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Research Article

SOME FEATURES OF WEATHERING IN THE EASTERN NORTH KARANPURA BASIN, JHARKHAND, INDIA

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ABSTRACT
The present paper concerns different weathering related features of eastern part of the North Karanpura basin. The study is based on intensive field work. The predominant rock types of the area are granite-gneiss and sandstone. The major weathering features found in the area are exfoliation, Flaking hollows, Different pits and hollows formed by solution and other processes, ball feature in sandstones, micro-ridge formation etc. Rock structure i.e. mineral composition, cementing material of the rocks and spacing of joints are of major controls of weathering.

Keywords: *Eastern North Karanpura Basin, Intensive Field Observation, Differential Hardness, Differential Heating, Rock Structure and Composition*

INTRODUCTION
The Chotanagpur plateau is an ideal area in metamorphic and sedimentary geology and tectonic history of India. The Damodar valley is one of the most important sedimentary units within the metamorphic terrain of Chotanagpur. It contains important coal basins of India. The North Karanpura basin forms a part of the coal belt among the important coal basins of Damodar valley, where all the Gondwana sedimentary units can be traced. The North Karanpura field, located in the Hazaribagh district of Jharkhand, India, covers an area of about 1230km^2 (Figure 1, 2). The extension of the basin is from 23^{0}38'N latitude to 23^{0}59'N latitude and from 84^{0}46'E longitude to 85^{0}28'E longitude. The basin is an oval-shaped elongated area, surrounded by the Precambrian shield of Hazaribagh plateau in the north and Ranchi plateau in the south. Having been flown through the middle part of the basin, the Garhi river divides the basin into two parts viz. east and west. The study is mainly concentrated on the eastern part of the basin i.e. east of the Garhi river (Blackwelder, 1925).

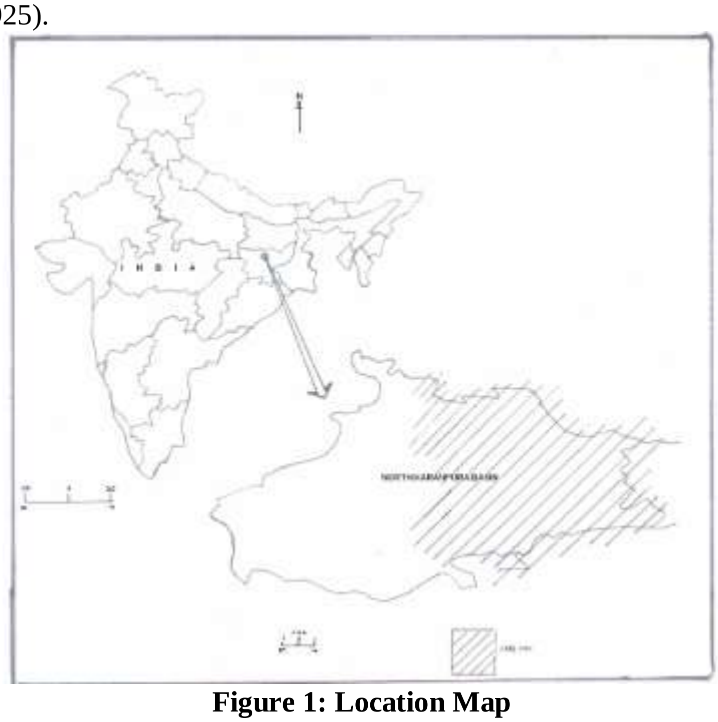

Figure 1: Location Map

Though this area is very much interesting from the point of geomorphological investigation, no attempt has yet been made for detail geomorphological study. Because of this, the researchers felt interested to study of different weathering features and reasons of the evolution of such features in that area.

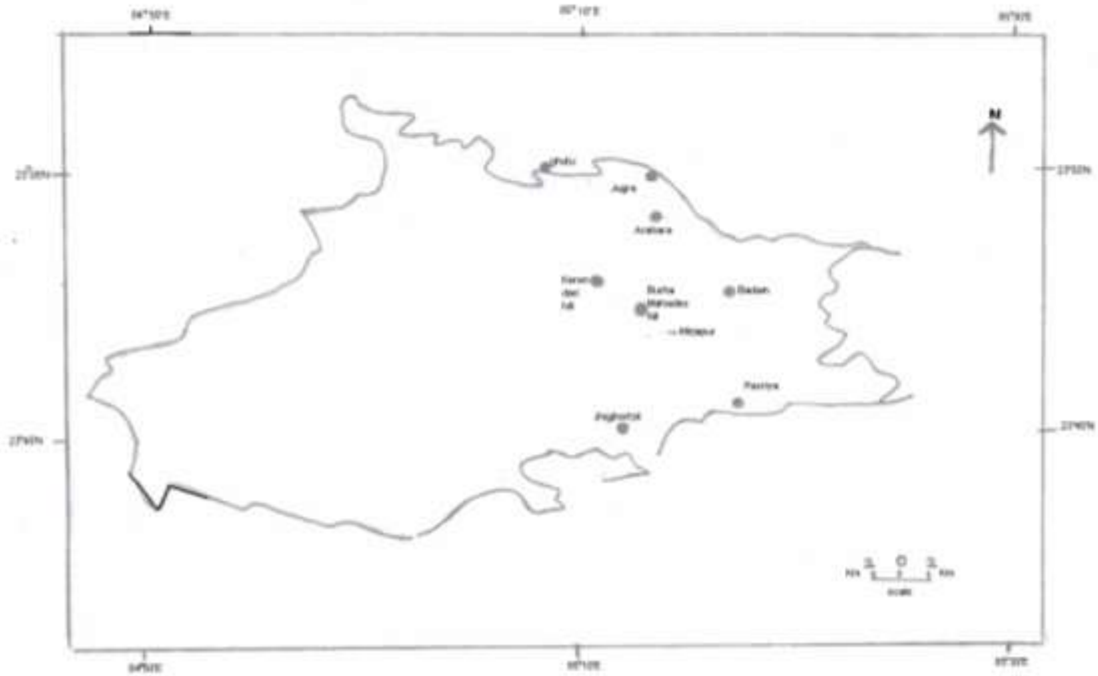

Figure 2: Location of different places in the study area

MATERIALS AND METHODS

Methodology

The procedure for achieving the goal set in the objective of the research work, data and information on lithology and geological structure which influence weathering, were collected from various publications, memoirs, records and papers mainly of the Geological Survey of India. Most of the observations in this study area are based on intensive field work in the area under consideration. Field observations include different features of weathering, and explanations are suggested regarding the causes of the formation of such feature.

Lithology

The basin area consists of soft fine as well as coarse variety of sandstone, grit, gritty sandstone, iron-rich and micaceous sandstone, shale, siltstone, conglomerate etc. granite and gneiss type of rocks are mostly found along the margin of the basin (Bland and Rolls, 1998).

Rock Structure and Weathering

Rock structure including mineral composition, joint spacing, bedding, minute inter-grain fractures and voids as well as folds, faults etc., influence weathering of rocks (Thornbury, 1954; Thomas, 1974). The most predominant rock types in the basin area consist of sandstone and granite-gneiss. Granite and gneisses are composed mainly of quartz, feldspar, mica, hornblend, olivine etc.; The dark, ferromagnesian minerals are more susceptible to weathering, especially chemical action as compared to the light-coloured minerals (Sparks, 1971).

Quartz-rich sandstones are hardest and strongest of the sandstones and often form high relief as observed in the Mahadeva sandstones. Clay-rich sandstones generally have little strength and they break down rapidly through the process of wetting/drying and frost action (Robinson and Williams, 1994). Iron oxide cemented sandstone is less resistant to chemical weathering. There is often migration of iron within the sandstone to form concretion. Iron concretion and associated features were observed near the foot hill zone of Mahudi. Calcite-rich sandstones are largely affected by solution (Ollier, 1969). Solution feature was observed at the foot hill zone of Kerendari and Tearia hills. "The amount of cement appears to be more important than its composition. Poorly cemented sandstones have great strength" (Robinson and Williams, 1994). Loosely cemented sandstones are weathered easily as observed in the Panchet sandstone in the North Karanpura basin. The well-cemented Mahadeva sandstone forms bold relief and scarp.

Joint spacing in the rock and inter-joint distance plays a great roll in controlling the rate and depth of weathering, both physical and chemical. It is observed that, joints often make the rocks weak which results in breaking of the rocks into pieces along joint planes.

The Features of Weathering

Cavernous Weathering (honeycomb):- Cavernous weathering is a general term used for the hollows made by weathering on the steep slope. The honeycomb form consists of some small pits or hollows of a few centimetres in diameter on the vertical or steep wall of sandstone. The hollows usually have a tendency to widen inwards with smaller openings on the surface. The vertical faces of sandstones in the Burha Mahadeo hill become pitted with roughly circular hollows or alveoles. They vary in size from a few mm to 20 cm in diameter. The alveoles are developed over cross-bedded sandstones at the sites of cross beds and on micro-cracks. The hollows are generally 'U'-shaped in cross section. The adjacent small holes often merge to form a bigger one (Figure 3).

Figure 3: Cavernous weathering, Burha Mahadeo hill

Honeycombing is also observed on the iron-crusted vertical wall of sandstone in Burha Mahadeo hill. Initially small chips are removed from different parts of the surface to make an opening to the inner softer rock mass. With time, weathering attacks the soft rock inside and breached areas develop in to deep hollows. The hollows often have a tendency to widen inward, and with time, deep hollows with narrow opening are formed. Cavernous weathering is a very common type of weathering which attacks many types of rocks but extensively found on sandstones.

Robinson and Williams (1994) observed cavernous weathering in Saxony, Bohemia and in South England. According to the authors, the cavernous weathering is less common on tough and harder sandstones. The feature is very frequently found in coastal areas of different parts of the world due to efflorescences of salt on the rocks especially on granite and sandstones. Though the cavernous weathering is observed on porous sandstone in the study area, but it is also found over granitic rocks.

Flaking: Flaking is the process of expansion of rocks due to external forces (Ollier, 1969). There are different causes of flaking but hydration (Clark, 1990), the most common cause, is responsible for the chemical alteration and decay of the rocks.

Flakes of a few millimetres thicknesses are observed on the boulders of sandstone near Mirjapur. Individual blocks of rocks become rounded or almost rounded in shape (Dodge, 1947), as the weathering takes place more on the corners and edges than on the flat surface of the blocks.

Multiple flaking is also observed on the flat surface of the granitic rock near Jugra, Arahara and Basriya. Each flake is characteristically a few millimetre in thickness and is frequently grouped with others as small ‘booklets’. In some cases they have step-like appearance. The process is related to cycles of heating/cooling/or wetting/drying of the rocks (Figure 4).

Flaking is a very common type of weathering found all over the earth surface. Ollier (1969) identified four major causes of flaking. These are, -- flaking caused by 1) fire, 2) salt growth, 3) chemical decay of minerals and 4) by other mechanisms. Thornbury (1954) also accepted flaking process caused by salt growth. So the process is widely observed in almost all environmental conditions. However, in the North Karanpura basin, the flaking is mostly induced by hydration process.

Formation of grooves and ridges as also steps on the rock surfaces by flaking is not uncommon in different parts of the earth surface. Ollier (1969) described examples of flaking hollows from Australia and South Africa. Robinson *et al.,* (1994) sited example of step features on feldspar in some European countries. Spark (1971) stated that hydration produces strictly a mechanical effect on the rocks but it becomes difficult to separate physical from chemical weathering when hydration combines with hydrolysis.

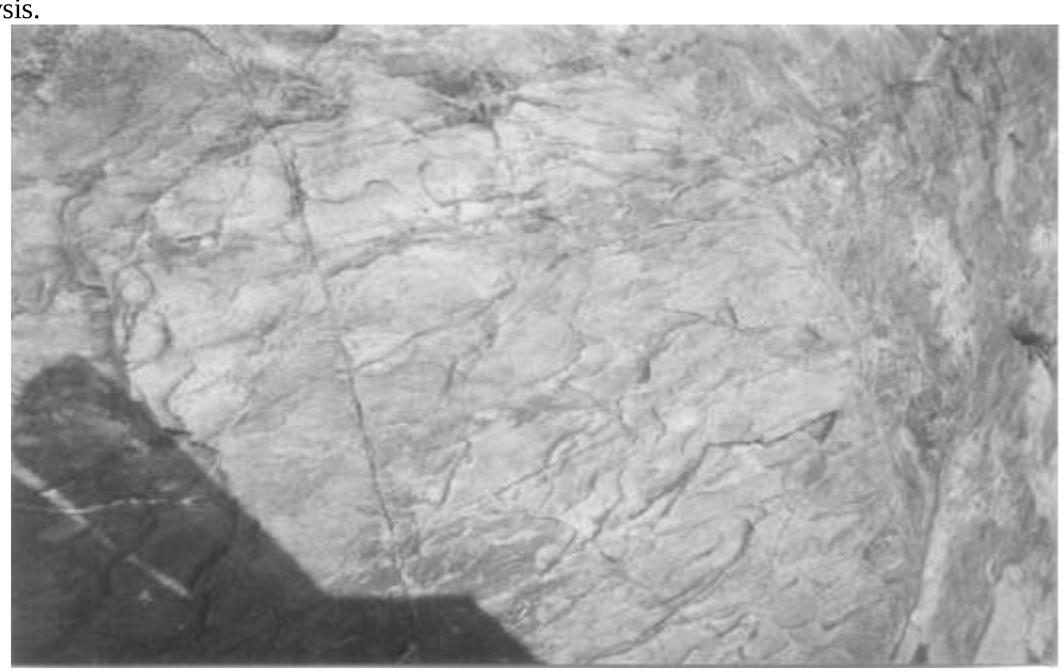

Figure 4: Flaking in granite, Jugra village

Weathering Pits: Weathering pits are very commonly found on limestone but it is also found in other rocks like granite, sandstone and similar rocks. Smith (1941) reported pits in granite in South Carolina. Dury (1966) found pits in sandstone in Sydney of Australia and in metamorphic rocks of Ruwenzori and Uganda. Ollier (1965) mentioned several processes of pit formation. These are—pits formed by 1) flaking, 2) granular disintegration, 3) organic acid released by algae and mosses (Ollier, 1969; Thornbury, 1954), 4) breaching of case-hardened surface. In North Karanpura basin, pit formation is mainly found on sandstones which are caused by flaking as well as breaching of the case-hardened surface. But solution process is also responsible for pitting where cementing material of sandstone is calcite, as observed near Deshwari village.

Pits Formed by Solution (Dury, 1966): Linear depressions and small pits are observed on the vertical wall of a big structure of sandstone, which is developed by solution of calcarious material of the rock (Franzel, 1971). Linear channels are 0.7metre to 1.6metre long. Solution process concentrates along the grain boundaries of the rocks due to which grains become loose and rain wash carried them away. Some shallow pits are also observed over the same rock, which are very irregular in shapes. Several pits often coalesce to form a single linear depression. This feature is observed at the foot hill zone of the Kerendari hill (Figure 5).

Figure 5: linear depressions and ridges in sandstone due to solution, Kerendari hill

Pit Formation due to Removal of Pebbles: Removal of pebbles from the rocks is sometimes responsible for pit formation. Due to removal of the pebbles, hollows are developed and gradually one hollow merge with another and ultimately a big hollow is formed. A few centimetres high ridge persists between two hollows. This type of hollow is observed over conglomeratic sandstone near Jhigjhortoli.

Figure 6: Grooves and ridges formed by flaking, Mirjapur village

Flaking Pits: Groove and ridge features are observed on the sandstone boulders (Hack, 1966) at the foot hill zone of the Mahudi hill, which result from flaking. Joints in the rocks provide lines of weakness and flaking process attacks the rock surface to produce the concave surfaces or depressions, which are separated by ridges. When a shallow concavity is developed due to flaking, it starts growing into a deep pocket. Flaking grooves are measured in the boulders, which are 20 to 26 centimetres long and are very shallow (Figure 6).

Linear depressions and hollows are observed on the vertical wall of a big structure of granitic rock near Ghutu, which are induced by flaking process. Shallow, linear depressions are formed on the surface of the rock due to this process. The length and the width of the depressions are not equal and narrow ridges separate them.

Small pits are observed on small blocks of feldspar, developed due to decomposition of feldspar by hydrolysis. "Hydrolysis in the weathering process refers to the reaction between the H and OH ions of water and the elements (or ions) of a rock or mineral" (Keller, 1957). Pits are also observed on quartz veins in granite and those are produced by the acid etching of quartz.

Figure 7: Tiger's paw stone, Pasriya village

Figure 8: Granular disintegration in soda granite, Jugra village

Tiger's Paw Feature: Irregular circles or little scallop-shaped hollows on the sandstone are termed as 'tiger paw stone' by the local people of Pasriya. The size of the hollows varies from a few millimetres to 10centimetres or more. This feature is observed on some small and low sandstone hillocks near Pasriya. Hollow formation is guided by differential resistant in rocks. The resistant parts of the rocks form micro-ridges-like feature on the surface and weak zones are marked by depressions and hollows. The deep burial of the rocks for a long period of time under the regolith cover is the main cause of such a deep hollow formation (Figure 7).

Granular Disintegration: Another temperature induced weathering process is granular disintegration. It is a type of weathering by insolation. The process of weathering is mainly induced by differential heating of various minerals of different colours (Hussey and Tator, 1950). Different minerals have different specific heat and coefficient of expansion. The dark minerals absorb heat at a faster rate than light ones. It may lead to the development of stress within the rocks which ultimately results into granular disintegration. This process of weathering is observed in granitic rocks, particularly to the north of Jugra village (Figure 8).

Durance (1970) stated that pressure release allied with temperature changes assist the process of exfoliation as well as granular disintegration that have been observed in hard rocks. But he also believed that release of strain energy may lead to granular disintegration of rocks. According to Spark (1971) granular disintegration is seen in arid and humid temperate region and mainly coarse crystalline rocks like granites and gneisses are subjected to disintegration, but the process is also seen in coarse variety sedimentary rocks like sandstones. Smith *et al.,* (1994) observed granular disintegration in Scrabo sandstone of Northern Ireland. Scrabo sandstone was susceptible to salt-induced breakdown.

Hydration process is also responsible for granular disintegration (Ollier 1969). Repeated wetting and drying of coarse variety rocks causes loosening of their grains, which facilitates this process. On the way to Jugra village, the exposed sandstone surface is found to be affected by this process and one can easily detach sand grains from the surface merely by gentle rubbing. This process is observed on a vertical block of sandstone near Nawadih village.

Rough Surface: Rough surface is often found on gneissic rocks where differential weathering gives unevenness (Lobeck, 1939) by developing low relief and depression on mica and other mafic mineral-rich sites. Resistant quartz often stands well above the adjacent surface. Rough surface is frequently found in different parts of gneissic terrain at the margin of the North karanpura basin (Figure 9).

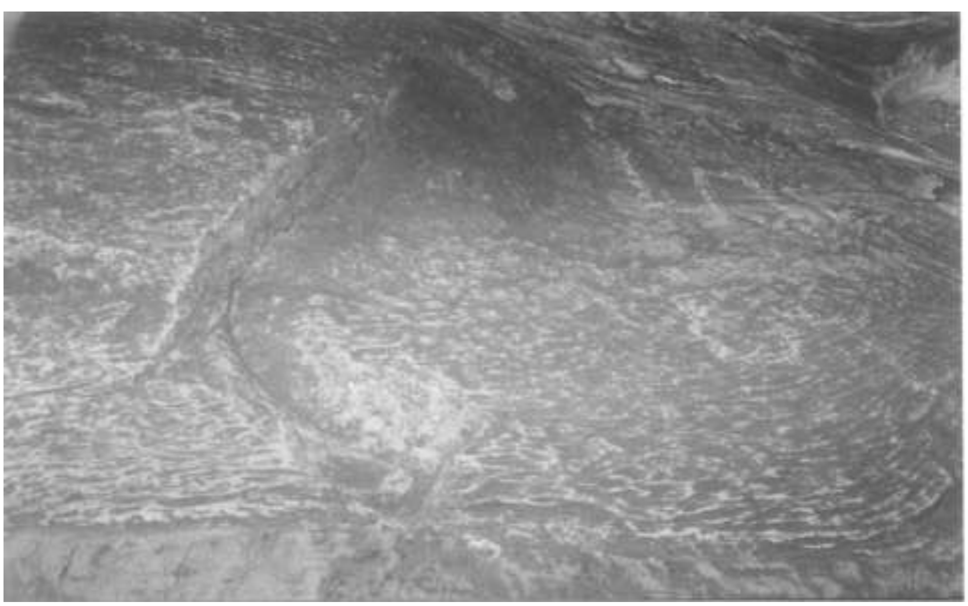

Figure 9: Rough surface formed on Gneiss, Ghutu hill

Cave: Near Jhigjortoli, a cave is observed in the low hillock of conglomerate on the bank of a small stream. The rock is porous and removal of pebbles from the rock surface creates hollows and weak zones, which imparts differential hardness to the rock. The location of the cave close to the soil surface suggests that wetting of rock could be an important factor of cave formation (Mainguet, 1972). Again, during rainy season, water level of the river rises and touches the base of the cave when basal sapping is one of the key factors which quicken the process (Figure 10).

Figure 10: Cave in Conglomerate, Jhigjhortoli village

Figure 11: Hunch-shaped hillocks, Pasriya village

Hunch-shaped Hillocks: Some hunch-shaped hillocks are observed on the road side in Pasriya. These are 5 to 6metres high and 10 to 12metres long. The surfaces of the hillocks are uneven, pitted and hollowed out. Parallel ridges and depressions are formed over the surface of the hillocks. Comparatively resistant minerals form ridges in some parts of the hillocks (Mathes, 1937). In between two hillocks there is low flat hard rock layer or flat rock pavement (Figure 11).

Flutes: Flutes are linear channels run roughly parallel to each other over soluble rock such as limestone. In this study area, flutes are well developed on different exposures of Barakar sandstones. Prominent flutes are found near Pasriya, Kerendari, Hewai and Badam villages over vertical or near vertical scarp faces of the rock surfaces. Movements of forceful rain water along joints and deep rotting of rocks through parallel joint surfaces are considered as the main cause of flute formation.

Figure 12: Flutes on sandstone, pasriya village

Exfoliation: Exfoliation is another very common type of weathering feature which is widely found in granitic rocks of humid and sub-humid tropical countries. Exfoliation is the weathering process in which strains lead to the splitting off of the surface of the rocks in layers, or more or less concentric shells over an inner core.

Insolation, pressure release and seasonal wetting and drying of the rocks (hydration) cause exfoliation (Ollier, 1969). Hydration results into the weakening of the mineral bonds and a considerable change of volume, which ultimately leads to the swelling of the rock mass leading to sheet formation along the planes of weaknesses.

Dodge (1947) observed exfoliation in pyroclastic and porphyritic volcanic rocks in the arid south-western part of the United States. Blackwelder (1925) stated that exfoliation landforms are typical of many areas of humid tropics where they are more subjected to chemical attack and he concluded that chemical decay and hydration were necessary factors for weathering. Twidale (1964) believes that sheeting develops after solidification of granitic rocks. Bradley (1963) described massive exfoliation on numerous sandstones in the Colorado plateau. Domes are resulted from expansion accompanying release of load. Ollier (1969) also accepted that exfoliation is mainly seen in granite, but also found in other rocks like sandstone, conglomerate, limestone, arkose and so on and so forth. Hack (1966) also supported the same thing. Mathes (1937) stated that exfoliation domes are resulted from expansion accompanying relief of load. Lobeck (1939) stated that exfoliation occurs under varying climatic conditions and he sited examples of exfoliation domes from Brazil, Kalahari desert, Sinai peninsula, Nubian desert as well as from cold regions like Norway, Sierra Neveda of California where rocks are massive granite or other igneous rocks, usually of coarse texture. According to Ollier (1969) exfoliation domes are found in all climates, hot and cold, wet and dry. Authors of the concern paper observed exfoliation domes in massive granites as well as in sandstones in different parts of the North Karanpura basin. Pressure release jointing is observed over the rock surfaces.

Exfoliation can be subdivided into the following:

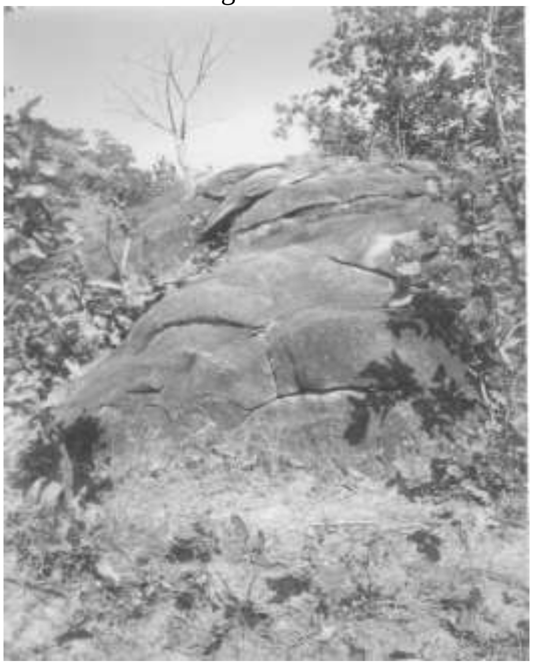

Figure 13: Unloading dome, Ghutu hill

a) ***Spheroidal Weathering:*** It occurs in well-jointed rocks (Robinson and Williams, 1976). Water penetrates the joints, attacking the blocks from all sides simultaneously, breaking off a succession of curved shells or skins, so that a succession of a new surface is presented to the weathering, leaving a mass of unweathered rock in the centre which is reduced to a round, often of spherical shape, surrounded by spherical shells (Ollier 1969; Clark 1990). Spheroidally weathered boulders are observed in different parts of the field. It is observed especially in small boulders of a few decimetres in radius.

b) ***Unloading:*** Unloading is a process of massive exfoliation which produces slabs of rock, several centimetres or more in thickness (Ollier, 1969). It is most commonly found in granites, but is also seen in sandstones (Abraham *et al.*, 1981). The dominant feature of unloading is the production of sheets or slabs of rocks (Robinson and Williams, 1987). Dome-shaped rocks are generally exposed beneath the sheets. This feature is observed in Jamira hill near Ghutu (Figure 13).

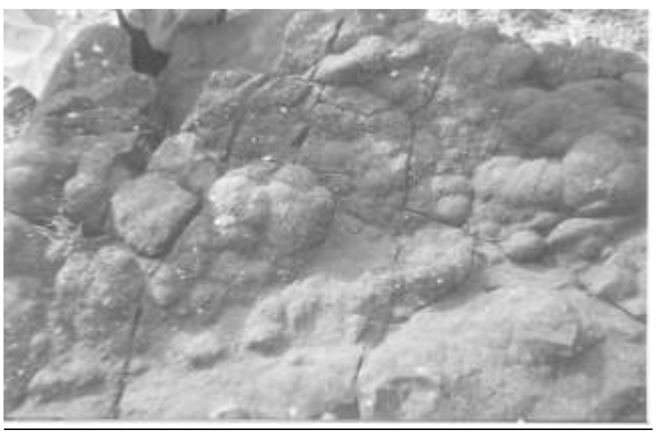

Figure 14: Ball feature in sandstone, Kerendari hill

Ball Feature in Sandstone: Sandstone spindles and balls are not very commonly found features like exfoliation domes or pits. The above-said features are mentioned by Hussey and Tator (1950) and Ollier (1969). They observed these features on arkose. Ollier (1965) mentioned that friable sandstones are especially prone to this kind of action. A peculiar type of feature is observed in jointed sandstone near Mirjapur. The whole rock mass is fragmented into rectangular blocks, and rock surfaces in the blocks swell up causing ball-shaped appearance. This feature results from ground water solutions attacking the cementing materials of the sandstone along the zone of weakness (Robinson and Williams, 1989), guided by the joint planes. The rock surface swells up due to the fluctuation of the ground water level (Figure 14).

The features result from ground water solution attacking the zone of weaknesses like jointing and bedding planes. Authors of the present paper observed ball feature in coarse to medium grained jointed sandstones.

Joint Softening: A typical feature is observed in jointed sandstone blocks in the Mahudi and Kerendari hills. Vertical joints are the weak zones in the rocks and provide channels for the quick movement of the water and dissolved ions. Erosion attacks faster along the joints and the rock masses between two parallel joints stand out in relief. The edge of the joints becomes rounded because of the movement of water (Figure 15). The process is called joint softening by Ollier (1969).

Figure 15: Joint softening, Mahudi hill

Surface Crust: Surface crusting is another known feature in sandstone. Robinson and Williams (1976, 1981, and 1989) found this feature on sandstone cliffs in Kent and Sussex, Cheshire, Saxony and North Germany. It has been suggested that it is a product of frost weathering (Franzle, 1971), insolation weathering (Mainguet, 1972) and wetting and drying (Netoff, 1971). Robinson and Williams (1989) suggested that porous sandstones are very much affected by surface crusting. Joints in the sandstones might have a strong effect on the process. Ollier (1969) suggested that crusting or case hardening is formed simply by addition of material to the surface of a boulder or impregnation of material (silica or iron oxide) from inside. Surface crusting is observed over the mass of sandstone to the foot hill zone of the Kerendari hill in the middle part of the Horhori valley. A brown crust is developed through capillary rise of solution to the surface of the rock. Water evaporates and iron oxide precipitates as crust on the rock surface. Surface crusting forms a resistant layer and protective mass over the soft inner core (Robinson and Williams, 1994). After rupturing and breaching of the surface in different parts of the rock, the chemical break down and etching of the inner soft part of the sandstone is going on. The rock is cemented with calcarious material and a depression or pit is excavated at the central part of the rock mass through solution (Figure 16).

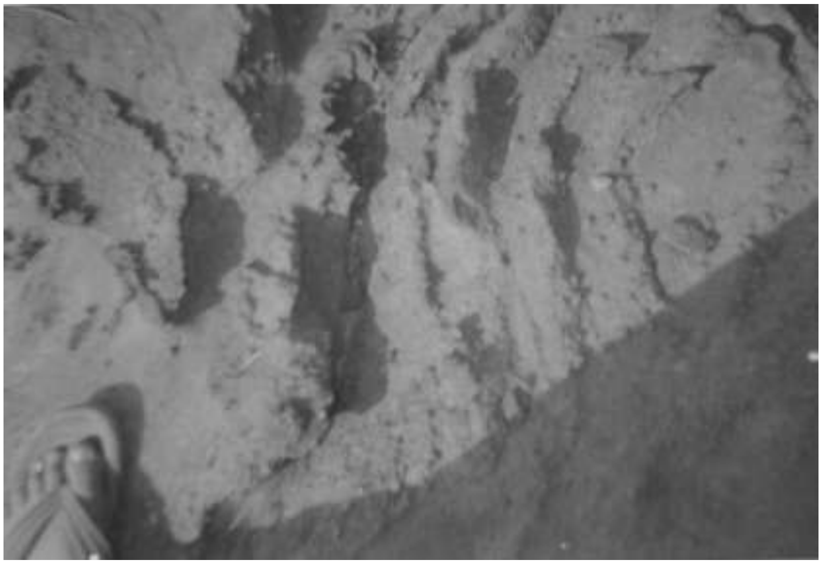

Figure 16: Surface crusting on sandstone, Kerendari hill

Sandstone Blocks: The ground surface near Choudamil is made up of sandstone. The flat sandstone surface is criss-crossed by rectangular joints. Weathering penetrates through joints and some rectangular joint blocks become rounded or oval-shaped in form. Some blocks of rounded and oval-shaped boulders are detached to form lowering of the ground. Some isolated round-topped blocks (6 to 7centimetres high) stand out in relief, rooted in the bedrock (Figure 17).

Figure 17: Block formation in sandstone, Choudamil village

Block Disintegration: Another type of insolation weathering is block disintegration. It is a type of insolation weathering. Temperature changes cause expansion and shrinkage of rocks which leads to the formation of two sets of cracks and rock masses disintegrate in to several individual blocks. Brown (1924) and Ollier (1969) reported sun-cracked boulders from the desert of Peru, Australia and other countries. Ollier (1969) observed block disintegration in pure white quartzite and exfoliation in less pure quartzite in the_same locality and he finally concluded that chemical weathering gives rise to exfoliation whereas physical weathering gives birth of block disintegration.

Figure 18: Block disintegration in sandstone, Motra village

In Motra hill area near Motra village, sandstone mass is fractured into cuboidal blocks. Individual blocks are bounded by two sets of joints—one parallel to the ground surface and another is perpendicular to it. Disintegrated blocks fall down and rest upon the base of the rock mass (Figure 18). The shale layer below the sandstone mass is fragmented into very small rectangular blocks. Alternate moisturisation and desiccation have a great effect on disintegration process of shale.

Fragmented Rocks: Weathering produces rock fragments of different kinds. Fragmented rocks are derived from the mechanical failure of the large boulders and rock masses. Hill slopes are covered by big boulders and rock masses dislodged from the scarp faces. They are often subjected to further disintegration. Small pieces of rocks and blocks, produced by insolation weathering, are usually angular in shape. Large cuboidal blocks of sandstone are observed on the foot slope of the Mahudi hill, which are disintegrated from the scarp face due to the splitting up of blocks along joints and fissures.

Granular disintegration of granite produces small grains of rocks. Decomposed coarse variety of sandstone produces loose sand and it is possible to detach sand grains from the surface of partly decomposed sandstone merely by gentle rubbing.

The Panchet red clay and white sandstone layers expose on the right-bank of the Dumaro river near irrigation well. The sandstone is very loosely cemented and easily breaks down into pieces. The red clay is very soft and not clearly laminated. It is removed in solution during wet season. Miniature cracks are developed due to desiccation and shrinkage of the rock and it is easily fragmented into small pieces.

Effects of Weathering on Local People

The entire basin area is surrounded by hilly uplands with a central plain. The soils of the basin result from decomposition of rocks (sandstone, siltstone, shale, clay etc.) for millions of years which make the region one of the most fertile and prosperous agricultural fields. The weathering and decomposition of granite-gneiss and sandstone produce ample quantity of sand and it is the main constituent of river deposit. Collection of sand from the bed of the river is the main occupation of many people of the locality. It has been observed that on an average 50 to 80 tones of sand is removed every day from the river Haharo near Barkagaon. Chemical weathering of feldspar, mica and shale produces variety of clay minerals. Clays of different colours (chocolate red, red, yellow, gray and bluish) are used by the local people for building construction and decoration of the walls of their houses.

Figure 19: Thick regolith cover on the bank of a river, Kerendari hill

Infiltration of water is usually high in porous sandstone. Occurrence of shale layers under the sandstones and grits helps to retain sub-surface water. Occurrence of clay layers below sandstones near the source of the Dumaro river makes the Dumaro a perennial sources of water to the local people. The fissures and cracks in the rocks control percolation of water.

The debris dislodged by weathering of the steep slopes is accumulated at the base of the hills to form huge talus cones which slowly and gradually become stabilised by sods and grasses to provide grazing fields to the huge number of village cattle. A thick pile of regolith is produced through deep weathering of rocks (Figure 19).

Fireclay mines are located in different parts of the basin. It is rich in kaolinite clay with commercial application as a refractory. Deep weathering of granitic rocks produces fireclay.

Weathering contributes to the recession of escarpments. Back wearing is significant at the edge of the sandstone hills of Mahudi, Kerendari and some other hills with steep scarp faces. Back wearing of slopes gives birth of a long foot slope at the base of the hills. Rock fall or localised slumping from hill slope often cause road block and pose a barrier to the traffic movement.

Weathering on the valley sides contributes immensely to valley widening process. Mass wasting becomes a dominant process on slope because of weathering.

The caves produced by weathering are utilised by the local people for taking shelter inside. Pits and hollows on the flat rock surfaces possess water and gives birth of algae and mosses which farther contributes to weathering and decay of rocks. Different minerals are released from the rocks through weathering process; enrich soils and river water of the locality.

Thornbury (1954) truly stated that just because it is difficult to identify landforms purely formed by weathering, it is unjustified to think that this process is of little geomorphic significance. Rather, weathering is so closely related to other processes that it is quite difficult to separate its effects readily.

RESULTS AND DISCUSSION

Discussion

This review has demonstrated certain landforms produced by weathering of granites and sandstones in a tropical sub humid environment where annual average summer and winter temperatures are 30^0 C and 17^0 C respectively with 172 Cm rainfall.

Chemical decay and hydration are most important necessary factors for weathering (Blackwelder, 1925; Sparks, 1971). The processes like exfoliation, flaking, cavernous weathering, granular disintegration and pit formation are found in almost all climates (Ollier, 1969; Lobeck, 1939) but the factors affecting the particular weathering process may be different in different climatic conditions. Such as granular disintegration is induced by temperature in tropical regions whereas it may be induced by frost action in cool temperate climate. In the same way, caverns may be formed by salt action in the coastal environment, by frost action in cold environment and by hydration or other processes in humid tropical environment.

Most of the weathering features are related to differential hardness provided by the mineral composition, texture and micro-structure of the rocks. Exfoliation domes are produced by the combined effects of expansion due to pressure release and chemical attack (Ollier, 1969; Blackwelder, 1925; Durrance, 1970). Granite is more susceptible to exfoliation, flaking, granular disintegration, cavernous weathering and pit formation but sandstone is also affected by the same processes (Bradley, 1963; Ollier, 1969). Ball feature is especially found in sandstones and friable sandstones are usually prone to this kind of action (Ollier, 1969). Coarse textured rocks are much more prone to weathering especially cavernous weathering (Robinson and Williams, 1994), granular disintegration (Sparks, 1971; Durrance, 1970) and surface crusting than fine textured rocks. Flaking and granular disintegration give the rock surface unevenness and are important causes of pit formation (Blackwelder, 1929).

Conclusion

Although there have been a careful observations regarding different weathering related features and the basic mechanisms responsible for the formation of such features, there is still a large area of ignorance relating to the role of particular processes on a particular feature formation as well as rock properties and climatic influences. A link between the laboratory simulations and field investigation is urgently needed. It is often difficult to establish the conditions under which weathering took place.

On the basis of this study it is possible to make a number of general statements regarding some features of weathering of North Karanpura basin. These are as follows: -

1) Caverns are found to be formed by breaching of surface crust and also by hydration.
2) Granular disintegration is induced by temperature condition.
3) Unloading domes are found to be formed by the combined effects of pressure release and hydration.
4) Flakes are found to be formed by repeated hydration and dehydration of rocks.
5) Pits are found to be formed by multiple processes like flaking, breaching of crust, solution and granular disintegration.
6) Crusts and balls are found to be formed in coarse variety friable sandstones.
7) Joint systems and cementing materials have found most important key factors of weathering.

The features of weathering may vary in the same type of rocks due to variation of rock properties. At the same time, a single feature may develop over a variety of rock types due to presence of same environmental condition, more or less similar rock properties and the processes operating on them.

Finally, it is necessary to keep in mind that knowledge is best enriched by way of gathering data and ideas from all sources. It is a fact that the specialist takes precautionary measures in course of observation and collection of data, yet there are chances of misinterpretation of observation, especially when weathering features and products are examined.

End Notes

The study is concentrated on the eastern part of the North Karanpura basin, east of Garhi river.

1) The area is endowed with sedimentary and igneous rocks.
2) Rock structure influences weathering of rocks.
3) Type and amount of cementing material in sandstone appears to be more important than its composition.
4) Cross-bedding and micro-cracks in the sandstones is the site of alveolar weathering.
5) Hydration is the most common cause of flaking.
6) Flaking in some boulders of sandstones gives the boulder rounded shape.

7) Grooves and ridges are formed by flaking.
8) Pits are also formed by solution.
9) Solution process in calcareous sandstone gives rocks a hollow and ridge appearance.
10) Flaking pits were observed on sandstone boulders.
11) Granular disintegration process is mainly induced by differential heating of various minerals of different colours.
12) Hydration process facilitates loosening of the grains of coarse variety sandstones.
13) Differential weathering gives unevenness in the granitic rocks.
14) Hydration and basal sapping processes facilitates cave formation in porous conglomerate.
15) Resistant minerals form ridges in the rocks.
16) Heat crack is induced by thermal expansion and contraction of rocks.
17) Insolation, pressure release and seasonal wetting and drying of the rocks cause exfoliation.
18) Spheroidal weathering occurs in well-jointed rocks.
19) Unloading is most commonly found in granites, but is also seen in sandstones.
20) Sheets of rocks are produced by unloading.
21) Ground water attacks the cementing materials of the sandstone along the zone of weaknesses.
22) Surface crusting forms a resistant layer and protective mass over the soft inner core.

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