities of weathering processes. This region is dominated by physical and chemical weathering

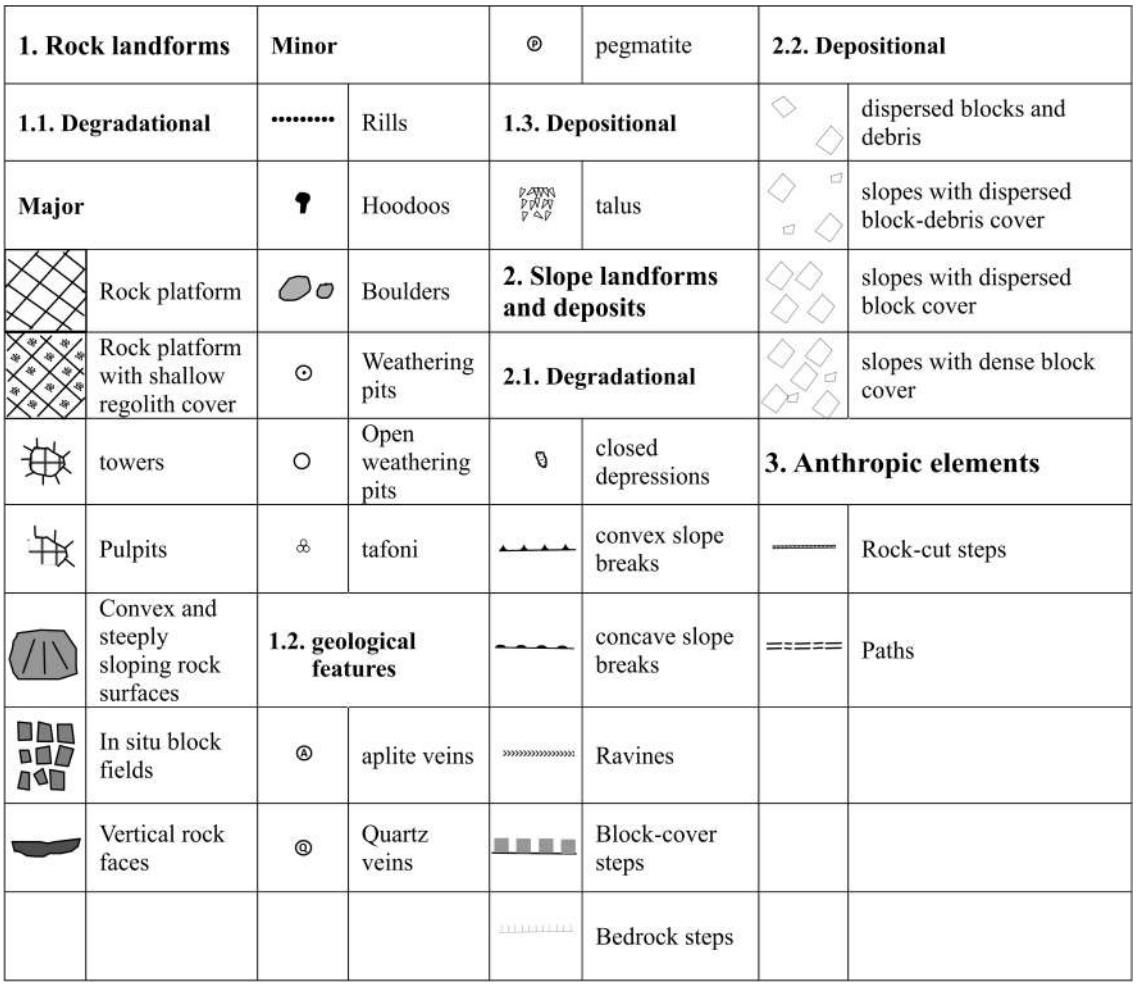


Fig. 4 Legend of the geomorphological mapping of tors of the selected sites (after Michniewicz et al. 2020)

(mean annual temperature and rainfall are 25.5 ℃ and 1313 mm), moderate wind action, and active soil erosion through running water. This Central Plateau exhibits high-intensity mechanical weathering in the form of block disintegration, exfoliation, granular disintegration and shattering due to the high range of daily, monthly and annual temperatures. The process of alternate contraction and expansion leads to the removal of the outer layer just like concentric form over the exposed granitic domes and it is a common geomorphic phenomenon over this region. The process of development of rupture leads to the enlargement of cracks by lowering the confining pressure and ultimate strength of buried rock masses due to the elimination of overlying materials by erosion. In the case of the Turi site, overlying materials have been removed by denudational processes and the internal stress of the granitic rock mass is being reduced accelerating the vertical splitting of the rocks. Occasional summer light shower over the heated granites in the Central Plateau region helps shattering and granular disintegration of rocks.

Turi site is also characterized by various weathering signatures such as weathering pits, different kinds of depressions, regolith materials and debris. The weathering pits are mainly present in the up and middle slope surfaces on the eastern side of the region. The debris materials with dispersed blocks are highly concentrated in the vicinity of the least weathered bedrock that survived the long-term weathering process. The secondary features over the tor surface have significant outcomes for the interpretation of the tor landform and provide information about the processes of the tor development (Fig. 7). The presence of the extensive amount of open and closed weathering pits in the large boulders, summit part of rock ridges and towers indicates long-term stabilization of the bedrock (Wilhelmy 1977). Large numbers of weathering pits stand on the eastern side

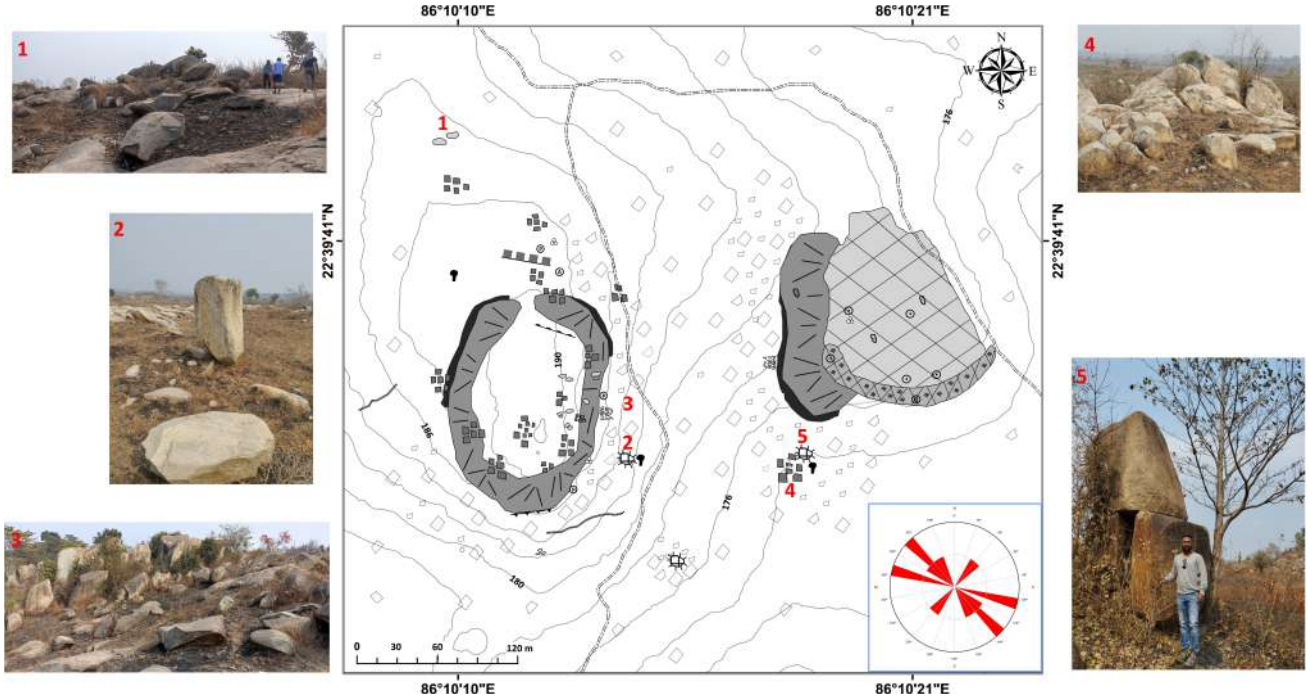


Fig. 5 Geomorphological map of the tor near Turi region (tor 1) at East Singhbhum District of Jharkhand, India

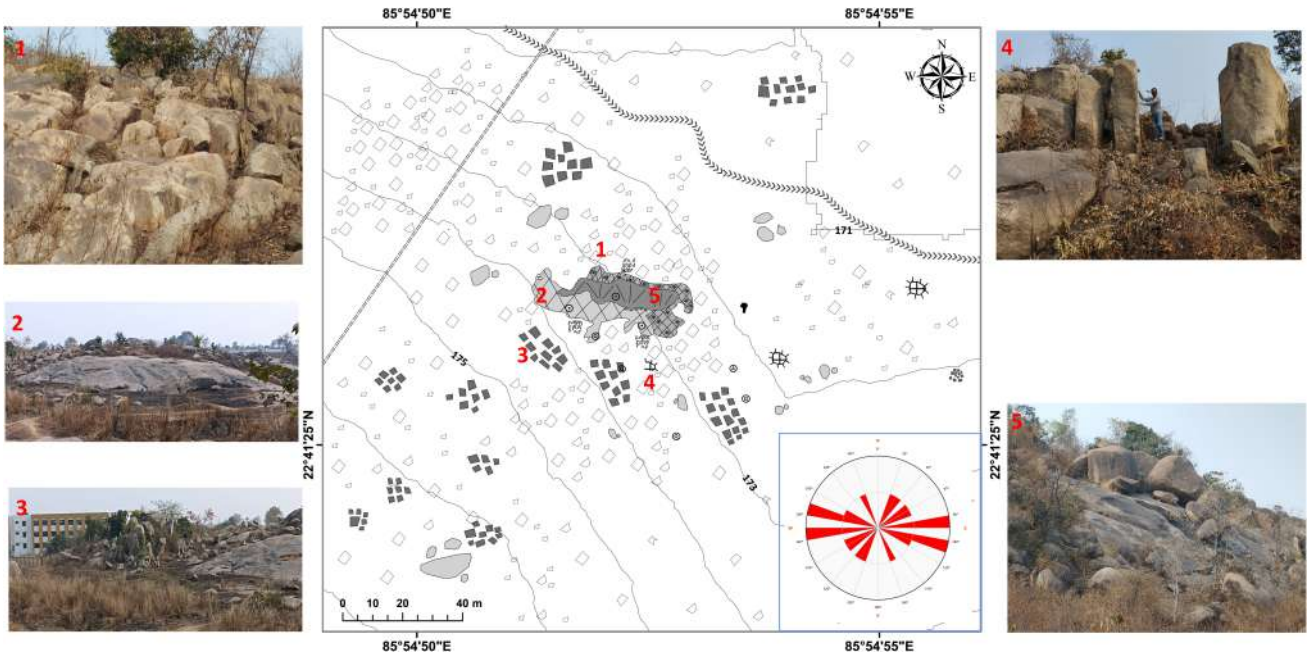


Fig. 6 Geomorphological map of the tor near Seraikela Town (tor 2) at Seraikela-Kharsawan District region at Jharkhand, India

of the Turi tor. A huge amount of in-situ block fields has been observed in the western part of the Turi tor region. Joint and discontinuity exert the role of erosion within the tor morphology. The primary joint orients approximately SE-NW direction within the Turi tor group (Fig. 5). Schmidt hammer rebound result shows that massif rock has a higher

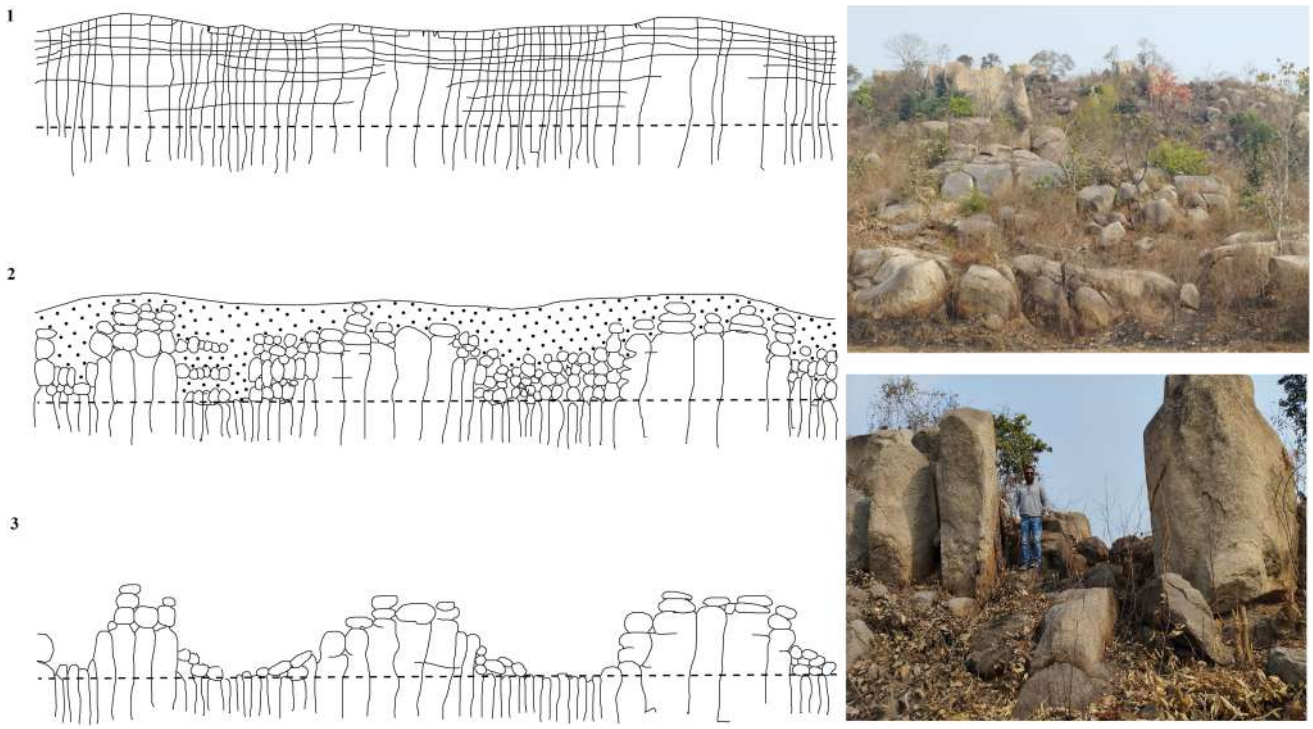


Fig. 7 Different stages of tor formation processes; 1. Highly jointed and fractured rocks; 2. Activation of deep weathering processes; 3. Removal of weathered sheets and formation of tors at the last stage (modified from Linton (1955))

rebound value than disintegrated rock masses. Sometimes, the rebound value exceeds 50 within the massif rock masses (Table 1). The rebound value in this region ranges from 54 to 20. The highest rebound value rock is termed as a fresh rock with minimum weathering imprints whereas, a low rebound value (20) was mainly observed over the residue rocks with high weathering imprints. Out of 30 points, a total of 16 points are classified under weathering grades I & II (that means rocks are good) whereas, a total of 14 points are classified under weathering grades III, and IV. It is also observable that near the discontinuity the rebound value is significantly low. Within the Turi tor group, the rebound value is greater in the northern and north-eastern parts and this region is also characterized by granitic outcrops and the rocks below the outcrops (mainly weathered) have low rebound value (Fig. 8).

The Seraikela tor group (tor 2) has similar characteristics compared with the Turi tor group. The granitic form outcrops are juxtaposed with each other consisting of large boulders, in-situ rock blocks and a huge amount of debris cover. In some cases, high block-covered steps and the disintegrated blocks are chaotically arranged. The highest density of debris occurs in the vicinity of steep rock faces, primarily dominated by the weathering process. A ravine also originates in the northern side of the tor region that also redistributes the regional debris cover and maintains the general hillslope process. Extensive in-situ blocks are noticeable in the southern part of the region. At the Seraikela tor group, the primary joint orients in approximately E-W direction, and other secondary joints are elongated in approximately NE-SW direction. Schmidt hammer rebound result shows that massif rock has a higher rebound value than disintegrated rock masses at the Seraikela tor group. It is also observable that near the discontinuity, the rebound value is significantly low. The rebound value in this region ranges from 51 to 23. The highest rebound value rock (51) is termed as a fresh rock with minimum weathering imprints whereas, a low rebound value (23) is mainly observed over disintegrated rocks. A total of 11 points are under weathering grade II (that means rocks are good). Rests are under weathering grades III, and IV. Within the Seraikela tor group, the rebound value is significantly high within massif corestones, and the entire region is characterized by disintegrated boulders with low rebound values (Table 2).

The geomorphological feature like tors is the common surface feature in this undulating terrain. These kinds of geomorphic features are the combination of several geomorphic processes through the geological time scale. Variations of bedrock types and processes are responsible for the variation

Table 1 Average rebound value and associated weathering grade of investigated points near Turi tor region

Sl no	Latitude	Longitude	Average rebound value	Weathering grade (Arikan et al. 2007)
1	22.66102	86.17181	38	III
2	22.66113	86.17173	46	II
3	22.66132	86.17176	52	II
4	22.66164	86.17183	54	I
5	22.66149	86.17206	36	III
6	22.66128	86.17234	50	II
7	22.661	86.17234	48	II
8	22.66078	86.17201	22	IV
9	22.65954	86.17009	34	III
10	22.66062	86.17257	38	III
11	22.66035	86.17243	21	IV
12	22.66008	86.16993	41	II
13	22.66046	86.16941	44	II
14	22.66095	86.17014	32	III
15	22.66035	86.17041	38	III
16	22.65964	86.17014	31	III
17	22.66163	86.17076	49	II
18	22.6599	86.1702	46	II
19	22.65987	86.16946	46	II
20	22.65996	86.17031	48	II
21	22.66069	86.17032	42	II
22	22.65941	86.16993	32	III
23	22.66048	86.17037	34	III
24	22.66058	86.16984	44	II
25	22.66039	86.17198	20	IV
26	22.66189	86.17196	52	II
27	22.66201	86.17047	46	II
28	22.66115	86.17203	44	II
29	22.66065	86.17166	22	IV
30	22.66061	86.17290	29	IV

of tors in terms of size. High physical weathering contributes to fracturing over the rock surfaces of this area, along with deep-seated chemical weathering which is highly active in this area. After denudation, the corestones are also exposed over the surface as tor. Variations of denudation processes and intensity of weathering agents control the size of the tors. Intense weathering, active erosive agents, and geological characteristics of the rocks are the main responsible factors for the size variation of the tors in this area.

Conclusion

The concept of this scientific research with cartographic sense and geomorphological significance can improve and unify the research outcomes. To conduct this research three distinct stages were followed; preparing the spatial dataset, extensive field investigation and symbolization along with different major and minor symbols and perfectly illustrating the tor morphology of the region. The granitic terrain of this region has faced a sequential erosional process since the Precambrian period. The terrain also exaggerates the rate of weathering based on its structural properties. Various circumstantial proved that structural control is one of the significant processes regarding the evolution of tor and domes in this area (Choudhary and Jha 2016). Tor features were identified from the field experience and symbols were taken from previous literature. This kind of detailed tor mapping study can support knowing the topographical setting, internal geodiversity, regional geology and landform evolution process in a subaerial condition. Based on the detailed morphological maps, we can easily explain the processes that act over the tor morphology. Based on the field investigation and cartographic analysis we can establish that weathering depth, joint

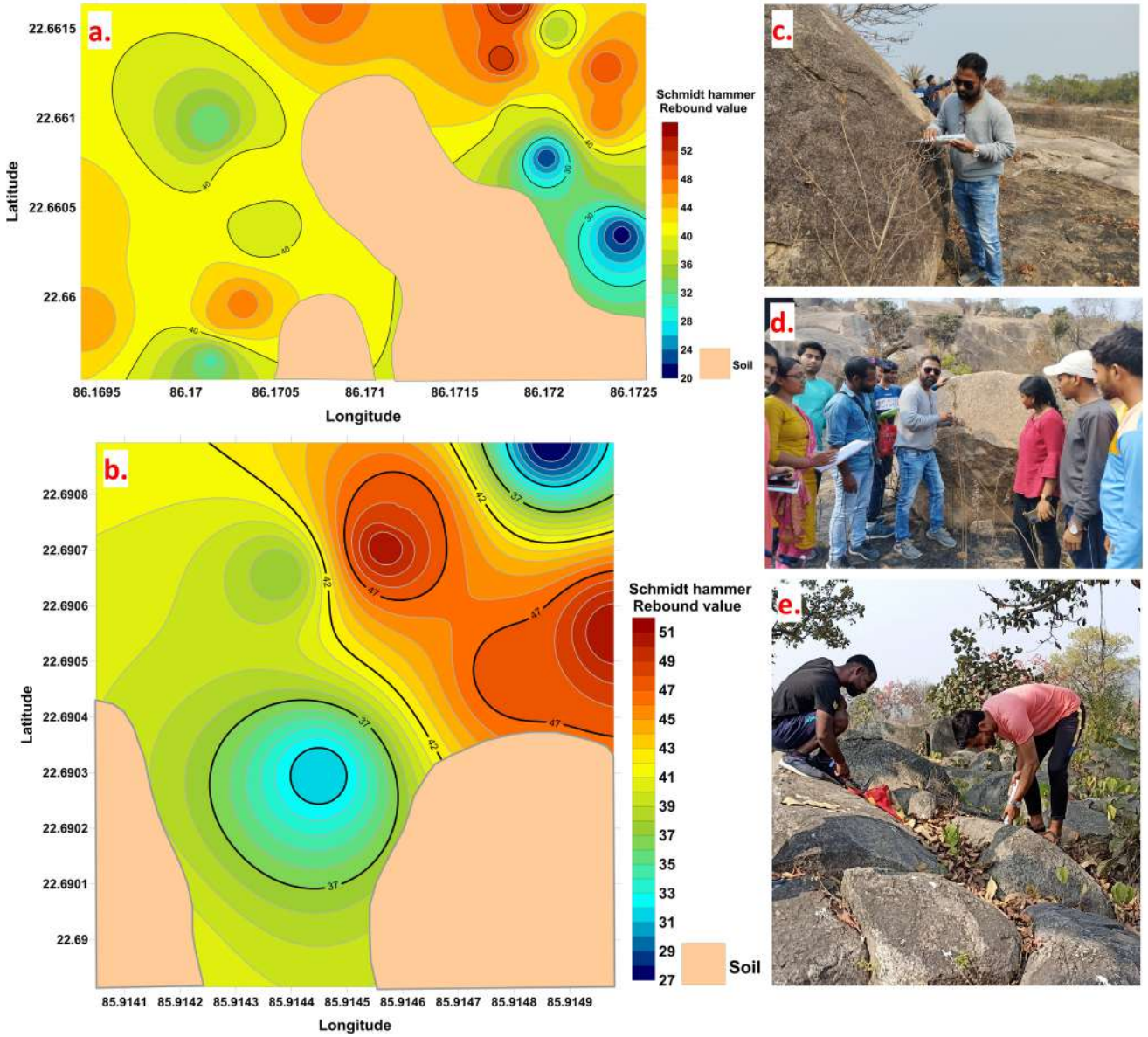


Fig. 8 Zonation of rock strength analysis within the selected sites: **a** near the Turi site; **b** near the Seraikela site; **c**–**e** Data collection of rebound values during the field

conditions, climatic factors and erosional rate are the major influential agents behind the formation of tors in this area. In addition, as the maps are prepared in a very large scale and two-dimensional plane; so, we cannot represent the spatiality of tor in a three-dimensional shape. In this kind of study, prior knowledge about the symbols is highly required for proper mapping and interpretation. There is very little study that directly mapped the tor region on a large scale. Therefore, this kind of study also opens a new pathway towards tor-related studies and makes a new research direction.

Table 2 Average rebound value and associated weathering grade of investigated points near Seraikela tor region

Sl no	Latitude	Longitude	Average rebound value	Weathering grade (Arikan et al. 2007)
1	22.69077	85.9146	48	II
2	22.69071	85.91457	51	II
3	22.69066	85.91438	37	III
4	22.69048	85.9148	48	II
5	22.6903	85.91445	31	III
6	22.68992	85.91405	42	II
7	22.69055	85.91498	51	II
8	22.69089	85.91487	27	IV
9	22.69000	85.91390	41	II
10	22.69014	85.91377	40	III
11	22.69035	85.91405	29	IV
12	22.69046	85.91385	32	III
13	22.69072	85.91410	34	III
14	22.69035	85.91434	29	IV
15	22.69027	85.91463	28	IV
16	22.69030	85.91476	34	III
17	22.69042	85.91486	46	II
18	22.69037	85.91494	45	II
19	22.69051	85.91515	48	II
20	22.69029	85.91502	44	II
21	22.69080	85.91510	23	IV
22	22.69059	85.91448	43	II
23	22.69037	85.91458	37	III
24	22.69044	85.91467	40	III
25	22.69087	85.91462	38	III
26	22.69109	85.91436	35	III
27	22.69088	85.91438	37	III
28	22.69050	85.91427	39	III
29	22.69048	85.91429	40	III
30	22.69069	85.91485	34	III

Declarations

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