STUDY OF WEATHERING CHARACTERISTICS OF SALPE GHAT REGION, DISTRICT SATARA, MAHARASHTRA

BY
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CERTIFICATE

Certified that the work incorporated in the thesis "STUDY OF WEATHERING CHARACTERISTICS OF SALPE GHAT REGION, DISTRICT SATARA, MAHARASHTRA" submitted by Mr. GUJAR SUSHILKUMAR PRALHAD was carried out by the candidate under my supervision. Such material as has been obtained from other sources has been duly acknowledged in the thesis.

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Declaration

I declare that the thesis entitled "STUDY OF WEATHERING CHARACTERISTICS OF SALPE GHAT REGION, DISTRICT SATARA, MAHARASHTRA" submitted by me for the degree of Doctor of Philosophy is the record of work carried out by me during the period from 15th Sept.2009 to 28th Feb.2013 under the guidance of DR. TUSHAR SHITOLE, and has not formed the basis for the award of any degree, diploma, associateship, fellowship, titles in this or any other University or other institution of Higher learning.

I further declare that the material obtained from other sources has been duly acknowledged in the thesis.

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Place: Pune

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Researcher

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CHAPTER I

Introduction

Weathering is one of the major important processes that modify the Earth's surface. A geomorphic agents or agency is for any natural medium which is capable of securing and transporting earth material. Thus running water, runoff, groundwater, glaciers, wind, and movements within bodies of standing waters including waves, currents tides, and tsunami are great geomorphic agencies. They may further be elected as mobile agents due to remove material from one part of the earth's crust and transported and deposited to some were else(Thornbury1954[RP2002]). This process breaks down and altered rock and mineral matter to products that are in equilibrium with newly imposed physic–chemical condition. Weathering is not only confined to the alteration of rocks exposed to the ground surface environment but it can occur at considerable depths below the surface. In general, within a weathering profile, zones closer to the surface are more weathered than are deeper zones. Weathering is part of denudation process, and weathering columns are the mirror of withering process. It involves the combined action of various processes which cause the weathering away and lowering of the land and it includes weathering, mass wasting, transportation and erosion. The rate of denudation varies according to change in climate, topography and lithology. It is lowest in hot arid lowlands(between 1.2mm per 1000 years) and highest in humid, cold and glacial uplands (3000 mm per 1000 years) (Siddhartha,p201).

Definitions of the weathering:

1. The process that alters the physical and chemical state of rock at or near the surface of the earth, without necessarily eroding or transporting the products of alteration, are collectively called rock weathering (Bloom, p119).
2. Weathering is a group of processes at or near the interface of the crust with the atmosphere which alter the physical and chemical characteristics of a rock in situ (Kale V. and Gupta A., p28).

3. Weathering can be defined as the process of rock and mineral alteration to more stable forms under the variable conditions of moisture, temperature and biological activity that prevail at the surface.(P.W.Birkeland p52)
4. Weathering is the general term applied to the combined action of all processes causing rock to be disintegrated physically and decomposed chemically because exposure at or near earth surface (A.H. Strahler and A.N. Strahler,p281).
5. Weathering is the total effect of various subaerial processes that co-operate in bringing about the decay and disintegration of rocks involving no large scale transportation (K.Siddhartha, p201).
6. Weathering is the breaking down of rocks, soils and minerals as well as artificial materials through contact with the Earth's atmosphere, biota and waters. It occurs in situ, or "with no movement", and thus should not be confused with erosion, which involves the movement of rocks and minerals by agents such as water, ice, wind, and gravity (Wikipedia Inc.Net.).

The materials left over after the rock breaks down combined with organic material creates soil. The mineral content of the soil is determined by the parent material, thus a soil derived from a single rock type can often be deficient in one or more minerals for good fertility, while a soil weathered from a mix of rock types (as in glacial, Aeolian or alluvial sediments) often makes more fertile soil. In addition many of Earth's landforms and landscapes are the result of weathering processes combined with erosion and redeposition. There are different weathering processes and they occur in association with each other. The processes which alter the physical or chemical state of rock at or near earth the surface of earth, without necessarily eroding or transporting the products of alteration, is collectively called rock weathering (Bloom2003-p117). It is an assemblage of various rock-altering processes which are powered by exogenic, essentially solar, energy. The depth of weathering is thereby restricted by the depth to which exogenic-powered processes can operate. For some purposes, it is important to distinguish weathering from other type of rock alteration, such as by hydrothermal liquids and gases.

The geologic structures can be change by sub aerial process acting on it. It has been the subject of philosophical comment as in the beginning of written history. A observation of Chinese scholar in 240 B.C. and mentioned by La Fargue(1992) and referred by Bloom is that, “Nothing is the world is offer or weaker than water, but it attacks what is hard and strong none of them can win out”. In the same way one of the oldest geomorphic deductions is mention in Isaiah (40:4) that “Every valleys shall be exalted and every mountain and hill shall be made low and the crooked shall be made straight and the rough places plain” In 1876 J.W.Powell a well known American geologist mention while exploring the mountain in western united state in one sentence that “we may now conclude that the higher the mountain, the more rapid its degradation, that high mountains cannot live much longer than low mountains, and that mountains cannot remain long as mountains, they are ephemeral topographic form, Geologically all existing mountains are recent, the ancient mountains are gone” (Bloom 2003-p118).

In 19th century, the geologists in there writings on denudation was clearly imagined as the net effect of all those processes, either sub-aerial or marine, which removed the landmass and contributed material to the sedimentary process. W.M.Davis was a well known geologists, in1902 he was advocating to for use a more restricted. He wanted the use of ‘denudation’ to be confined to active removal of regolith or waste rock from slopes, a process that would occur in the sort of steeplands depicted by the early stages of his ‘geographical cycles’ of landform evolution. He insisted that the term degradation should be employed for those less active processes that gradually reduced the gentler, waste-covered slopes during the later stages of the cycle. Thus in contrast to its broader use, Davis excluded river action from the term denudation but Young , a modern geomorphologist in 1972 mention that although the precise distinction between denudation and degradation has largely been forgotten, still persists with Davis definition by excluding the work of streams and other linear processes from the concept of denudation (M.J.Crozier 1986,p4)**.** Crozier further mentions that denudation ultimately involves in mechanisms through which the rock weathered or weakened and the regolith carries away by different processes.

Weathering is the first stage toward denudation of any land form. Weathering also plays a major role in denudation. Weathering broken down in to smaller particles and a transition from unstable to stable minerals occurs. After weathering rocks ended up but new minerals formed which are softer and easier to erode. The eroded material consequently reaches either to the rivers or to the sea and to be deposited as sediment. Furthermore, soft weathered rock finally leads to soils formation in second stage of modification. Here in lies the importance of weathering in geomorphology. Disintegration and decomposition of various kinds of hard bedrock greatly facilitate the erosion of the land surface by running water. Besides this function, weathering leads to a number of distinctive landforms, which we shall describe in this chapter. Weathering as a one way series of change leading to chemical stability of minerals in the surface environment, it is important to keep in mind that the physical weathering process continue to be agitate and move soil and regolith. Frost action, alternative wetting and drying, growth and decay of roots and various other respective processes cause the soil and regolith to expand and contract in ceaseless daily and seasonal cycle Otherwise rocks would have been very difficult to erode and from soil if weathering did not happens. The moon is an example where has very little atmosphere and rocks are not weathered there as on earth. Hence, the rocks on the moon have broken on smaller scale and there is no soil formation on moon surface.

Weathering is in general term applied to the combined action of all processes causing rock to be disintegrated physically and decomposed chemically because of exposure at or near the earth surface. The products of rock weathering tend to accumulate in a soft surface layer, called regolith. The regolith grades downward in to solid, unaltered rock, known simply as bed rock Regolith ,in turn, provides the source of sediment, consisting of detached mineral particles transported and deposited in a fluid medium, which may be water ,air, or glacial ice. Both regolith and sediment comprise parent materials for the formation of the true soil, a surface layer capable of supporting the growth of plants.

The spontaneous downward movement of soil, regolith and rock under the influence of gravity is included under the general term mass wasting. The role of gravity is a pervasive environmental factor. All processes of the life layer take place in the earth gravity field, and all particles of matter tend to respond to gravity. Movement to lower levels takes place when the internal strength of a mass of regolith, sediment or rock declines to a critical point below which the force of gravity cannot be resisted. This failure of strength under the present force of gravity takes many forms and scale. We shall see that human activity is a major agent in causing and intensifying several forms of mass wasting (A.H. Strahler and A.N. Strahler.)

Weathering process alters the principal or chemical state of rock at or near the surface of the earth, without necessarily eroding or transporting the products of alteration is collectively called rock weathering. It alone does not make landform. But it provides altered or broken rock from which landform which landforms are shaped. Rock weathering always studied in detail geochemical processes. Rocks are assemblages of minerals. Every Mineral has specific response like physical and chemical to the near-surface environment. However, for many geomorphic generalization, it is sufficient to speak of weathering at the scale in which an entire rock mass is the unit of alternation. It is an assemblage of rock altering process that is powered by exogamic, essentially solar energy. The depth of weathering is there force restricted by the depth to the exogamic-powered process which operates.

Weathering is distinguished from other destructive process by the inclusion in its definition of the concept of in situ non transported alteration. When a mineral grain reacts with water, the soluble products are carried out by solution. But the basic structures of the rock mass including bedding and others remains.

Weathering reduces hard rocks into soft rocks. It maintains the structure of the unbroken rocks, but they are characterized by higher void ratios and reduced bond strength. Soft rocks are transformed in to granular soils generally called residual soils .Residual soils differ from their parent rocks in mineralogical composition and structure.

Weathering processes belong to two categories depending on the type of weathering process they are Physical or Chemical. Physical weathering causes the mechanical destruction of rocks without mineralogical change where as chemical weathering is due to chemical reactions leading to the decomposition of the constituent minerals to stable or metastable secondary mineral products.

Types of weathering

Classification of weathering process, traditionally, divided into a group like chemical, mechanical or physical and biologic weathering. According to process which alters rock, weathering can be divided in to three main types:

i)Physical or Mechanical weathering,

ii)Chemical weathering,

iii)Biological weathering.

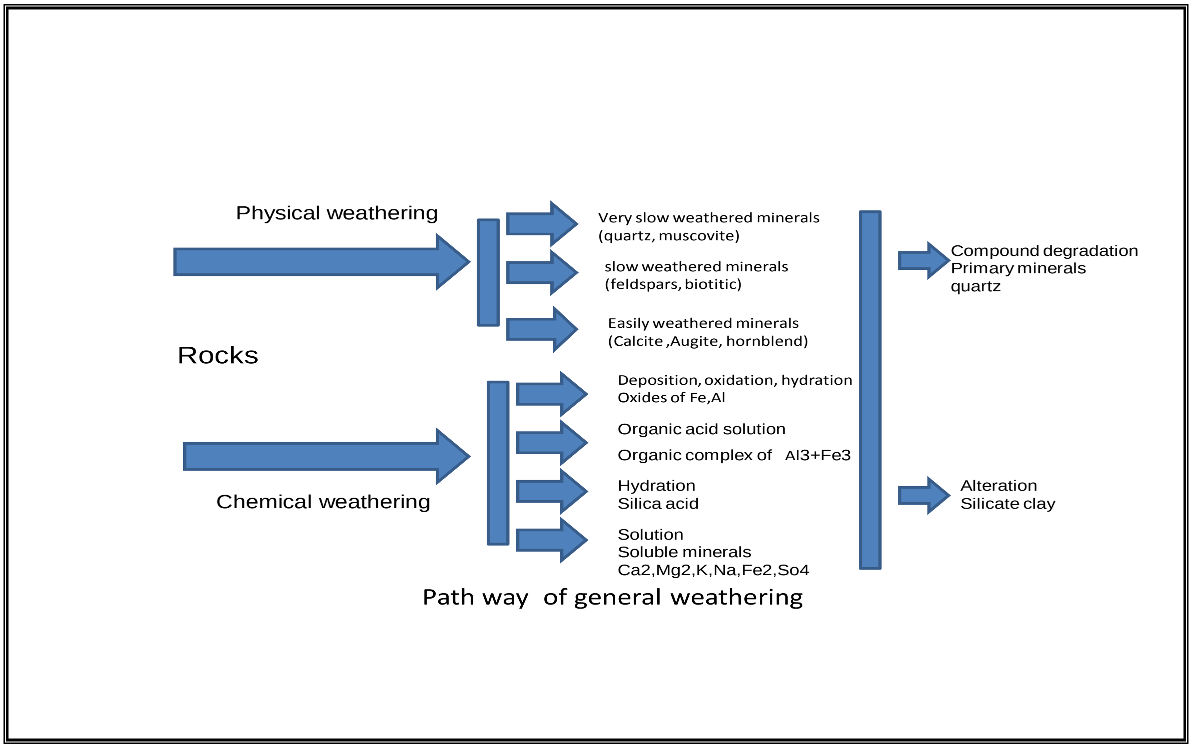


Figure - 1

Physical or mechanical weathering is generally credited with being about six times more effective than chemical weathering in preparing surface rocks for removal by erosion (Lasonga). Mechanical or physical weathering is also called disintegration. It gives more emphasis on disaggregated of rock without alteration. Physical weathering is due to processes such as: freeze-thaw cycles temperature variations causing swelling shrinkage cycles, wetting drying cycles, salt crystallization, rain and wind action, living organism action.

Freeze and thaw cycles cause rock fracturing. Water thawing process needs a volume expansion to occur which if constrained by surrounding rock, leads to an increase of presser in enlarging and developing cracks. Pressure exerted by ice may reach up to 200 MPa.

Temperature variations cause variation of the state of stress within rock mass leading to swelling –shrinkage cycles responsible of rock fracturing. Temperature variations between night and day may reach up to50^0 C in desert or mountainous areas. Anyway, thermal excursions may be caused by fires or volcanic eruptions as well.

A similar phenomenon is due to wetting-drying cycles which cause variation of state of stress within in clays soils leading to swelling-shrinkage cycles responsible of cracking development.

Precipitation

Precipitation is the main input of water to the Earth's surface, which varies greatly both in time and space. The amount of water that later will occur as runoff or soil storage is influenced greatly by the timing, rate and form of the precipitation. Heavy rainfall, even if of short duration, can supply water faster than most soils can absorb it. A larger amount of precipitation spread over several days of gentle rain could, however, more slowly into the soil, therefore increasing the stored water available for plant absorption, as well as replenishing the underlying ground water (Brady and Weil 2002).

In general, precipitation is attributed to vertical air motion (frontal/cyclonic, convectional and orographic) depending on the meteorological conditions. In broad terms, the greatest rainfall occurs in equatorial areas associated with converging trade wind systems, monsoon climates and high moisture contents due to warm temperatures. The secondary maximum precipitation occurs in the mid-latitude (40-65^0) due to the occurrence of polar fronts and associated cyclonic disturbances. The lowest rainfalls are either at the poles due to descending air masses and the low water content of the extremely cold air, or in some subtropical areas (e.g. many of the world's largest deserts) (Faniran and Jaje).

There are a number of other factors including unexplained of random variations in the global atmosphere circulation, which modifies this simple general pattern. As evaporation from the oceans (especially subtropical oceans) is the main source of atmospheric moisture, precipitation tends to decrease with distance from the sea. In coastal areas, precipitation is generally greater overland than over the nearby sea due to the greater mechanical and thermal overturning of the air. Mountain ranges tend to accentuate precipitation amounts, particularly in areas where the prevailing air movement is onshore (Ward and Robinson 2000).

The measurement of rainfall comprises two aspects: the point measurement of rainfall at a gauge and the use of a number of gauges to estimate areal rainfall (Ward and Robinson 2000). The rainfall data are more readily available, for more sites and for longer periods, than for other components of the hydrologic cycle. In some parts of the world precipitation data may constitute the only directly measured hydrological records (Perks et al. 1996).

An estimate of areal rainfall input is a basic requirement in many hydrological applications. There are a large number of techniques that can be used to calculate area rainfall from point measurements, including polygonal weighting, inverse distance weighting, isohyetal trend surface analysis, analysis of variance and kriging (Singh 1989). The selection of the most appropriate one for a particular problem will depend on the density of the gauge network and the known spatial variability of the rainfall field. In general, the accuracy of areal rainfall estimation will increase with the total number of gauges, the length of period considered and the size of area (Ward and Robinson 2000).

Infiltration and Runoff

The term infiltration is used to describe the process of water entry into the soil through the soil surface. The maximum ret at which water soaks in to or is observed by the soil is termed infiltration capacity, which may be measured using devices such as a ring infiltrometer (Jury and Horten 2004). The value is normally greater for permeable, coarse – textured soils than for lower permeability clays. In general, the infiltration capacity of a soil by retarding surface water movement, stabilizing loose particles, reducing raindrop compaction and improving soil structure (Ward and Robinson 2000).

The relationship between rainfall intensity and infiltration capacity determines the partitioning of precipitation, i.e. how much of the falling rain will flow over the ground, and how much well enter the soil (Ward and Robinson 2000). If the rainfall intensity is less than the infiltration capacity, all the water is absorbed by the soil. Surface runoff is generated by the process of 'infiltration excess' when the rainfall intensity exceeds the infiltration capacity. Runoff is measured in collecting ditches or small streams using weirs or flumes (White 2006).

Rain falling on the soil surface is drawn into the pores under influence of both a pressure and gravitational head gradient. In the early stages of wetting a dry soil, the pressure had gradient decreases and the gravitational head gradient becomes the main driving force. The flux density then approaches the saturated hydraulic conductivity (Ksat), under which circumstances the soil underneath may not be able to accept water rapidly enough to prevent ponding on the surface (White 2006). In other words the infiltration of a soil generally decreases during rainfall, rapidly at first and then more slowly, until a more or less stable value has been attained. This decline of infiltration capacity is determined by a number of factors, including limitations imposed by the soil surface, surface cover conditions and the rate of downward movement of water through the soil profile.

Percolation and Drainage

Once water has infiltrated the soil, the water moves downward into the profile by the process termed percolation. In many soil profiles, the soil horizon may differ markedly in terms of texture and hydraulic conductivity; such stratification may greatly affect the movement of water through the soil profile. In the case where the coarse layer such as sand overlies a finer textured layer, percolating water will slow down markedly when it reaches the impeding layer with a lower hydraulic conductivity in the opposite case, where fine material overlies coarse, the effect on water percolation is similar, i.e. the downward movement of water is impeded, which occur because the larger pores of the sand offer less attraction for the water than do the finer pores of the overlying material and therefore the matric potential is lower in the overlying material than in the sand(Jury and Horten 2004).

Percolation or drainage water finally recharges the ground water. In idealized conditions a processes of displacement occurs where by the water that is added to the water table during rainfall is not ‘new rainfall but previously stored rainfall that has been displaced downwards in the zone of aeration by successive bouts of infiltration (Horten and Hawkins 1965). This piston flow process is also referred to as translator flow. It is major factor in explaining the commonly rapid response of water table to precipitation, even in low-permeability material, especially when the soil water content is at field capacity or wetter. One result of transitory flow is that deep water tables to precipitation, even in low-permeability material, especially when the soil water content is at field capacity or water.

At the time of percolation the dissolved and carries downward a Variety of inorganic and inorganic chemical leached from the soil or on the soil surface. Slope condition also plays an important role especially during heavy rainfall in the development of through flow, which moves laterally at shallow depth below the ground surface.

Evapotranspiration

It is the only way through which water is lost from soil in the form of vapors instead of liquid is evapotranspiration. The general available information about water losses is that by the two ways through the evapotranspiration. The most commonly is by the climatic variables such as temperature, relative humidity, cloud cover and wind speed they influence the vapors generation in wet soil, leaf, or body and the atmosphere the evaporation is generally greater at the equator than high latitudes. The dense well-water vegetation typically transpires water about 65% it is as rapidly as water evaporates from an open pan. Hence, dense vegetation evaporates more water.

Temperature and rainfall parameters are generally regarded as the most important parameters of the natural environment; others like relative humidity and evapotranspiration are to a large extent closely related to them. Hence geomorphology of arid and semi arid regions affects above parameters.

Directs and indirect effects of the temperature on weathering process are observed by various scholars stated below,

1. High solar radiation incident on exposed rock surface directly effects thermal weathering of such rocks through the processes of flaking, spelling and boulder cleaving (Ollier). Extremely high daily and annual temperature is one of major aspect in weathering.
2. Von’t and Hoff’s law stated that an incise in10^0C of temperature doubles or trebles the rate of chemical reaction. Hence chemical weathering would be expected to attain its greatest intensity and depth.

1. Heat effecting on biochemical reaction in plants. As temperature and high pH the rate of decomposition and mineralization is very fast.
2. Temperature is important in determining the rate of solubility of certain element, like silica is more soluble in high temperature area (Ollier).
3. The seasonal range of soil temperature to the depth of 60 cm is most important factor in the upward movement of water and dissolved minerals (Thomas).
4. Day heating and cooling during nights caused for alternatives expansion and contraction of rock constituent minerals. As some minerals expand more than others .the temperature change setup differential stresses that eventually cause the rock to crack apart.
5. The outer surface of rock may be warmer or colder than inner protected portion. Such rock coming off outer layer is called exfoliation. In the same way freezing and melting of water also caused in the surface cracks.

When water freezes, it expands with force of about 1465mg/m^2 .This action decomposed huge rock mass and dislodging grains from smaller remains.

Alternative wetting and drying may also lead to physical disintegration of soil and also that of certain type of minerals .Such minerals get change in volume due to absorption of water for e.g. mica.

The weathering process also influenced by lithology of the rock, types of rock, composition of rock, generally the volcanic rocks like basalt, granite, are compact in nature and hence they require more time to erode then sedimentary rock. The structural influences in rock weathering are also observed. Lithological character determines by structural influences of rock weathering. The end product of weathering process is soil formation. But they are not unique because of time, weathering process and parent rock. Weathering is continues processes. The processes cause a progressive irreversible degradation of the slope material manifested as a reduction of its mechanical properties. Therefore, as time goes on rock fall and landslides occur. The time scale relative to evolution of natural slopes range from a decades' to thousand of year depending on soil type and weathering process acting on slope weathering process may have different velocities depending on the type of weathering.

Moisture in the atmospheres, especially in the form of the rain is direct or indirect related to operation of most geomorphologic process on the earth surface. The moisture influenced rate and amount of denudation on the exposed surface directly. The moisture affects rate of chemical and the biological reaction in the plant. The final product of weathering, soil formation its kinds are determined by moisture.

Salt crystallization occurs during rainy seasons and in marine costal areas where waters with high salt content go in to rock cracks and pores. Crystals formed within cracks and pores exert pressures which develop fracturing.

Living organism actions such as tree root growth and burrows contribute to cracking development as well. Chemical weathering is mainly due to chemical reactions which oxygen in the atmosphere, water and weak acids present in to it are involved in.

Another typical example of weathering is due to the chemical decomposition of granite. When water comes in to contact with intact granite, Potassium feldspar and mica are transformed in to kaolinide /clay. This type of weathering is typical of granitic batholiths in the Hong Kong region.

Since long time ago, (lumb1962) made a systematic study attempting to characterize the mechanical behavior of the weathered granite. Such knowledge was requested to satisfy the demand, particularly strong in that region of engineering structure, such as high buildings, bridges.

To understand the mechanical weathering process, Slaby defined eight parameters for assessing rock-mass strength for geographical purpose. (M. J. Slaby. 1980)

1. Strength of intact rock.
2. State of Weathering of rock.
3. Spacing of joints
4. Orientation of joints with respects to the hill slope.
5. Width of the joints.
6. Lateral or vertical continuity of the joints.
7. Infilling of the joints.
8. Movement of water and of the rock mass.

Except first one other seven fractures that divide the rock. First refers to the strength of rock material.

Major factor affecting on weathering are climate, topography, time and process of mechanical and chemical weathering.

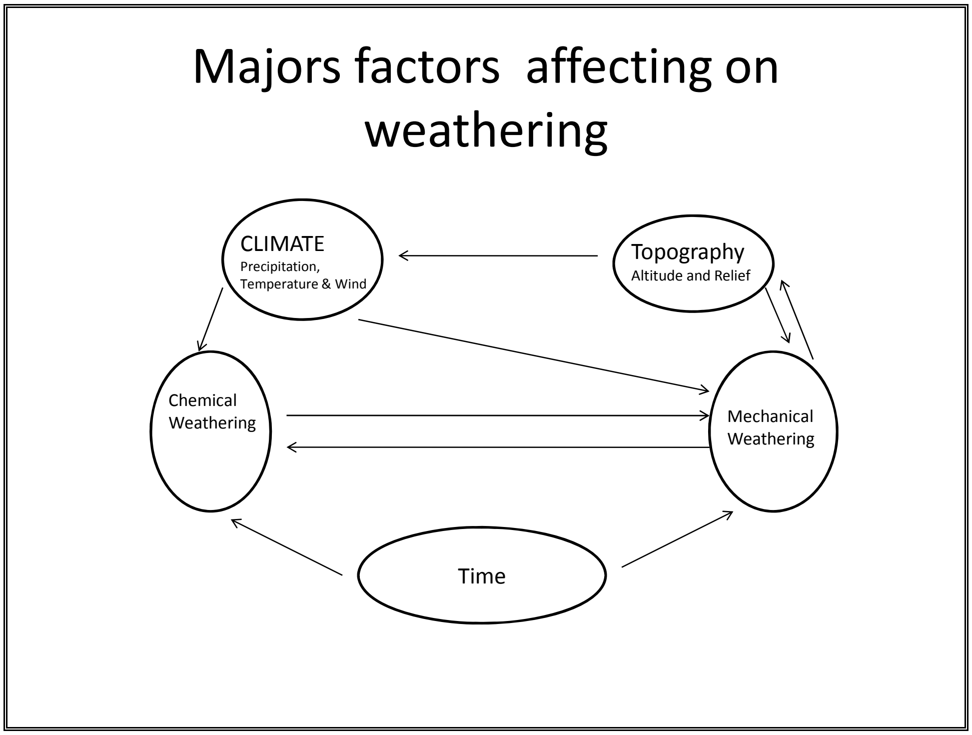


Figure - 2

Features and properties of soil and regolith

Regolith is loose, unconsolidated material at the earth surface. Regolith can have one of following origins, first formed in place where bedrock weathers (in situ) and second formed by the transported to aside by gravity, water, wind, ice or another agent. The first materials are referred to as residual regolith, or residuum. It is most common on stable up lands in unglaciated parts of the world; in glaciated regions it is either deeply buried or long since eroded. Transported regolith can take many forms, such as alluvium, glacial drift and Aeolian sands (Schaetzl & Anderson 2005). The residual regolith is weathered out of rock, and therefore all parts of it can be considered weathered. And the types of transported regolith are little weathered when it buried deeply. Weathering profiles evaluate downward into bed rock of unweathered regolith. The inter face with the bedrock of unweathered regolith is called the “weathering front”.

Chemical Weathering process

Chemical weather is called decomposition, it emphasizing on Brock down of the chemical composition of the mineral grains of the rock make that rock (Bloom 1998). These processes can be grouped in to four different type, Weathering, erosion, digenesis and metamorphism. The latter two are phenomena leading to rock formation, whereas the former two are the opposite (Stefano Utili 2004). Chemical weathering can be predicted from the condition under which rock forming minerals crystallize or precipitate oxidation, carbonation, hydrolysis, hydration, etc. are important principles of the chemical weathering processes. Dissolution of minerals species in water is most effective process of chemical weathering.

Rock and mineral matter are broken down and altered by weathering processes to products to that are in equilibrium with newly imposed physic –chemical condition (Ollier1984). Weathering is not restricted to the alteration of rocks exposed to the ground surface environment; it can occur at considerable depths beneath the surface. In general, within a weathering profile, zones closer to the surface are more weathered than are deeper zones (Phillips 2001).

There are different weathering's processes are occurring in association with each other. The physical weathering is refers to the mechanical disintegration of rocks, they allow it to expand and crack (Schaetzl and andreson 2005). Chemical weathering refers to chemical alteration of rock and minerals with surface water, temperature and pressure. Primary minerals are decomposed and new minerals are formed, which are more stable under condition existing at the earth surface (Peter W.Birkeland 1974).

Important chemical weathering process includes carbonation that releases metal cations as well as produces bicarbonate ions. For examples, the weathering of albite to kaolinite is written as;

$4\ NaAlSi_3O8+6H_2O_2+4CO_2=SiO_2+Al_4Si_4O_{10}\ (OH)_8\ +4Na^++4HCO$

Carbon dioxide is fixed from the atmosphere by photosynthesis and enters the weathering system though the intermediary of respiration by plant roots and the breakdown of plants debris by bacteria. Carbon dioxide is abundant in the atmosphere of soils, especially those characterized by high rates of organic activity. The dissolution of carbon dioxide in precipitation provides and additional source of bicarbonate ions. In general it appears that the leaching of metal cations from silicate minerals is controlled by supply of acids; this not only involves carbonic acid, although this is the most pervasive, but also sulphuric acid and more significantly a range of organic acids (Ghorbani et al.2007).

Oxidation is the process by which an element loses electrons. Oxidation and reduction are the two other most important weathering processes. The tendency for oxidation or reduction to occur is indicated by the redox potential (Eh) of the environment. This is measured in units (mV), with positive values registering an oxidizing potential and negative values a reducing potential. Abundant oxygen is dissolved in most surface waters and the Eh is predominantly positive in weathering environments that is oxidation occurs spontaneously, though not necessarily rapidly. However, in some localities, such as below the water table and in water-logged soils, reusing conditions can prevail. Redox potential also varies with pH, becoming generally lower as alkalinity increases. This relationship can be seen clearly by plotting pH and Eh values measured in various earth surface environments. As observation takes place, the range of Eh- pH values encountered. The enclosed area represents the extreme limits of the natural Eh-pH values. The letters represents typical values for various types environments., (P)precipitation,(S)Stream water, (B), bog water,(W)water-logged soils,(G) groundwater, and aerated alkaline environments (Summerfield 1997).

Mineral stability and the clay minerals

Goldich (1998) studied the stability of common silicate minerals occurring in the weathering environment. He developed a weathering series that closely matches the order of crystallization of silicate minerals from a silicate melt known as Bowen’s reaction series. Olivine, for instance, is the most unstable mineral in the weathering series and crystallizes at the highest temperature. Quartz, on the other hand, is the most stable and crystallizes at the lowest temperature.

In addition to quartz, which can at least partially survive prolonged weathering in most environments, the mineralogical composition of primary minerals and the incorporation of dissolved constituents in to new minerals are forms, by far the most important of which clay minerals (Summerfield 1997).Clay minerals are formed through the recombination of silica, aluminum and metal cations released during weathering in to layered phyllosilicate-type structures. They major group of clay mineral are kaolinite (hydrous aluminum silicate), illite (hydroos potassium silicate), smectite(complex hydrous magnesium aluminum silicate), chlorite(hydrous silicate of aluminum , iron and magnesium), vermiculite(hydrous magnesium silicate),mixed layered, and playgorskite and sepiolite (hydrous magnesium silicate).

The type of clay minerals produced during weathering depends on the composition of the circulating pore waters (specifically the concentration of dissolved silica and the type and concentration of cations), the mineralogy of the bedrock, the intensity of leaching and the prevailing Eh-pH condition (Essington 2004).

The intensity of leaching is to be the major kinetic control in most weathering environment. Clay minerals such as kaolinite, which have been stripped of metal cations together with iron aluminum oxides and hydroxides, are prevalent in environments characterized by intense leaching since there the large throughput of water removes cations in solution ant prevents their concentration in pore waters within the regolith. Where leaching is of only moderate intensity, cations released during weathering can build up in the solutions the formation of cationg bearings clays such as illite and smectite is favoured. In arid and semi-arid regions leaching may be minimal and solutions in the regolith can attain high concentrations of dissolved constituents. This condition commonly leads to accumulations of calcium carbonate at or near the surface, while under more extreme conditions of aridity soluble salts as gypsum($CaSO_4.H_2O$), halite(NaCl)and thenardite (Na_2SO_4) may be precipitate (Summerfield 1997).

The intensity of leaching is never uniform throughout and entire weathering profile throughput of water normally decreases with depth due to comaction and the downward translocation of the fine particles which reduces the size of voids. The resulting reduction in the intensity of leaching is generally reflected in mineralogical changes with depth.

Clay minerals such as illite smectite, which are readily altered in the zone of active leaching towards the tops of a profile, may be relatively stable at lower levels where leaching is less intense. Vertical differentiation in mineralogy in weathering profile may also reflect the stage by stage alteration of primary rock minerals. Smectite and illite may form preferentially near the weathering front only to be eventually altered to kaolinite and perhaps gibbsite as gradual lowering of the weathering front and erosion at the profile effectively causes individual clay minerals to move up through the profile.

X-ray diffraction analytical methods generally allow for the distinction among different clays based on the expansion or contraction of the interlayer space- the region between adjacent 2:1 or 1:1 layers – in the presence of different cations and solvents (Moore and Renylolds 1997). The basic principle underlying mineral identification by XRD is that minerals are crystalline materials with periodic, repeating plans of atoms with uniform distances between them. The distances between adjacent plans are calls the d- spacing and is characteristic of the layer type and type of interlayer material. X-ray diffraction not only allows specific clay minerals to be indentified from complex mixtures, 90but also can provide semi quantitative estimates of their abundance (wilson1987; McManus 1991;courchesne and Gobran 1997).

Ferricrete and Silcrete

Ferricrete (rich in iron) and Silcrete (rich in silica) are two of the many kinds of duricrusts that take form of hard nodules of crusts of hard layers within soil or sedimentary layers. They are created as a consequence of the absolute or relative accumulation of particular components through the replacement or cementation of pre-existing rock, soil and regolith (Summerfield 1997).

Ferricrete and alcrete is most cases, represent the relative accumulation of Iron and aluminum oxide and hydroxide as more mobile components are removed from the weathering profile, where intense leaching occurs with abundant rainfall for a significant part of the year. Locally absolute accumulation may occur as iron and aluminum are mobilized to a limited extent within the weathering profile or are transported either mechanically or in solution from high to low topographic positions. The term laterite has long been used to describe iron and aluminum –rich weathering deposits, however, relatively weak materials and the terms ferricrete and alcrete are reserved for the indurate forms (Summerfield 1997). The structures of laterite range from those in which the iron forms discrete segregations (commonly pisolithic structures) to those in which the irons occur as a continuous skeleton (commonly vermiform or vermiform structures). Between these extremes lies a range in which both types of segregation co-exist, with varying predominance (Mc-Farlane 1983).

Laterate was defined by Ndrton (1973)as the product of rigorous chemical selection, developing where conditions favour greater mobility of alkalis ,alkali earths and Si rather than of Fe. The enrichment is relative; therefore some laterites may develop from Fe-poor parent rock (Schellmann 1981). During the process of lateralization, the primary minerals in the parent rock are broken down, leached of some of their components and secondary minerals form from the residua. These in turn broken down and suffer the loss of some of their components such that the residua re-group to form more stable secondary minerals in a continuing process. In general, later stages of mineralization are found higher in the profile each horizon being parent material for overlying horizon. Laterites are essentially residual accumulation of chemically resistant materials. This explains the concentration of Fe in the ferricrete on top of deep weathering profiles (Mc-Farlane 1983).

Mc-Farlane (1976) also described" ground water laterite" formed in the vadose zone in the narrowband of water table oscillation where Fe-oxides can segregate. Within areas where rainfall exceeds evaporation and at depth in water saturated conditions, the parent material weathers in to ferruginous oxyhydroxides and kaolinite (Mabbutt 1980). Ferrous iron (Fe^{2+})in the ferruginous oxhydroxides is reduced and dissolved, laving kaolinite and quartz in the saprolite and pallid zones(Mc-Farlane 1976,Nahon 1986). The reduced Fe^{2+}move up the profile in small scale migrations by capillary suction to oxidizing conditions and deposits as Fe^{3+} when oxidized over time the micro –transfers of iron develop pseudo-congmeritic iron crusts and ultimately pisolithic crusts (Nahon 1986). A critical factor in its formation is an alternating or variable moisture cycle, and it is formed in association with deep weathering profiles in moist, well-drained, tropical conditions (usually in areas with a significant dry season) on a variety of different types of rocks with high iron content(Bourman 1993). Mounting evidence now indicates that laterite and laterite profiles are not the result of a single set of hydrological conditions, but the result of a variable hydrological history, strongly controlled by geomorphologic history (Mc-Farlane 1983).

Eggleton (2001) defined silcrete as “strongly silicified, indurate regolith, generally of low permeability, commonly having a conchoidal fracture with a vitreous luster. Silcrete appears to represent the complete or near complete silicification of precursor regolith by the infilling of available voids, including fractures. Most are dense and massive, but some may be cellular, with boxwork fabrics”. Silcrete occurs across the Australian continent from contemporary humid to arid climates from Cape York to Tasmania, and from sea level on the south coasts of New South Wales to Western Australia (Taylor and Eggleton 2001). In some cases they occur in close association with ferricrete (Goudie 1985; Summerfield 1997).

Silcrete forms through absolute accumulation of silica, which requires a source, a means of transferring to the site of formation and a mechanism for precipitation. Possible sources include the weathering of bedrock or sediments, inputs from rainfall or dust, plant residues and solutes in groundwater. Translocation can be lateral or vertical, and in the later case may be either upward as a result of capillary rise, or downward through percolation (Summerfield 1997).

Precipitation can arise from a variety of factors, while change in pH appears to be of particular importance in the case of silcrete. It can explain why the silcrete can be found in both predominantly alkaline arid and semi – arid environments, and in acid humid tropical weathering profiles. The solubility of silica is more or less constant up to a pH of around 9; above that point, its solubility increases dramatically. In alkaline environments, such as those commonly found around ephemeral lake beds in semi-arid and arid regions, pH may vary between 8 and10 over short distances. Silica in solution moving from a locality where the pH is above 9 to one where it is below 9, therefore, will be precipitated. In such circumstances, silcrete can develop within calcrete, while under different conditions; calcrete can be seen replacing silcrete. A contrasting situation exists in the highly acidic conditions associated with abundant organic activity in humid tropical regions. At a pH below 4, aluminum becomes more mobile than silica, so clay minerals can be silicified as they lose aluminum, even though the concentration of silica in solution in invariably very low (Summerfield 1997).

Deep weathering profiles/Ideal weathering profile

It has long been recognized that five factors control the nature of soil development: climate, parent material, topography, organic activity and time. The factors controlling weathering can be viewed in a similar way. Deep weathering profiles are wide spread in the lowland humid tropics, where high temperatures and abundant rainfall create conditions in which the potential for chemical weathering is great (Liaghati et al.2005).

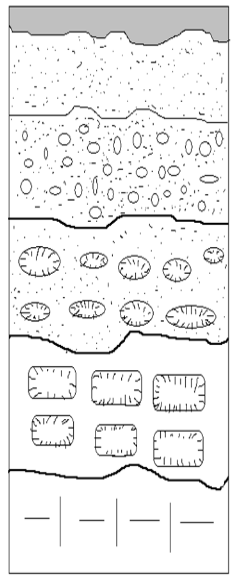
A number of geomorphic studies have focused on weathering profiles developed on granite under humid tropical and subtropical climates. Walther (1915; 1916) first formalized a common zoned deep weathering profile, termed a ‘Walther profile’, which has the following distinctive horizons: soil, ferricrete, mottled zone, pallid zone, and fresh bedrock. The soil at the top of the profile is variable, but commonly is a red soil with ferricrete. Silcrete may also be associated with a Walther profile, most commonly above the mottled zone, but it can occur at any level, and may occur at several levels within a profile. The pallid zone consists mainly of kaolinite , and is oxides in a matrix of pallid zone saprolite; it can extend up into disturbed regolith and may merge with ferricrete (Ollier and pain 1996).The terminology for describing a typical deeply weathered profile has , however, not been uniform depending on the authors ‘ interest and was summarized by Anand and Paine (2002).

The Soil Profile

The weathering profile was defined and developed by geologists and viewed as a part of their realm (Kay and Pierce 1920; Leighton 1958). Some soil scientists may equate the soil profile to the weathering profile, which extends from the ground surface to the depth of fresh bedrock (Mc Donald et al. 1990). However, it is commonly held that only those layers of regolith closest to the land surface, which have been subjected to the soil-forming processes, can be considered soil (Murphy 2000). Soil means many different things to different people depending on their occupation or interest and they see soils in a variety of ways. Soil was defined by Schaetzl and Anderson (2005) as an internally organized natural body of weathered mineral and organic constituents arranged in soil horizons form a soil profile, which commonly appears as multicolored layers in road cuts and housing foundations. Soil horizons are labeled with letters, starting at the surface as in (Merritts et al 1998).

For each horizon, colour is one of the most obvious basic soil morphological properties. The soil colour is measured on the surface of a freshly broken aggregate of moist soil by comparing it with a munsell soil colour chart or its equivalent (Fujihara Industry Company 1967). Soil colour is determined by four main factors: the quantity and type of organic matter, the nature and abundance of iron oxides, inherited features from the original parent material or accumulations of mobile constituents, and water content (McKenzie et al 2004) Mottle colouring are described separately, which are spots blotches or streaks of subdominant colours different from the matrix colour. The colour, size and contrast of mottles are good indicators of a range of soil processes including the degree of biological activity, chemical reactions and seasonal water-logging (McDonald et al .1990; McKenzie et al 2004) Texture gives a field estimate of the relative amounts of clay silt and sand in a soil, and is generally determined on the soil fraction that is less than 2 mm diameter. There is only an approximate relationship between texture determined in the field and particle size analysis done in the laboratory (McDonald et al. 1990). The full procedure for determining texture is set out in the reference just cited ;six main soil texture groups consist of lands , sandy loams, loams, clay loams ,light clays and heavy clays , with increasing clay content . The variation of texture in a soil profile is also important for deciphering the pedogenic and geological history of the soil as well as determining soil water behavior. Northcote (1971) defined three types of texture profiles: uniform, gradational and duplex, based on how much and quickly the texture changes from the A horizon to the B horizon. The duplex or texture – contrast soils constitute about 20% of the Australian continent (Chittleborough 1992).A large proportion of the occurrences of water-logging is associated with such duplex soils.

Weathering profile



Model of weathering by Ruxtton and berry

Figure - 3

Soil structure, it involves a bonding together into aggregates (peds) of individual soil particles, is described by type or shape and size of the peds. Structure is important to the movement of water through the soil and to surface erosion. A –horizon structures, although they vary from soil to soil, tend to produce larger –sized pores than would be the case for a structure less surface soil. This larger pores allow soil to take up large amounts of rain water over a short period of time (high infiltration rate), and thus reduce the possibility of runoff and surface erosion. B-horizon structures provide avenues for the translocation of water and any contained solids along the ped interfaces. Indeed, this is where most clay films are located (Birkeland 1999).

Other soil morphology when describing a soil profile may coarse fragments if there is any. They are particles greater than 2 mm in diameter and not included under texture. Most commonly they are rock fragments, such as quartz, shale or basalt floaters.

Segregations and concretions may be present in some soils. These are discrete mineral accumulations in the soil that occur as a result of the concentration of some constituents generally by biological or chemical means. Segregations tend to be soft and concretions hard. Types include calcium carbonate, gypsum, manganese compounds and worm casts. They very widely in size, shape hardness and colour, are indicative of soil-forming conditions (Murphy and Murphy 2000a).

Zones of Subsurface water

Subsurface water movement can be briefly described as: Water enters the regolith via infiltration from the surface, moving through it until it reaches the water-table and becomes part of the ground water system. At that point it moves laterally until it is eventually discharged at the surface as springs, seeps into river or lake systems, or enters the sea (Taylor and Eggleton 2001). Water in the soil and regolith may exist in an unsaturated or Vadose zone (above the permanent water table or phreatic surface), or in a saturated zone (below the water table).

Regolith Aquifer

Generally porosity in weathering profile is high at the surface, low in the upper saprolite and high again in the lower saprolite and decreases again into fresh rock. This was well documented by Thomas (1994). The data of Thomas show that the relative permeability is high at the surface in residual from which many fine-grained components have been winnowed or eluviated. It decreases rapidly in mobile and saprolite zones where clay-sized materials have not been removed or have been added by illuviation. The fact that porosity is relatively high in this zone while permeability is low suggests that the clay minerals (and perhaps Fe-oxides) maintain the porosity but block fluids passing through the material. Once the zone in which corestones occur is reached, permeability increases only to fall off again in the fresh basement. Some relevant studies have been reported from Africa. Howard Karunda (1992) described the role of the regolith in the exploitation of ground water in Uganda. The common practice in that country was to drill to the fractured bedrock, and seal the bore so that water was not lost to the regolith. Studies showed that the basement rocks form a very weak aquifer is the lower part of regolith. Taylor and Howard (1994) provided a cross-section in which the 'sand' layer at the base of the regolith profile is the aquifer. The fact that the water- table corresponds to the top of the sand suggest that the aquifer is confined by the upper clay it is interesting that the high permeability is not associated with high porosity, and is largely associated with permeability in fissures.

Soil water

Soil water is normally considered to include both the water contained in the soil profile itself and the subsurface water in the unsaturated subsoil layers between the soil profile and the water table. Thus defined, soil water includes all the water in the zone of aeration, which may extend tens or even hundreds of meters below the ground surface (Ward and Robin 2000). Knowledge about the factors controlling water storage and movement in the soil is essential to understand a wide range of processes, including not only the supply of water to plants but also the generation of runoff, recharge to underlying groundwater (Bear and Verruijt 1987).

Significance of weathering studies:

The aim of the study is to discuss the implications of surface weathering and temperature rainfall in Salpe Ghat area. Weathering in Salpe Ghat is occurring over thousands of year. The aim of the present research work is to study, identify, discuss, analyze and to interpret Study of Weathering Characteristics of Salpe Ghat Region in Satara District. The study aimed to understand weathering characteristics in Salpe Ghat region. Geomorphologic study deals with the study of process such as weathering, denudation, deposition and structural geology. It consist endogenic dynamic and exogenic process. Weathering is not a uniform it varies from place to place and time to time. Significance can be mention by following way.

1. To study the depiction of Weathering Characteristics in the selected area of Satara District.
2. Study of weathered rock gives an idea about weathering processes, rock strength, mineral formation and time to alteration of rock.

3. Weathering study provides idea about climatic change in past period. It gives evidences of historical climate.
4. The study of beach rocks is very much helpful to geologist and geomorphologist, because of rock structure and there location.
5. To suggest measures for increasing weathering among students by using diagrams, 3D model and cross profile.
6. To study the weathering process. To emphasize distinctive feature of weathering and to know various types weathering.
7. To evaluate the natural slope of weathering process.
8. To interpret the weathering phenomenon.

Weathering study in salpe ghat is ignored, but Dr. Perdeshi and Dr.Sayyed are presently working on study of redbol in this region.

1. Review of the Related Research:

A great deal of work has been done so far on various Weathering characteristics in Salpe Ghat Region. The main findings are regarding the weathering characteristics. A lot of work has been focused on portrayal of weathering characteristics. The researcher thought it appropriate to focus on the depiction of weathering process, their characteristics, evaluation of natural slope, and soil formation. The researcher has come across with the following research focusing in weathering characteristics.

1.1 Surface weathering of Rapakivi granite outcrops – implications for natural stone exploration and quality evaluation – Dr. Paavo Harma.

In this paper, the researcher studied the weathering of Rapakivi granite. The type of weathering is known as grusification and it comprises both mechanical and physical process. Weathering of Rapakivi granite varies intensity almost unweathered rock to total disintegration of the rock. The upper surface parts of outcrops are weathered down to a dept of one – two meter on average.The study on granites rock carried out by Paava Harma and Olavi Selomem in South Finland (Estonian Jr. of earth science vol.57 2008 p-135 to 148). The rock uses natural stone as a row material in Finland. Rapakivi granites are highly potential for natural stone. The special type of weathering can extend to deep in to the rock. The first production rock layer from the outcrop surface down can in the worst case. It can be unusable as natural stone. The upper part of pyterlite outcrop weathered down to 1-2mtr deep with variation in intensity. It can also occur as random sub-horizontal and sub -vertical zone deeper down in the rock. The outcrop can in places appear to be intact on the horizontal surface but the vertical section of the same outcrop reveals that the whole outcrop is totally weathered down to a depth of a two meter. The color of pyterlite on the outcrop is often, altered and represents the color of the weathered rock with pale and rusty color. The hardness of Rapakivi granite also changed due to the weathering.

The canyon land with semi arid climate makes finding sand stone with desert varnish highly probable. Pinyon-Juniper tresses dominate flora in this aria. The sand stone weathered in this climate which is composed mostly of quartz grains with very of small rock from fragments, feldspar and clay mineral. Quartz in sand stone is highly resistant to chemical weathering decomposition of the rock consist largely attack on the cement. It is important to note that all landscape is evolving equilibrium. Weathering and erosional process are acting to tear this landscape. (Ref. Kari P., Picketwire Canyon, 2007.)

1.2 Evolution of natural slopes subjected to weathering : an analytical and numerical study- Dr. Stefano Utili

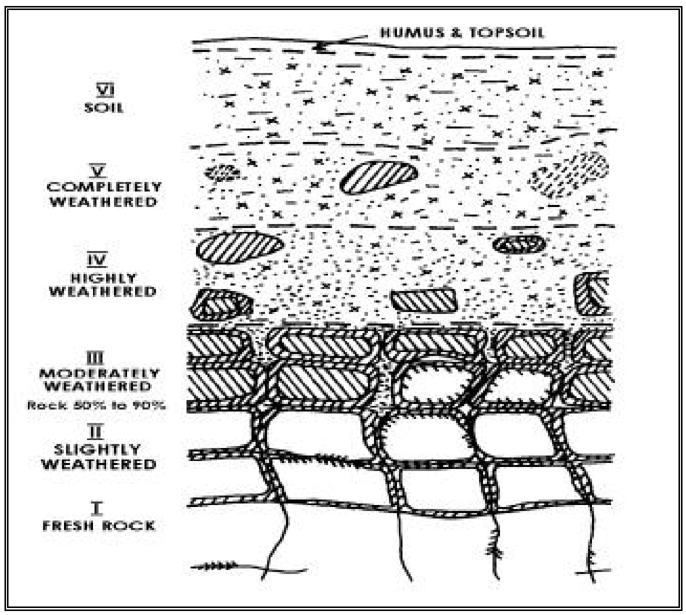
In this thesis, the researcher aimed at to study evolution of the natural slope subjected to the weathering process. The time scale are relative to the evolution of natural slope ranges from decades to thousands of year depending on soil type and weathering process acting on slope.

1.3 Qing Wangand others researcher has studied deep weathering profile and groundwater characteristics within a low-lying coastal pine plantation the costal lowlands of southern Quensland of east Australia. Water-logging associated with duplex or texture contrast soils is relatively well understood. It is caused by a perched groundwater occurring on top of more finely-textured B-horizons. In some cases, on top of the C horizon, depending on the variation in the subsoil horizontal hydraulic conductivities and textural contrasts. Secondary salinity is often associated with water-logging. Notably in the wheat belt areas of Western Australia, the wholesale clearing of native vegetation has resulted in extensive lands being affected by dryland salinity. Rising water levels provide a transport mechanism whereby salts that are reposted in deep weathering profiles are lifted to the soil surface. 33 groundwater bores was Established to evenly cover the study area , prior to the onset of the summer wet season. Drilling confirmed the widespread presence of a deep lateritic weathering profile that is commonly sandy at the surface and grades into a low-permeability clayey eight shallow bores were established for monitoring perched groundwater, presumably formed on top of this clayey layer, or on top of a duripan (ferricrete or silcrete) in cases where the duripan appeared shallower than the clayey layer. Four intermediate-depth bores (B4, C3i, C4 and C5) were slotted within the clayey layer, and one deep bore, C2d, adjacent to the shallow bore C2s, was drilled to 13 m depth and slotted within a sand-gravel aquifer above the bedrock layer at varying depths. Twenty-eight shallow bores were established for monitoring perched groundwater, presumably formed on top of this clayey layer, or on top of a duripan (ferricrete or silcrete) in cases where the duripan appeared shallower than the clayey layer. Four intermediate-depth bores (B4, C3i, C4 and C5) were slotted within the clayey layer, and one deep bore, C2d, adjacent to the shallow bore C2s, was drilled to 13 m depth and slotted within a sand-gravel aquifer above the bedrock. The weathering profile and three groundwater bodies deeply weathered regolith profiles that contain distinctive layers including soil, (ferricrete), mottled saprolite, fine saprolite and coarse saprolite are widespread in the inter-tropical belt between latitudes 35°N and 35°S, such as in Australia, Africa, India and South Africa, where the regolith is considered to have been produced by intense weathering over long periods (Tardy and Roquin 1992; Anand and Paine 2002). The distinctive zonation developed within these typical deep weathering profiles has a substantial control on groundwater hydrological processes (Ollier and Pain 1996). Typically, permeability is high near the surface, decreases rapidly in the mottled and fine saprolite, and increases again in the coarse saprolite (Thomas 1994). This permeability trend with depth is reflected in this study by the mineralogical variation. Kaolinite content is almost zero close to the top in the sandy soil, increases to around 26–56% in the mottled saprolite, and to more than 80% in the fine saprolite, and then drops to around 10% within the coarse saprolite. This mineralogical profile also indicates a decrease in weathering intensity.

The deeply weathered regolith profiles examined in the northern Tuan State Forest have the following distinctive zones: soil, (ferricrete), mottled saprolite, fine saprolite and coarse saprolite. The soils are generally sand-rich, while the saprolite is clay-rich, largely kaolinite. During the wet season, shallow groundwater is perched above the ferricrete or mottled saprolite. Intermediate-depth semi-confined groundwater occurring within the mottled saprolite is recharged from the shallow perched groundwater probably via preferential pathways. A deeper confined aquifer is present within the coarse saprolite at the base of the weathered profile, which consists mainly of smectite and feldspars. The three groundwater bodies identified exhibit distinctive chemical characters. The shallow groundwater is low in EC and slightly acidic, which reflects typical shallow plantation settings. The intermediate groundwater has high salinity and is low in pH, and the deep groundwater is low in EC and the pH is circum-neutral. Sodium and chloride are the major cation and anion, present in all the groundwater. As the weathering profile is essentially siliceous, all the groundwater shows a depletion of Ca relative to Na. The considerable amount of minor elements (Mg, Fe and SO4) present in groundwater within the Quaternary alluvium distinguishes this unit from Tertiary (Elliott Formation) and pre-Tertiary (Maryborough Formation) geological units.

1.4 **Bujang B.K.Hunt** and others studied tropical soils of semi arid areas and tries to understand Tropical Residual Soils of Various Weathering Grades with deep ground water table in Malaysia, residual granite Shear Strength Parameters of Unsaturated Tropical Residual Soils of Various Weathering Grades In Malaysia, residual granite rock soil and sedimentary rock soil occur extensively, i.e. cover more than 80% of the land area. Yet, not much research works have been carried out on these materials. The situation is even worst in the case of unsaturated residual soils.

Tropical residual soils have some unique characteristics related to their composition and the environment under which they develop. Their strength and permeability are likely to be greater than those of temperate zone soils with comparable liquid limits. Most classical concepts related to soil properties and soil behaviors have been developed for temperate zone soils, but there has been difficulty in accurately modeling procedures and conditions to which residual soils will be subjected. According to researcher Engineers appear to be slowly recognizing that residual soils are generally soils with negative in situ pore-water pressures, and that much of the unusual behavior exhibited during laboratory testing is related to a matric suction change in the soil (Fredlund and Rahardjo 1985, 1993). There is the need for reliable engineering design associated with residual soils (Ali and Rahardjo 2004).



Typical classification of weathering profile

Figure - 4

Soil samples were obtained from residual soil of weathering grade VI, according to the commonly used weathering classification for igneous and some sedimentary and metamorphic rocks of Little (1969), as shown in Figure. The soil was reddish brown in color and consisted mainly of sandy silty clay.

1.5 Nikhil S.Shejwalkar (2007) studied the morphology and erosional history of the Deccan basalt province. A GIS based approach for his Ph.D. study. According to him the

Deccan basalt province (DBP) region lives on the western passive continental margin of India and is one of the largest continental flood basalt regions of the world .The DBP is the youngest morpho-tectonic unit of the Deccan peninsula and covers about 15% of total geographical area of Indian region. In comparison with other part of the Deccan or Indian caraton, the Himalayan Mountain and indio-gangatic plain, the DBP displays distincy geomorphic and tectonics characters. The dbp is geomorphologically interesting because (a) The DBP is one of the largest passive continental basalt floods. Basalt region in the world, (b) it displays many mega-geomorphic features common to other passive continental margins e.g. great escarpment of western ghat. The evolution has been studied from longer time.

He tries to identify the geomorphic process responsible for erosion and recession of the Western Ghats. Escarpment and to estimate the range and average rate of recession of the western ghat escarpment .To understand the impact of scarp recession on the western ghat escarpment .He also estimate the palocon –Position of the western ghat, and to identify the role of lithology (flow type) on the morphological of landform and rivers of Deccan Basaltic Region and the cretaceous of Deccan basalts. He divides Deccan basalt region in major river basin.

1.6 Courtney Hugo and Michelle Smith studied the Tombstone Weathering. Marble is rock of choose to study the effect of chemical weathering. It is made out of calcite, the calcium carbonate which erodes rapidly in the presence of acid rain water. For example, sulfur oxide, nitrogen oxide and carbon dioxide which is present in acid rain. (Courtney Hugo and Michelle Smith**,** 2006, pp 4-8.)

CHAPTER II

Study area and methodology

The study is located in northern part of Satara Dist. in Khandala Taluka. The latitudinal extent is 17^0 56' 063"N to 17^0 58' 865" N and longitudinal extent is $74^0$09' 477"E to $74^0$09'931"E. (Figure – 5,6) Study area is a water divide between Krishna and Bhima River basin. The divide between two river basins is known as "Jogmath Donger" which is part of Mahadeo – Khanapur plateau. The southern slope is drain by "Vasana nadi" a north tributary of Krishna River while the northern slope of Jogmath donger is drain by "Sarhad nala "a south tributary of river Nira. The plateau slopes are generally east ward. The area lies between 695Mtrs and 780Mtrs height from sea level.

A large region like the state of Maharashtra represents different physical elements which have hardly fused into homogeneous. The people of Maharashtra traditionally divided the state on the basis of the history and topographic situation Kokan, Desh, Marathawada, Khandesh and Vidharbha are the five principles unit of Maharashtra. Geographically, Kokan, Desh, Sahydari, Marathawada, Khandesh and Vidharbha, They include the different valleys and plateaus (K R Dikshit pp 268,269).

According to geological survey of India almost the whole rock formations of Pune and Satara is stratified trap. Beds of basalt and amygdaloidal alternate, whose upper and lower planes are strikingly parallel with each other, as far as the eyes, can judge, with the horizon. Barometrical measurements and the course of the rivers show a fall in level to the east, south-east and south-east.

The study region is situated on eastern slopes of Sahyadri. The Sahyadri is also known as Western Ghat. It is a chain mountain extending from south of Tapi river in Gujarat to the tip of peninsula of India. The term, Western Ghat, was adopted by British after Ghat's a world used in Maharashtra refer to these mountains were qualified with a prefix Western Ghat to Eastern Ghat.

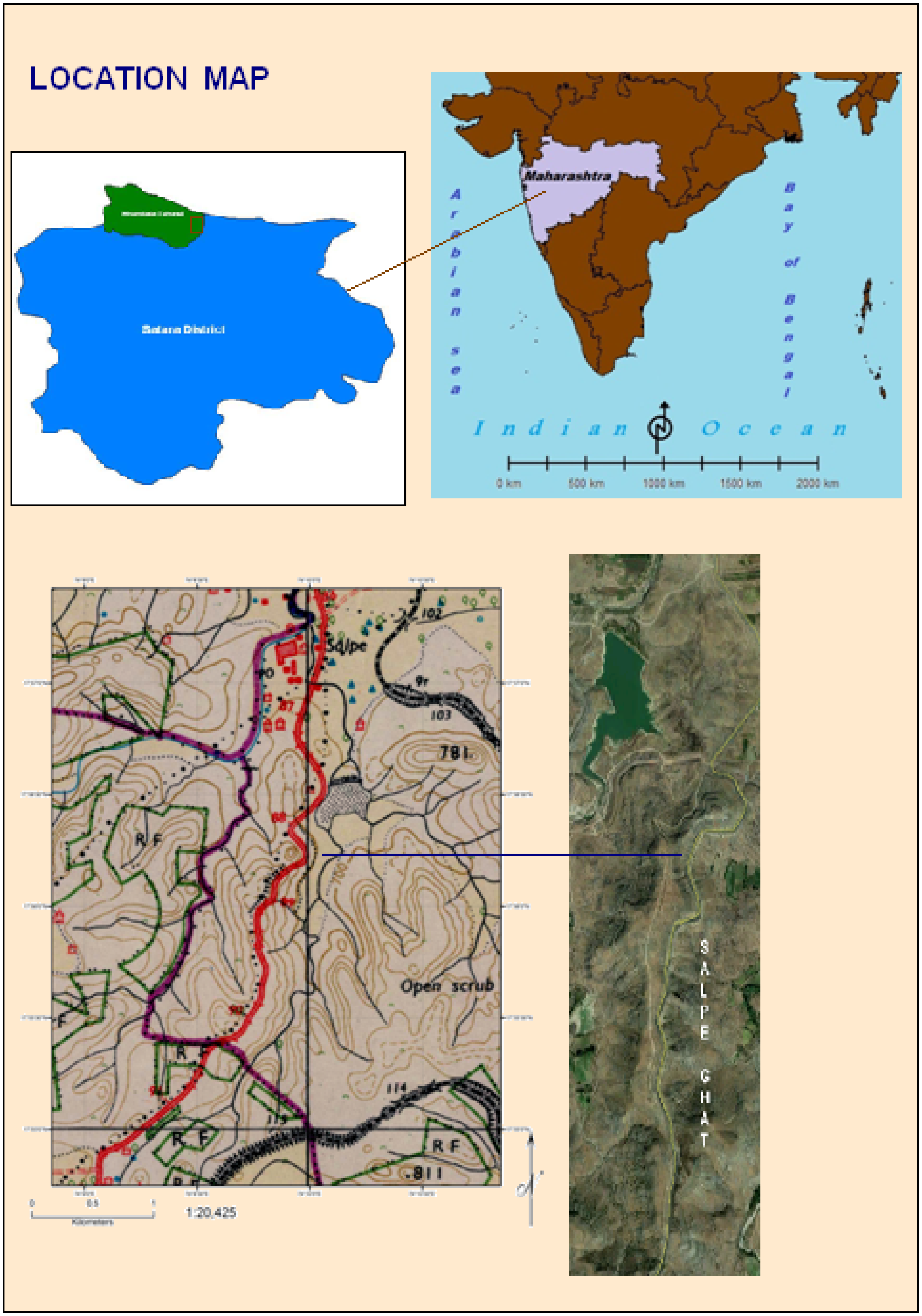

LOCATION MAP
Maharashtra
Arabian sea
Bay of Bengal
Indian Ocean
0 km
500 km
1000 km
1500 km
2000 km
Satara District
781
Open scrub
RF
811
1:20,425
Kilometers
SALPE GHAT

Figure - 5

Western Ghat is facing 700mtr scarp. Lithologically, they are part of lava plateau, the basalts having erupted during the cretaceous to nearby tertiary period. Western ghats rocks popularly known as “Deccan Basalt”. The geological world identifies this volcanic province either as the "Deccan Volcanic Province" (DVP) or simply the "Deccan Traps" and recognizes it as one of the Large Igneous Provinces (LIPs) representing high magmatic fluxes involving large amount of thermal energy in short period of geological time. The term “Deccan Trap” was coined by W.H. Sykes in 1833 and it is derived from a Sanskrit word Dakshin meaning south or southern and a Swedish word Trapp/ Traps meaning Stair. The term was aimed to describe the step like or terrace like topography peculiar to this terrain (Maharashtra geological survey report).

The nature of rocks varies over short distance. The rock shows greater resistance to weathering and erosion. They are partly denuded rim of this part where the earliest rocks are 17 millions year olds. The relief and height of this mountain very with the degree of detection, entrenchment by the river and the level of plantation achieved. At their lowest in the saddles, they have height of 700mtrs whereas some of the plateaus associated with the Ghat like Mahabaleshwer attain the height of over 1500mtrs. From Kokan to Desh mountains presents a formidable barred and they are traversed by road and railway only at few points (K R Dikshit pp 268, 269).

Weathering is a common process found in semi arid climate area. Deccan plateau is mainly made up with basalt rock. East slope of Western ghat enjoys dray climate which undergoes weathering process. Depth and weathered material weathering column is different from place to place. Weathering process also determines occurrence of land slide. As well as soil formation the vegetation cover, outcrop weathering. The weathering process is different in Salpe ghat area.

Digital elevation model draped by google image and contours

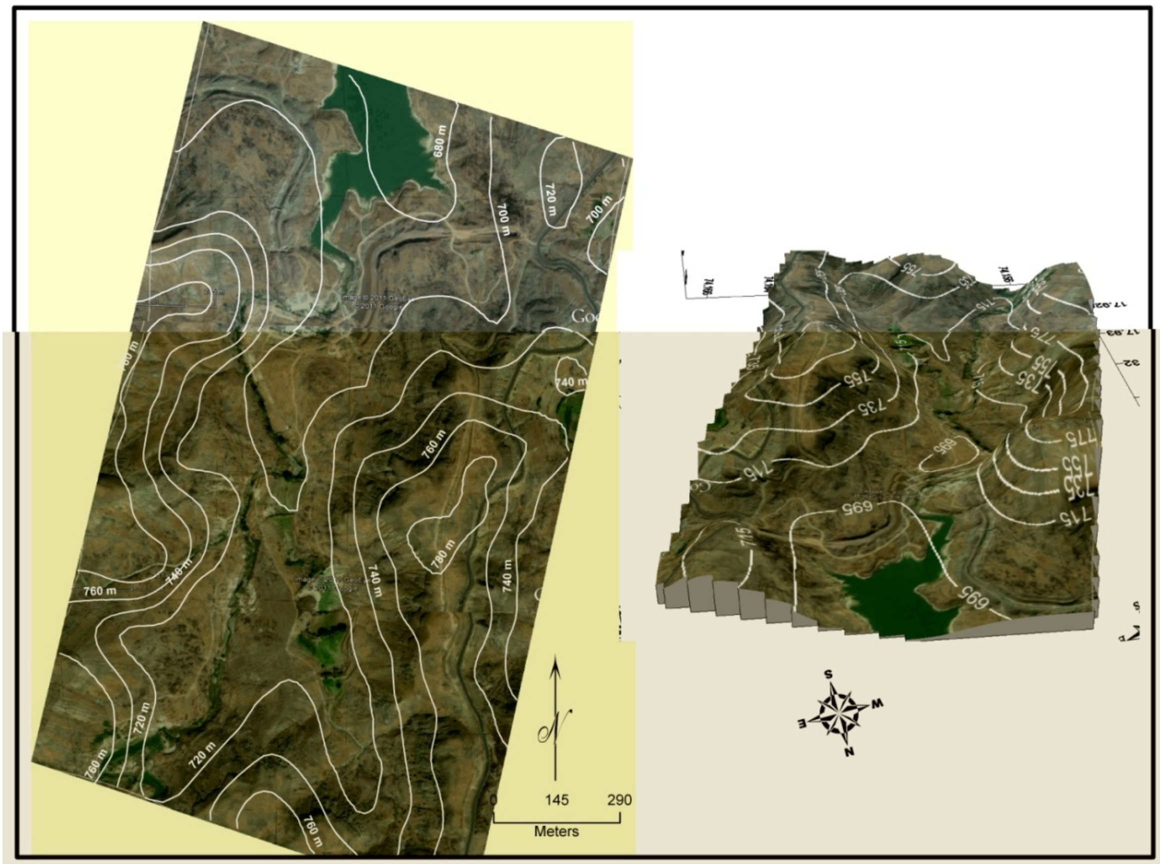


Figure -6

2.1 Climatic condition of Salpe ghat region

Study area is located in Satara District of Maharashtra, which is about 19Km away. The study area enjoys semi arid climate in which evaporation exceeds precipitation in the long part of the year. Summers are characterized by high temperature and extreme aridity in May and June. From June to march max temperature remains below 35^0C. The day temperature remains generally about 40^0C on an average. Satara gets higher rainfall in month of August, and dry months are December to March. Rainfall to the leeward side of the western ghat is between 50 cm to 60 cm in the year (Alka Gadgil pp 89).

Three distant seasons can identify as follows.

a. Dry summer from March to May.

b. South-West monsoon from June to September.

c. Winter season from December to February.

The semiarid weather has a special geomorphic significance. It characterized by alternative humid and arid climatic condition [(Garner H.F.)A. Faniran and L.Jeje1983] it has many definitions of precipitation, grass ground cover, intermittent stream-flow, in term of its probable geomorphic effects. The semiarid condition appears to be much more closely allied with classic humidity than with aridity. The semi-arid or tropical regions refers to the areas between latitudes $23^{1}/_{2}{}^{0}$ N to $23^{1}/_{2}{}^{0}$ S that is tropic of Cancer to Tropic of Capricorn.

Humid tropics has been distinguish by various scholars Fosbarg uses the visitation criteria ,defined as humid tropical area characterizes tropical rainforest, semi-deciduous, deciduous forest and savannas, while others Koppen, Garnier, Hodder, Gourou, Tricart uses climatic criteria to determining humid tropical region. All they are agree that the area falls under winterless climates characters with the mean temperature of the coolest month at 18^{0}C. The high lands exclude this condition where temperature of coolest month is less than 18^{0}C.

Precipitation is another criteria to determine humid tropics Fosberg, Garnier And Kuchler two types of humid tropics they are constantly humid and seasonally humid. Koppen divided in to three types' Af-tropical rainforest climate, Am- tropical rainforest monsoon type and Aw- tropical savanna. Tracert divided in to four types; they are constantly humid, constantly humid with a very short dry period, seasonally humid with a long dry period.

The study area is located on the leeward side of western ghat. Indian climate is characterized by seasonal monsoon rainfall. By the observation of temperature data of Satara, the maximum temperature varies from 31.1^{0}C (1974) to 42.6^{0}C (2001). The minimum temperature varies from 4.8^{0}C (1974) to 14.5^{0}C (1971).It has been observe that temperature gradually increase from November to May and started decreasing falls during the southwest monsoon from May to October. Daily and annual variation in temperature is very high, the temperature variation in summer April 2008, it was 41.5^0C during day and during night it was 12.3^0C, during winter in January 2008 it was 34.8^0C during day and 7.5^0C during night. it shows that annual and daily temperature variation is very high. This is a major cause for weathering at salpe ghat area. (Table 1) (Figure -7)

Annual rainfall at Khandala Dist Satara was observed 76 cm in 2006.most of the rain fall is in the month of June to September. Rainfall varies from 91 cm (1993) to 21.8 cm (2003). We can say that alternate dry and wet season and variation in rainfall lead to physical weathering in salpe ghat area. (Table 2) (Figure-8)

Table-1 Distribution of Maximum and Minimum temperature At Satara(1971- 2008)

Year	Highest Max. Temp. (in ^{O}C)	Lowest Mini. Temp. (in ^{O}C)	Rain fall in mm
1971	33.4	14.5	33.4
1972	36.9	19	36.9
1973	--	--	--
1974	31.8	9.4	31.8
1975	39.9	11	39.9
1976	35.5	8.9	35.5
1977	38.5	10.5	38.5
1978	39.5	10.5	39.5
1979	40	10.6	40
1980	39.1	7.6	39.1
1981	40.4	8.7	40.4
1982	36.8	10.9	36.8
1983	38.5	9.5	38.5
1984	37.2	7.3	37.2
1985	38.8	11.1	38.8
1986	37.7	10.3	37.7
1987	39.9	10	39.9
1988	41.4	10.4	41.4
1989	38.6	7.8	38.6
1990	41	5.8	41
1991	40.7	4.8	40.7
1992	40.1	6.4	40.1
1993	41.4	8.5	41.4
1994	--	--	--
1995	40.5	8	40.5
1996	40.9	7.3	40.9
1997	39.5	6.1	39.5
1998	41.9	9.8	41.9
1999	41.5	7.3	41.5
2000	42.1	7.3	42.1
2001	42.6	10.2	42.6
2002	42.2	8.6	42.2
2003	41.4	9.2	41.4
2004	40.7	10.2	40.7
2005	39.6	8.2	39.6
2006	41	8.6	41
2007	42	9.6	42
2008	41.5	7.5	41.5

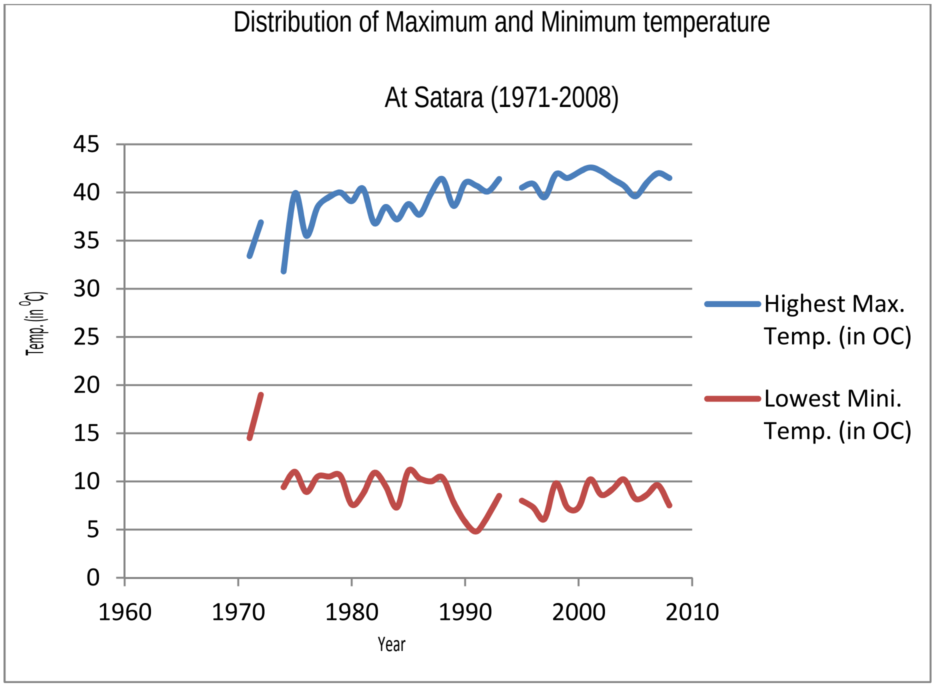


Figure - 7

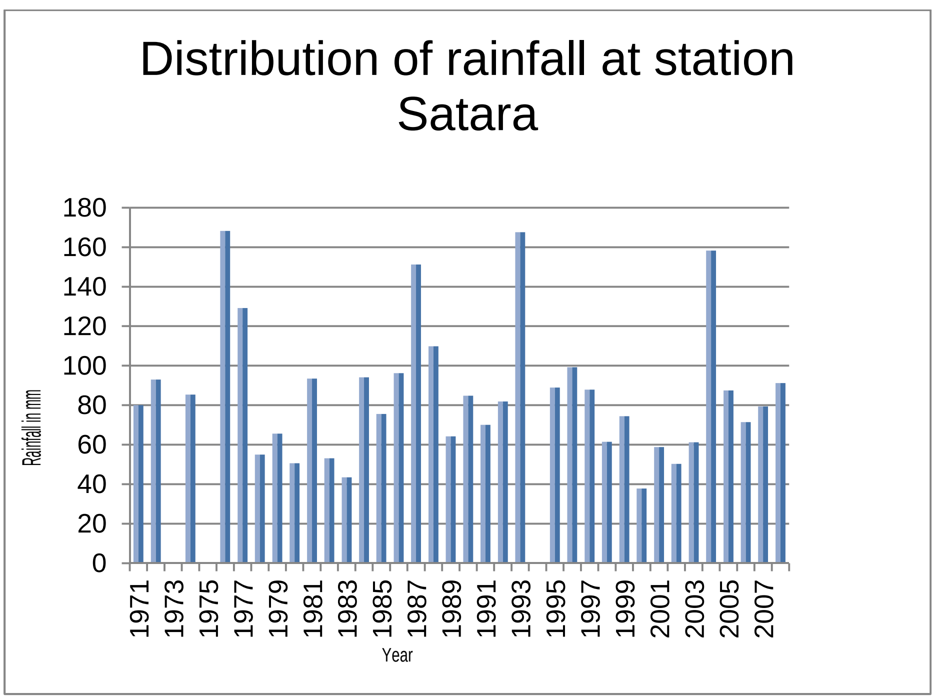


Figure - 8

Table – 2 Monthly variations in climate at Satara in 2008

Month	Max.Temp in ^{0}C	Min.temp in ^{0}C	Rainfall in mm
January	34.8	7.5	0
February	35.5	9.4	0
March	38	14.4	51.9
April	41.5	12.3	1.2
May	40.1	19.8	33.8
June	37	21.6	132.2
July	32.2	20.8	78.3
August	35.2	19	239.5
September	32.2	18.2	111.9
October	34	13.5	103
November	34.3	13.3	22.4
December	32.4	9	10.4

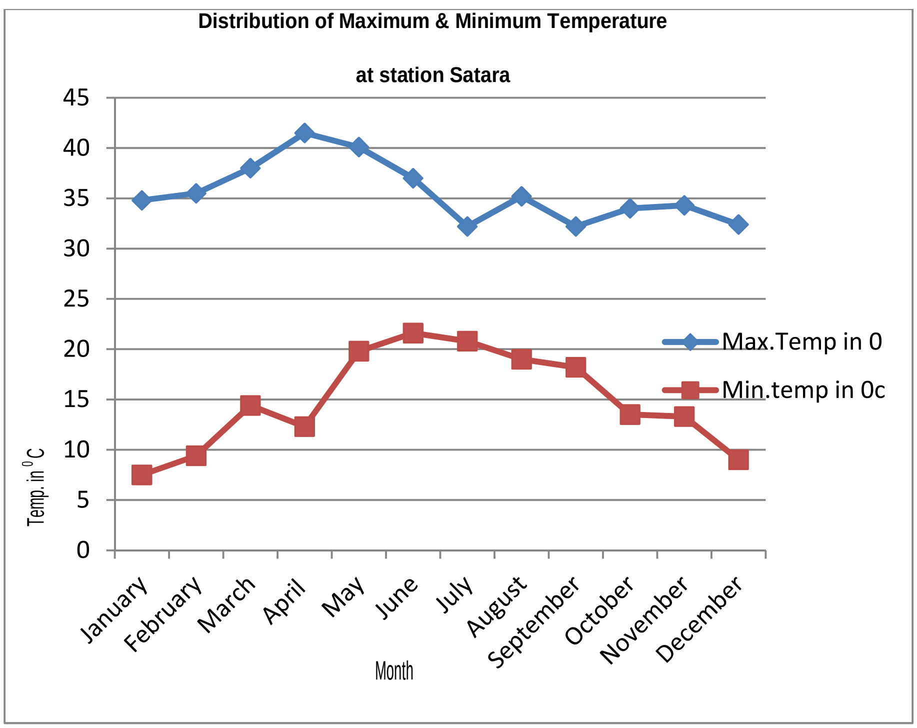


Figure - 9

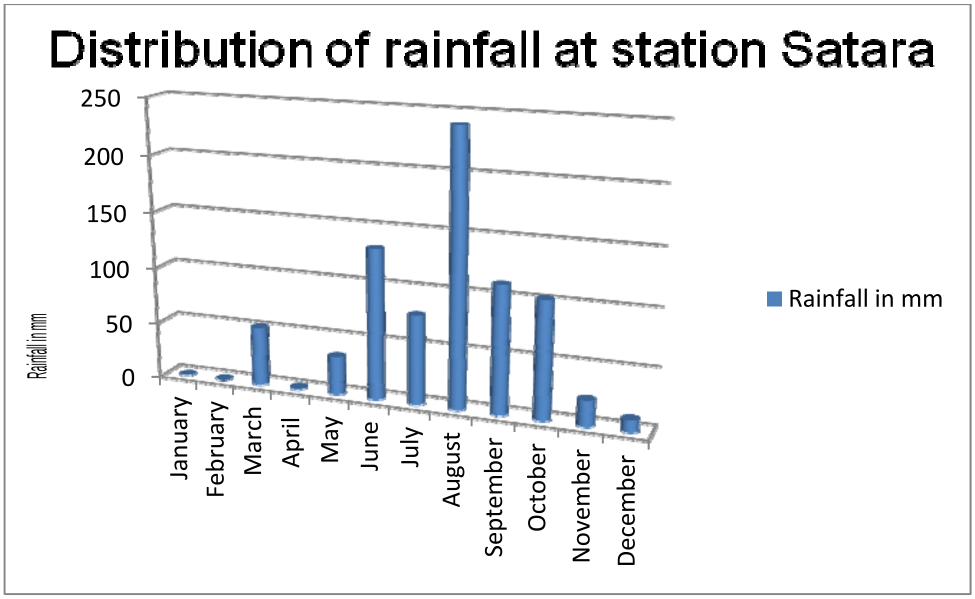


Figure - 10

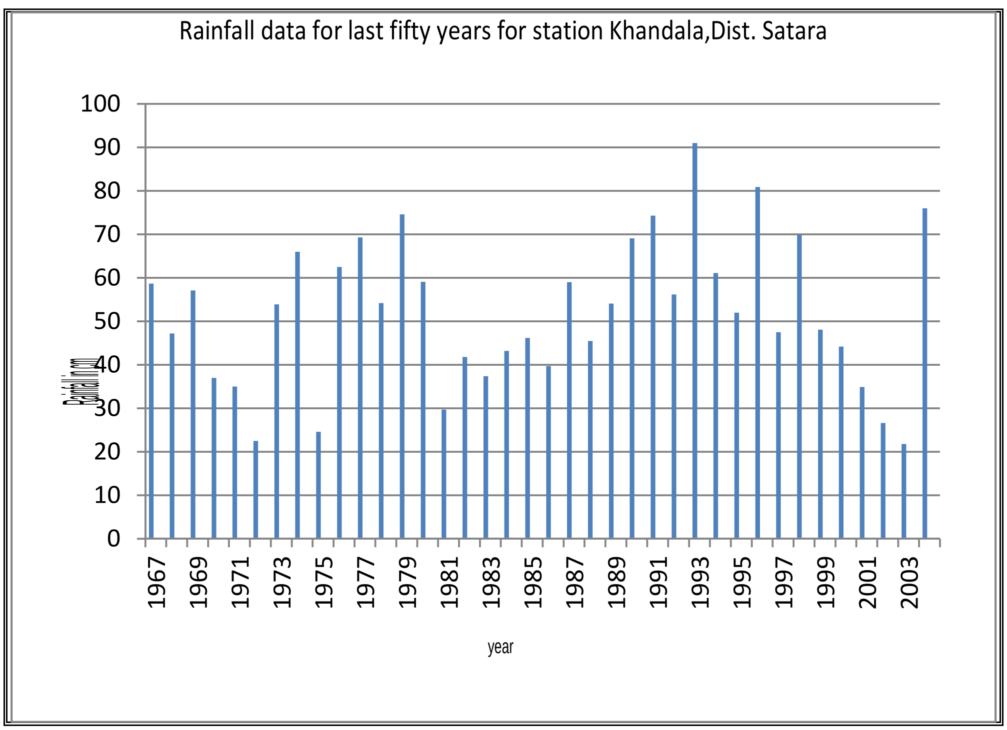


Figure - 11

2.2 Physiography of Salpe ghat area:

Salpeghat section is located in Jogmath donger. The general slope of this area is west to east. The area is drain by east and west tributary of Sarhadnala. Maximum height in study area is recorded 780 m in the central part of the study area. The lowest height is in the northern section, which is 690m. Typical “trappean” topography with flat top can be observed in this region. (Figure 12)

Topography and cross sections of Salpe ghat region

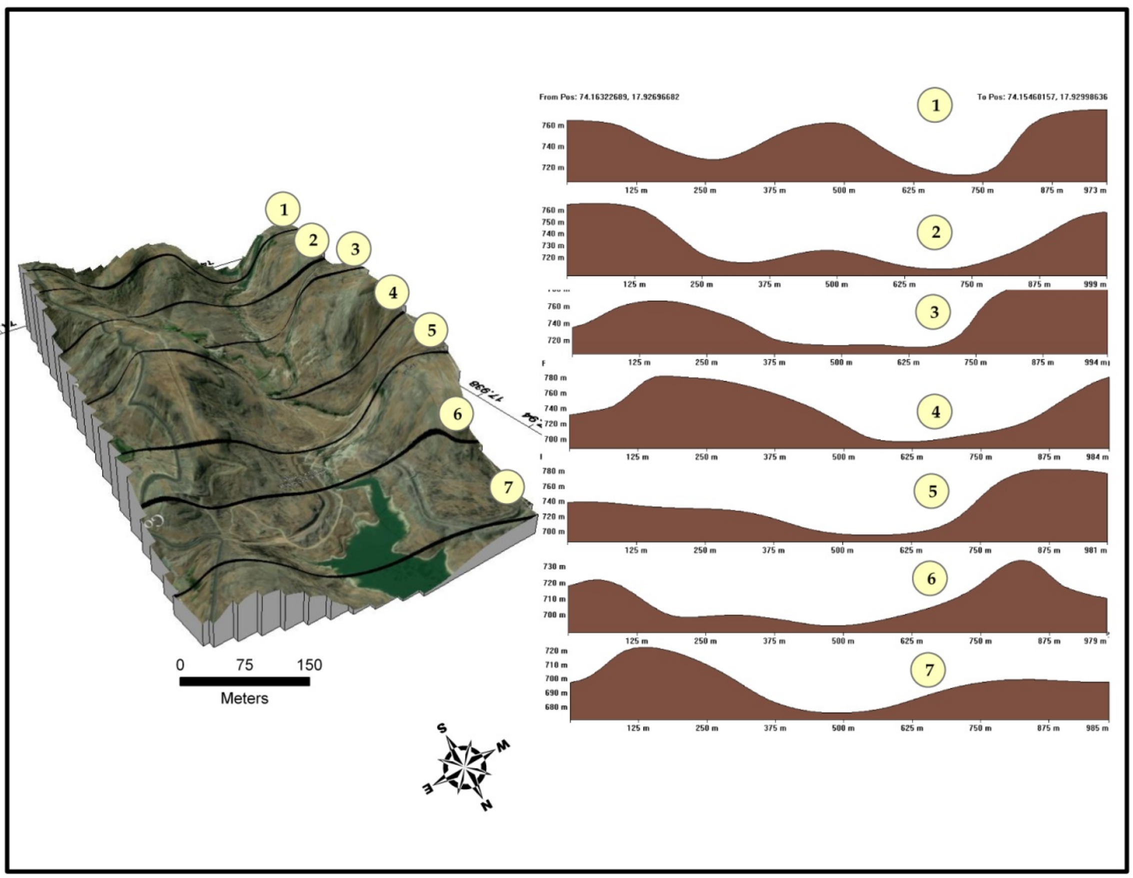


Figure - 12

2.3 Statement of the Problem

The backdrop of the above discussion, the study of weathering characteristics of the Salpe ghat region was undertaken. Thus, the research topic entitled as ‘Study of Weathering Characteristics of Salpe Ghat Region in Satara District.’

Research Methodology

In order to carryout study the morphology and sediment of weathered rock the field visit and analytical procedure were selected. Field work requires lot preparation. It is carried out by planning and its implementation.

The data would be in the form of the primary and secondary sources.

a. **Primary Sources** As the work is mainly depending on field work at Salpe ghat region carry out. The measuring of weathering profile, their GPS to obtain elevation, location and collection of weathered mater samples, photograph of weathering profile to identify lithosection, type and characteristics of weathering, ground water level were majored. To complete research four time field visits programs were arranged, they are carried out in month August, September, December, and January.

b. **Secondary Sources:** Google image of study area, ISO toposheet with scale of 1:250,000were major source in addition weather data from IMD Pune, browsing of websites the reviews, articles, weathering works published in various journals, magazines and in the books, PhD thesis on related topic.

Laboratory Analysis

The information thus obtains in field used for further analysis and mapping. To fulfill the object of understanding the sediment size and weathering process 38 sights were observed six sight used for lithosection, samples were collected from ten sights, and ground water level observed at five sights. Sample of weathered material collected from base of the profile where it was accumulated.

The weathered material samples thus collected in the field where analyzed. The samples were sieve mechanically to get proportion of particles in different size group.

The data obtained through sediment analysis used to determine major parameters like mean size, sorting index, skewness and kurtosis. All these work were carried with the technique of 'Fork and Ward'. It shows textural group of the sediment samples. The variation in the sediment distribution is plotted geographically.

For the further analysis of data collected from field survey and laboratory component, different software's were used. A Google image of the year 2011 was used for geo-coding and digital mapping. Arc GIS 9.1 version software was used to obtain DEM of the study area. The analysis subsystem is the heart of GIS. GIS analysis uses the power of the modern digital computer to measure, compare and describe the contents of the source databases. It provides ready access to the raw data and allows aggregations and reclassification for further analysis. It can also combine selected data sets in unique. It is useful ways for provides multiple information on single map sheet.

Sedimentology of weathered rock

On the basis of textural analysis of sediment samples collected from Salpe Ghat region, percentage of sand, course sand and silt were determined. The results of mechanical analysis were used to obtain various properties, like mean, mode and median. The parameters of sediment distribution, such as skewness and kurtosis were also obtained to understand the weathering processes of the region.

The results and data plotted graphically. To understand the topography of the region 3D models of the area were prepared.

CHAPTER III

Weathering at Salpe Ghat region

The Deccan Volcanic Province occupies 500000 sq.km area, hence one of the largest continental flood basalt province in the world which extending over hundreds of kilometers across western and central part of India. The thicknesses of basaltic flow, dominantly tholeiitic in composition, are over 1.5 km to 2 km in the western part of the province. The age of over and under laying basalt, an earlier proposal of 67 to 65 Ma as the age range of the Deccan basalts, a more resent study constrained the age to 65.2 $\pm$ 0.4 Ma. The palaeomagnetic age and the geo-chronological age of basaltic flow from the Mahabaleshwar suggested an eruption timing of 65.2 $\pm$ 0.4 Ma. It was also suggest that at least 1800 m out of the 2500 m thick composite trap section was erupted in a relatively short interval. The basaltic stratigraphy of the area was comprised of 47 horizontal flows. Each flow has a thickness ranging from 7m to 60m (Geological survey India- report).The Deccan trap upper and lower surfaces composed of rubble blocks and flattened and irregular, larger but fewer vesicles in their core.

Weathering profiles provide a record of chemical and physical processes occurring at the surface of terrestrial planets. Their mineralogical and geochemical compositions record information on the composition and abundance of weathering solutions, and their depth and complexity provide insight to the longevity of their development and the role that climate and biologic processes have in enhancing weathering processes. The global distribution of weathering profiles shows the impact of rainfall and temperature gradients. The profiles also shows the balance between chemical-physical weathering and chemical-physical erosion, providing insight into landscape evolution and global geochemical cycles.

Moderately weathered basaltic rocks are heterogeneous and present evidence of spheroidal weathering, leading to centimetric pebbles. These pebbles are surrounded by mixed phases, with colors varying from yellow to brown, where the intensity of fractures is greater. The core of the pebbles remains quite unweathered, whereas the outer parts are largely transformed. The initial texture is conserved, but numerous interconnected fractures and cracks affect both phenocrysts and matrix and cross all the samples. Some fractures and cracks are empty, whereas others are partly or completely filled with very fine yellow to brown material coating the walls of the cracks. Similarly, part of the primary minerals is replaced by very fine-grained mixture, also yellow in color.

Regolith is most common on stable uplands in unglaciated parts of the world, loose, unconsolidated material at the earth surface. Regolith can have one of following origins, first formed in place where bedrock weathers (in situ) and second formed by the transported to aside by gravity, water, wind, ice or another agent. The first materials are referred to as residual regolith, or residuum. Transported regolith can take many forms, like alluvium. The residual regolith is weathered out of rock, and therefore all parts of it can be considered weathered. And the types of transported regolith are little weathered when it buried deeply. Weathering profiles evaluate downward into bed rock of unweathered regolith. The interface with the bedrock of unweathered regolith is called the “weathering front”. The regolith accumulated at the base of profile and on western slopes of the ghat region. The shape and size of regolith is highly uneven.

Weathering profile is a vertical section, from the ground surface to unaltered bedrock, which passes through weathering zone. It is usually best developed in the humid tropics, where depths of 100 m have been recorded but where 30 m is more common. The nature of the profile is a complex response to climatic and geologic controls, and to long-term changes in external conditions (A Dictionary of Earth Sciences).

The combine effect of origin and weathering can be seen on Salpe ghat weathering. At seven weathering profiles, various zones were identified, sampled and studied like unweathered basaltic rock (parent rock), slightly or moderately weathered basaltic rock (crusts of basaltic boulders or coarse fragments), Red/khaki bole, and 3) weathered basaltic rock with block weathering and migratory layer(soil aggregates). Each zone of weathering profile varying in width as elevation and site differs. (Table 3) (Photo)

Table - 3 : Weathering columns and their width

Profile no.	Type of weathering Colman	Average depth (m)
1.	Block weathering	1.3
	Columnar weathering	2.3
	Khaki bole	0.35
	Red bole	0.96
	Unweathered rock	1.96
2	Block weathering	3
	Slightly weathered	2
	Red bole	0.53
	Weathered rock	0.7
	Unweathered rock	1.06
3	Block weathering	0.93
	Angular weathering	1.21
	Slightly weathered	1.9
	Unweathered rock	1.36
4	Block weathering	5.4
	Chocolate bole	0.4
	Khaki bole	0.5
	Unweathered rock	0.85
5	Block weathering	1.6
	Slightly weathered	3
	Unweathered rock	3
6	Block weathering	1.4
	Migratory layer	1.5
	Weathered rock	0.3
	Pebbles line	0.2
	Rock out crops	0.5
	Pebbles line	0.25
	Migratory layer	4.5
	Weathered rock	1.15
	Rock out crops	0.3
	Unweathered rock	1.5
7	Block weathering	0.7
	Migratory layer	0.35
	Green bole	0.25
	Weathered rock	0.55
	Khaki bole	3.5
	Red bole	2
	Block weathering	1.37
	Weathered rock	1.6

A number of attempts have been made to characterize weathering profiles. Many of these attempts relate to regoliths on granitic rocks and these commonly display a series of zones.

In weathering profile one different zones are identified. The basal zone of unweatherd rock or parent rock material is exposed of 1.96m in depth. The zone above parent rock is of red bole and khaki bole they are in situ or transported clay-rich (soil) horizons that may have formed by oxidation of the lava flows. Alternatively, they represent altered (lateritized) pyroclastic material; attain a thickness of 0.96m and 0.35 m respectively. The upper part of this zone shows column weathering of 2.3m depth. The upper weathering column shows core stones, largely rectangular and interlocked with average depth of 1.3m. (Table 3) (Figure 13)

Profile two shows the five zones of weathering the basal zone of unweatherd rock is exposed showing the depth of 1.06m. The zone above parent rock is of red bole attain a thickness of 0.53m. The upper part of this zone shows partially weathered zone of 2.3m depth. The upper weathering column shows block weathering of average depth of 3m. (Table 3) (Figure 14).

Profile three clearly shows four distinct zones. The basal zone of unweatherd rock is exposed showing the depth of 1.36m. The zone above parent rock is of slightly weathered rock attain a thickness of 1.9m. The upper part of this zone shows angular weathering zone of 1.21m depth. The upper weathering column shows block weathering of average depth of 0.93m. (Table 3) (Figure 15).

Profile four clearly shows four distinct zones. The basal zone of unweatherd rock is exposed showing the depth of 0.85m. The zone above parent rock is of slightly weathered rock attain a thickness of 1.9m. The zone above slightly weathered rock is of khaki bole and chocolate bole they are in situ or transported clay-rich (soil) horizons that may have formed by oxidation of the lava flows. Alternatively, they represent altered pyroclastic material; attain a thickness of 0.5m and 0.4 m respectively. The upper part of this zone shows block weathering zone of 5.4m depth. (Table 3) (Figure 16).

Profile five shows only three distinct zones of unweathered rock, slightly weathered rock and block weathering with 3m, 3m and 1.6m depths respectively. (Table 3) (Figure 17).

Profile six shows ten distinct zones lower 1.5m column of unweathered rock is headed by rock outcrops of 0.3m depth. The zone above this is weathered rock of 1.15m depth. Due to change in slope there is a migratory layer of regolith of 4.5m depth. The upper part of this layer is composed of pebble lines centered by rock outcrops of 0.5m depth. Second weathered rock upper layer with depth of 0.3m headed by second migratory layer and block weathering of 1.5m and 1.4m respectively. (Table 3) (Figure 18).

Profile seven shows eight zones of weathering The basal zone of unweatherd rock is exposed showing the depth of 1.6m. The zone above parent rock is of block weathering attain a thickness of 1.37m. The zone above this layer is red bole and khaki bole attain a thickness of 2m and 3.5m respectively. The upper part of this zone shows weathered zone of 0.55m depth. The upper weathering column shows green bole, migratory layer and block weathering with varying depth of 0.25m, 0.35m and 0.7m depths respectively. (Table 3) (Figure 19).

Weathering Profile – 1

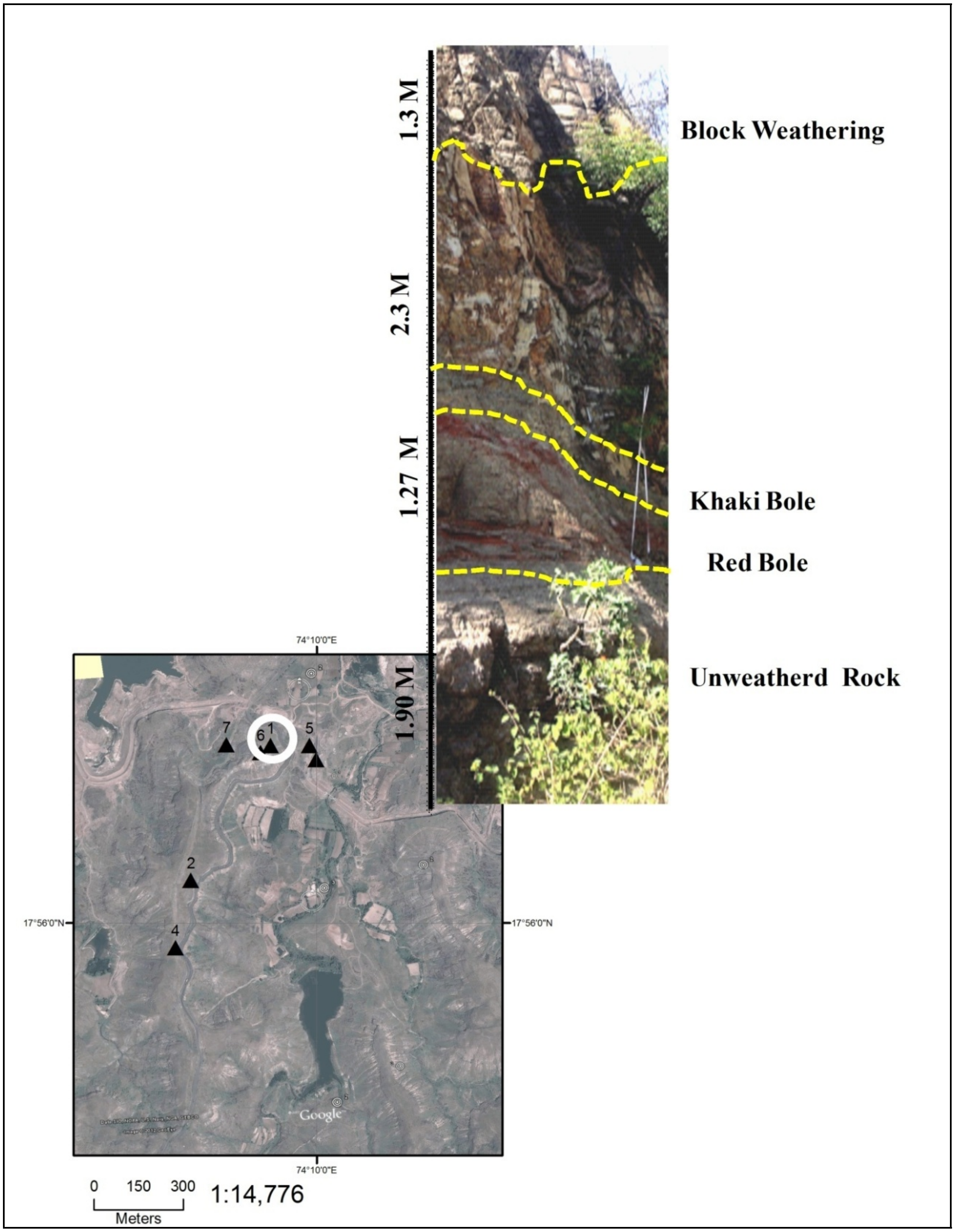


Figure - 13

Weathering profile – 2

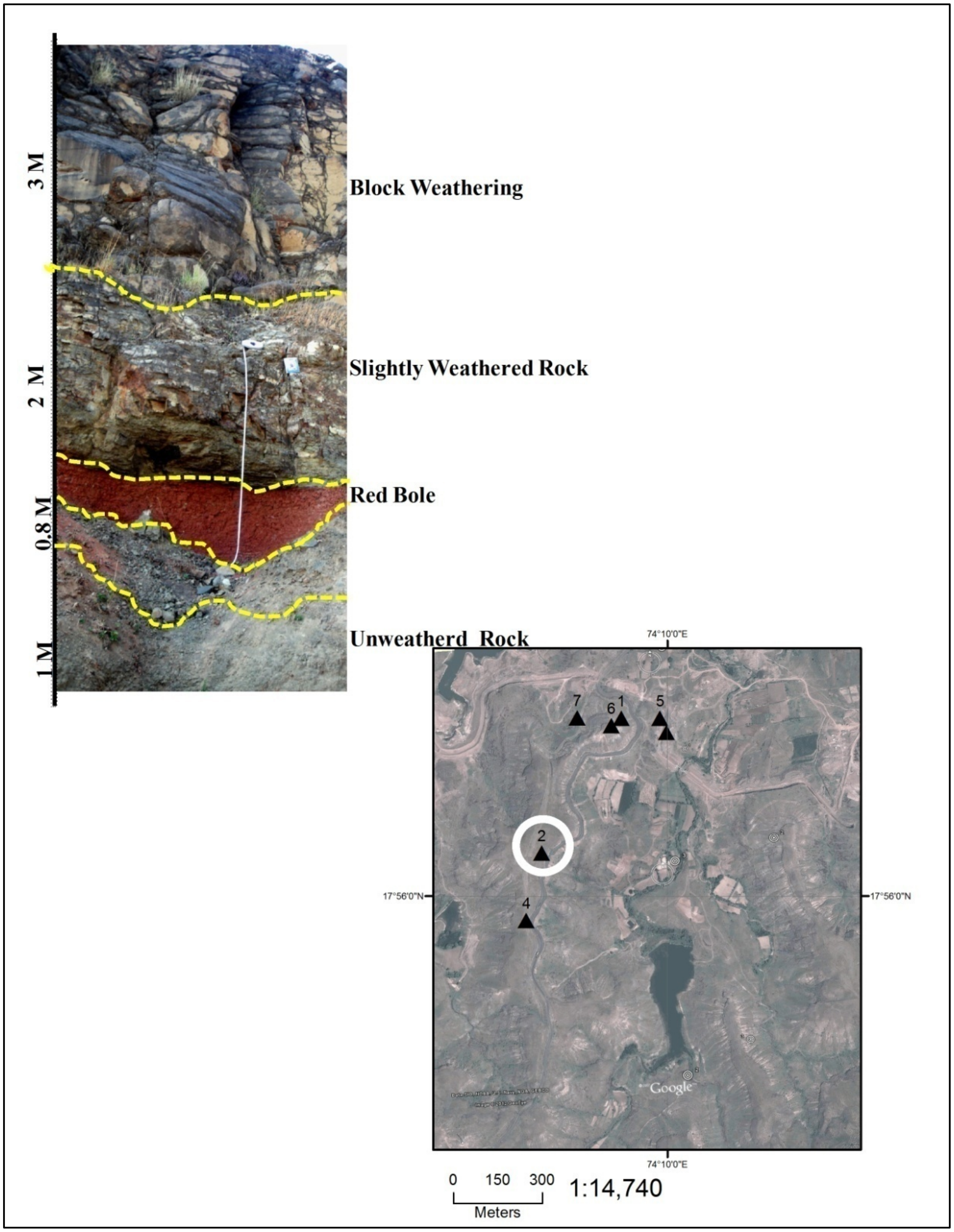


Figure - 14.

Weathering Profile - 3

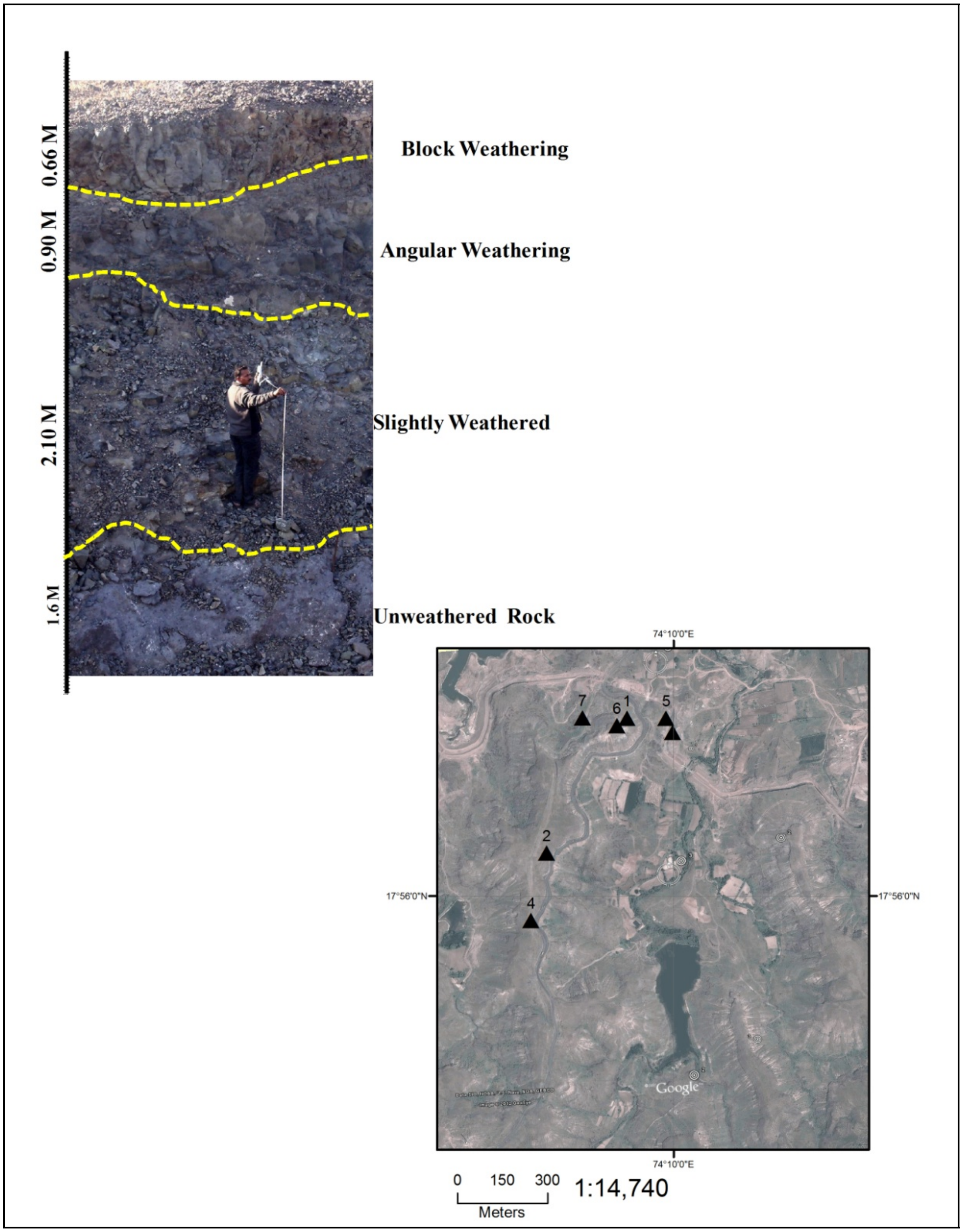


Figure - 15

Weathering Profile - 4

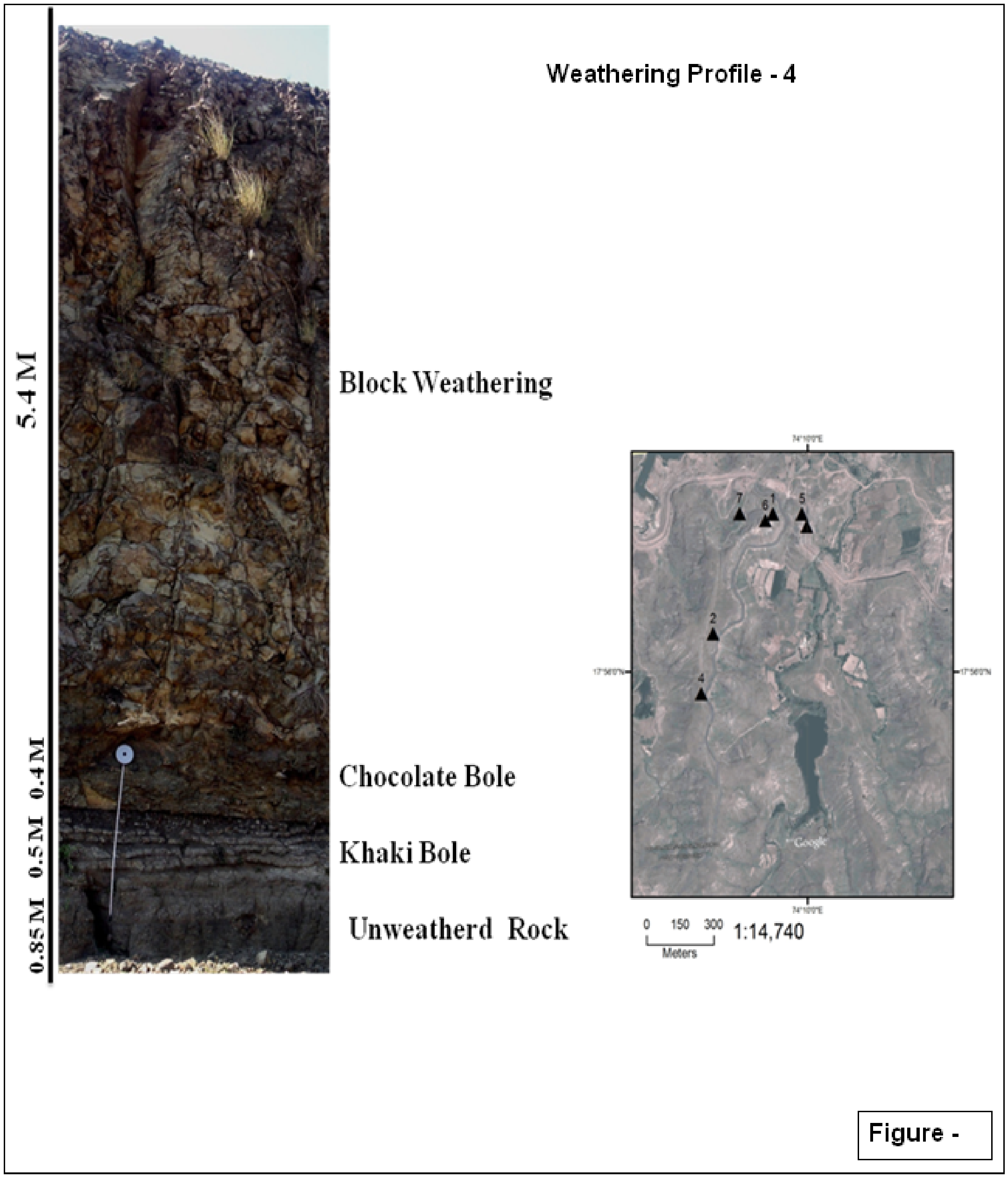


Figure - 16

Weathering Profile - 5

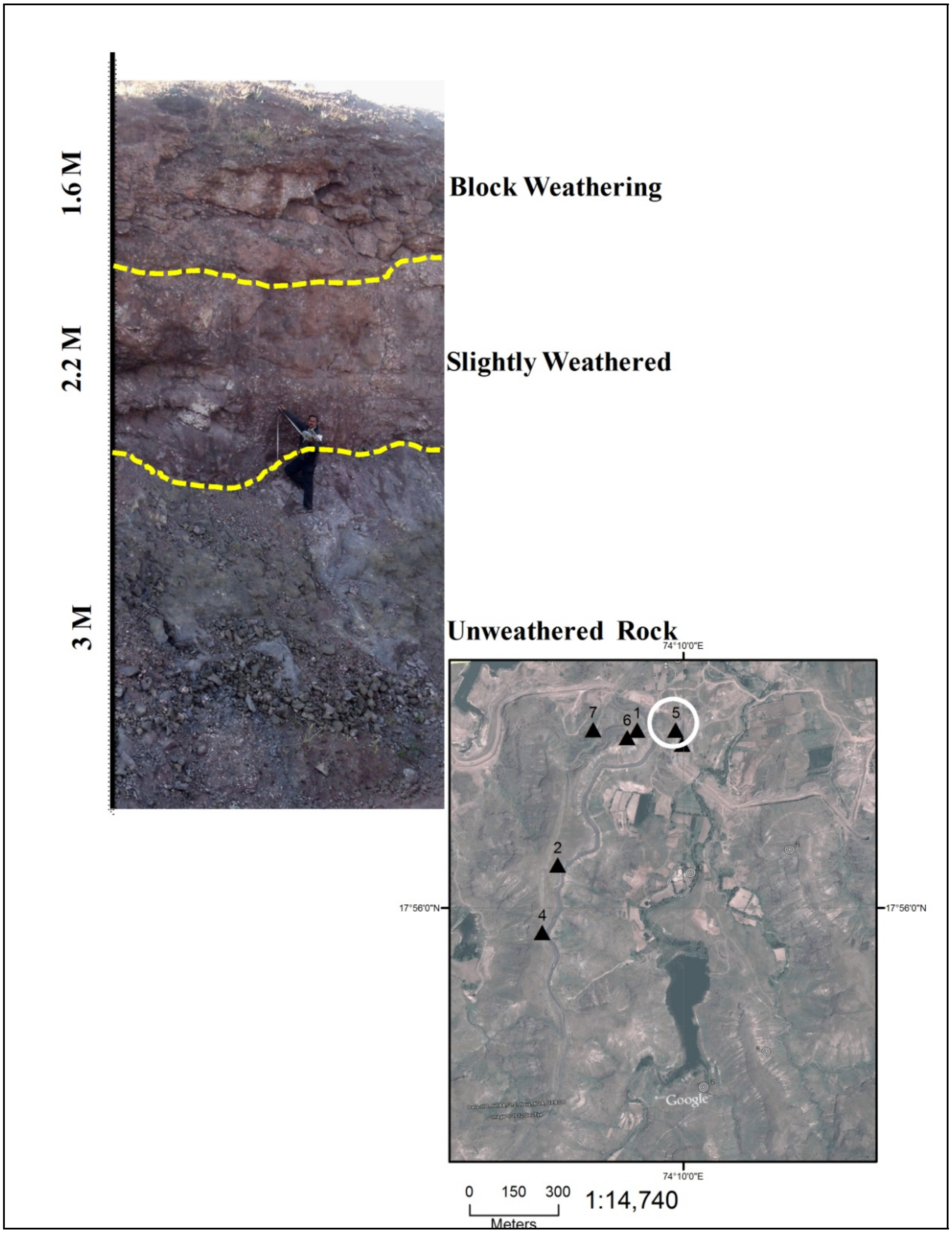


Figure - 17

Weathering Profile – 6

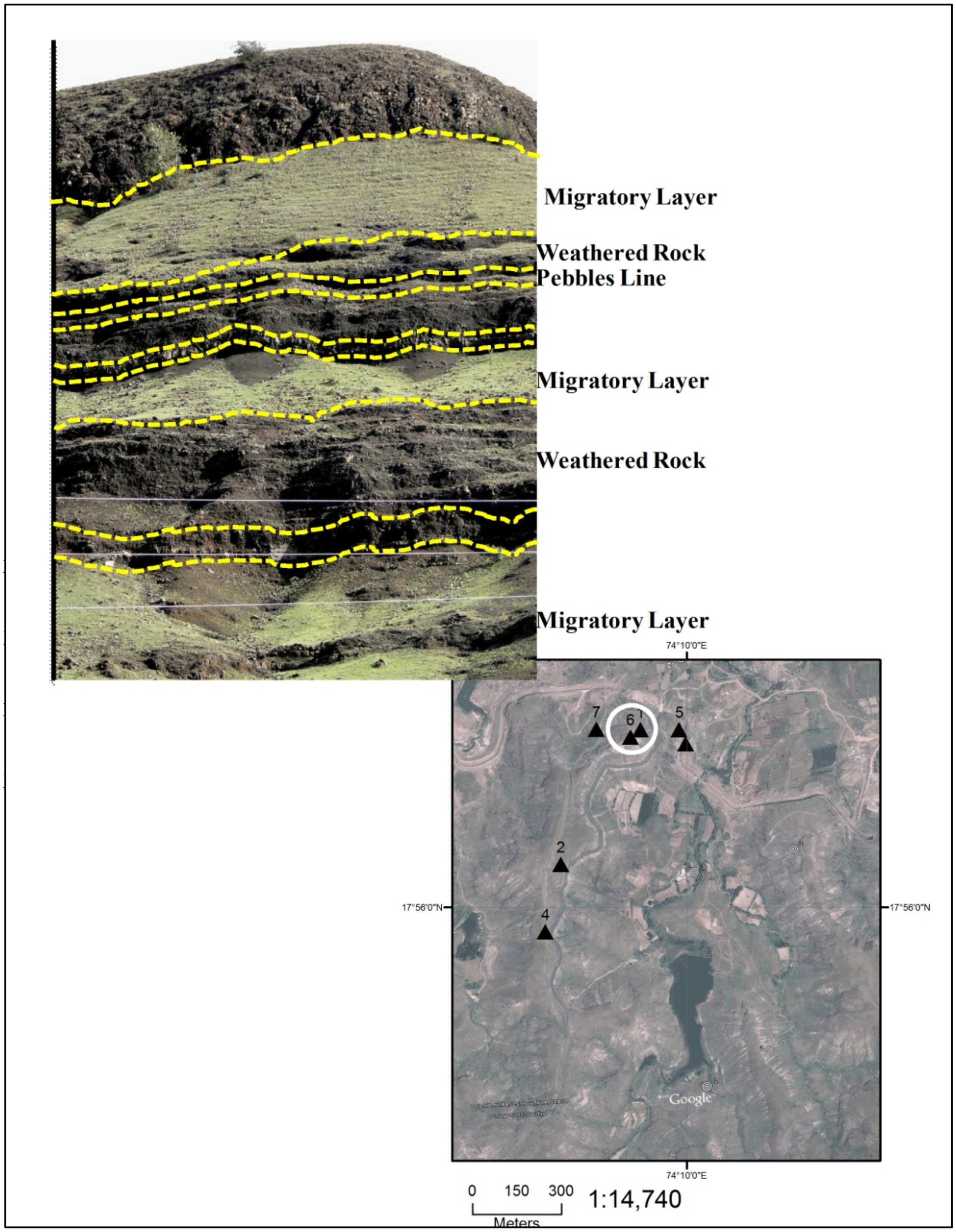


Figure - 18

Weathering Profile - 7

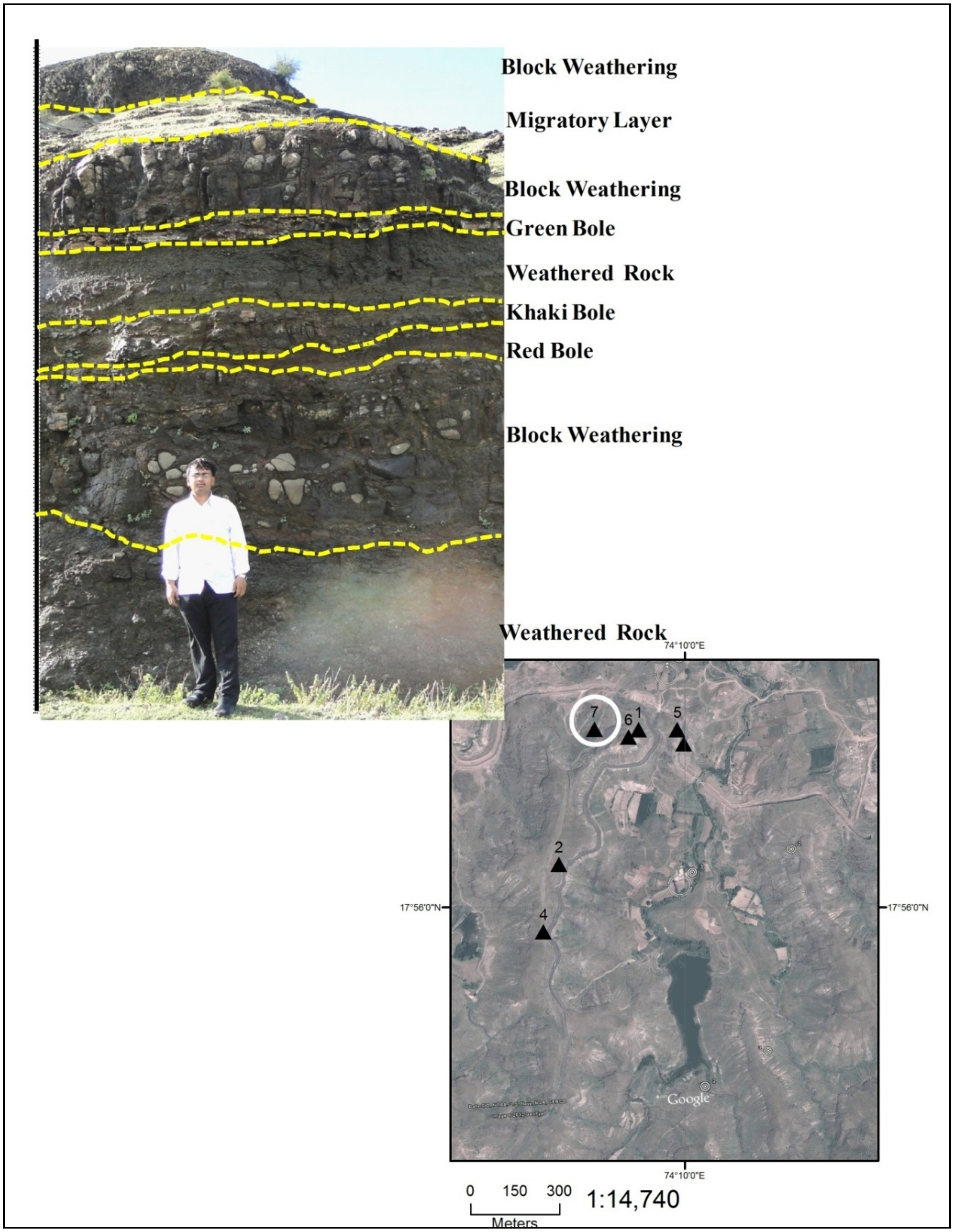


Figure - 19

Photoplate 4 shows the locations of ‘red bole’ or red clay-rich horizons. There are two fundamentally die rent interpretations of such horizons (e.g., Hooper et al 1988; Wilkins et al 1994; Inamdar and Kumar 1994; Inamdar 1995, Gupte 1995). One interpretation is that they are in situ or transported clay-rich (soil) horizons that may have formed by oxidation of the lava flows. Alternatively, they represent altered (lateritized) pyroclastic material (Wilkins et al 1994). while the red bole (soil) was forming at the surface, the subsurface magma chamber was undergoing a dormant (non-eruptive) phase during which the magma was differentiating and plagioclase crystals in it were growing to large sizes. As mentioned before, GPB eruption perhaps occurred when a new batch of magma entered the magma chamber from below and squeezed the giant phenocryst basalts (GPB) out of the chamber or the chamber itself collapsed. It would seem that as the giant phenocryts were forming near the roof of the magma chamber (dormancy implied), heat conducted out of the magma chamber and set up convective circulation of groundwater. Such heated fluid may have later been responsible for pyroclastic eruption. Removal of the roof by the pyroclastic eruption would have created the pathway for a GPB eruption. (**Gautam Sen 2001**)

Stone line - Layer in the regolith composed of gravel-size angular to subrounded fragments of weathering-resistant rock, commonly quartz, and normally occurring at a depth between 0.3 and several meters below a gently sloping ground surface. Stone-lines have been variously interpreted as marking an unconformity, as the base of bioturbation, or as the boundary between in-situ weathered parent rock (saprolite) below an originally residual soil layer gradually moving downslope. Weathering profiles of the study area shows distinct layers of stone line overburden by weathered rock or migratory layer.

Weathering and ground water

Once water has infiltrated the soil, the water moves downward into the profile by the process termed percolation. In many soil profiles, the soil horizon may differ markedly in terms of texture and hydraulic conductivity; such stratification may greatly affect the movement of water through the soil profile. In the case where the coarse layer such as sand overlies a finer textured layer, percolating water will slow down markedly when it reaches the impeding layer with a lower hydraulic conductivity in the opposite case, where fine material overlies coarse, the effect on water percolation is similar, i.e. the downward movement of water is impeded, which occur because the larger pores of the sand offer less attraction for the water than do the finer pores of the overlying material and therefore the matric potential is lower in the overlying material than in the sand(Jury and Horten 2004).

Weathered rock holds groundwater. The zone of groundwater saturation is topped by a water table which separates an upper oxidised zone from a lower, reducing zone. Some elementary weathering scenarios envisage weathering in only the acid, oxidizing upper zone, but weathering can proceed at the base of the saturated zone by hydrolysis. Weathering products must be removed if the reaction is to continue: in upper groundwater zones they are washed away; in lower zones chemical diffusion removes weathering products from the weathering front to the zone of mobile groundwater. Since deep weathering profiles may be tens of metres thick, the temperature at the ground surface does not affect the temperature at depth.

Table -4 : Ground water table

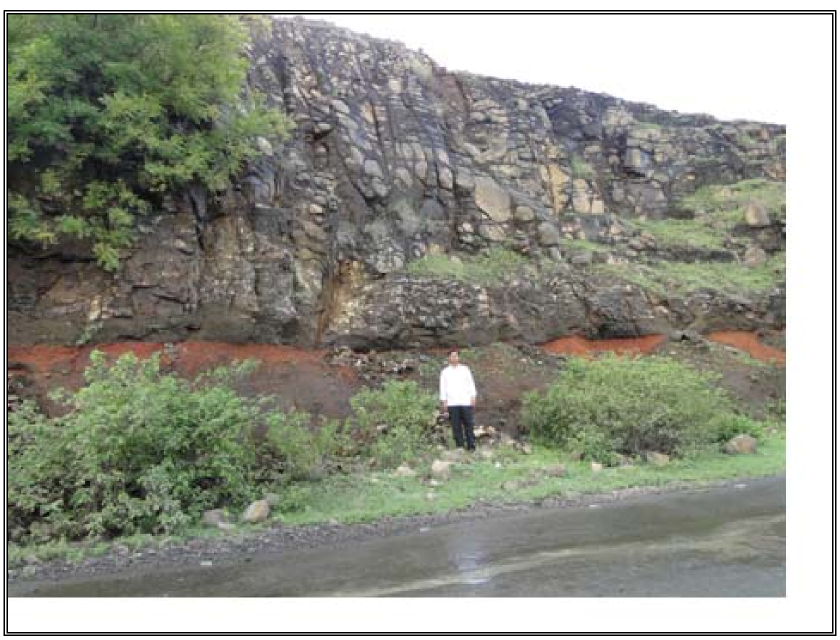
Sr. no	Latitude /Longitude	Elevation from sea level	Depth of water in well
1	$17^0$56'157"N $74^0$09'542"E	694m	2.15m
2	$17^0$56'074"N $74^0$10'001"E	691m	0m
3	$17^0$56'016"N $74^0$09'992"E	689m	1.40m
4	$17^0$56'000"N $74^0$09'925"E	689m	0.90m
5	$17^0$56'240"N $74^0$10'032"E	686m	0.1m
6	$17^0$56'465"N $74^0$09'931"E	689m	0.1

Ground water level was checked in six wells in the study area. It shows the increase in groundwater level towards valley floor. Increase in groundwater level towards valley floor indicates high infiltration rate on hill tops and hill slopes because of weathering and disintegration of rocks in this region.

Photoplate-1 Angular rubble blocks occurring near the upper surface of a typical lava flow exposed due to weathering.

Photoplate2 Columnar joints in lava flow from ghat section. Irrespective of flow types, the lavas show various type of joints and fractures .some of these joints and fractures have resulted during cooling of hot lava.

Photoplate-3 The pyroclastic component of the Deccan province is represented by bright red to green to khaki to brown horizons that occurs between successive lava flows at Salpe ghat area.



Photoplate-4 A typical mineral assemblage and textural features in a red pyroclastic "interflow horizon"

CHAPTER IV

Sedimentary Environment

Features and properties of soil and regolith

Regolith is loose, unconsolidated material at the earth surface. Regolith can have one of following origins, first formed in place where bedrock weathers (in situ) and second formed by the transported to aside by gravity, water, wind, ice or another agent. The first materials are referred to as residual regolith, or residuum. It is most common on stable up lands in unglaciated parts of the world; in glaciated regions it is either deeply buried or long since eroded. Transported regolith can take many forms, such as alluvium, glacial drift and Aeolian sands (Schaetzl & Anderson 2005). The residual regolith is weathered out of rock, and therefore all parts of it can be considered weathered. And the types of transported regolith are little weathered when it buried deeply. Weathering profiles evaluate downward into bed rock of unweathered regolith. The inter face with the bedrock of unweathered regolith is called the “weathering front”.

Weathering gradually weakens rocks, and eventually produces new geological materials (rock fragments, sands, silts and clays) that are more stable in the new environment. Weathering generally produces finer and less dense rock materials, and weaker, more porous and permeable rock masses.

In the tropics and subtropics, intense weathering in the hot and humid conditions produces thick weathered profiles, which may be up to 100 meters, or more, thick.

Weathering processes penetrate down discontinuities (planes of weakness), such as faults and joints, in the rock mass and then attack the faces of the joint-bounded blocks, penetrating the solid blocks.

Weathering preferentially attacks the corners and edges of the joint blocks, causing them to become rounded. This action is assisted by stress release, which causes the rock to flake into curved shells in a process termed exfoliation. Weathering of some rock, results in the development of thick weathered profiles that are characterised by rounded boulders (core stones) set in a matrix of weak, silty, clayey, sandy material.

In order to study the sedimentary environment of the study area 8 sediment samples were collected from different sites at different altitude. The textural analysis was carried out and results are interpreted. (Table 5) (Figure 20)

Table - 5 : Location of sediment (regolith) samples

Sample No	Lat./Long.	Height of weathering column	Elevation of profile from sea level
1	$17^0$56'402"N $74^0$09'847"E	3.9M	712m
2	$17^0$56'266"N $74^0$09'477"E	1.3M	701m
3	$17^0$56'211"N $74^0$09'474"E	3.4M	709m
4	$17^0$56'277"N $74^0$09'471"E	6.8 M	708m
5	$17^0$56'253"N $74^0$09'501"E	6.4 M	703m
6	$17^0$56'063"N $74^0$09'737"E	7.2 M	810m
7	$17^0$56'296"N $74^0$09'987"E	6.8m	693m
8	$17^0$56'321"N $74^0$09'989"E	4.2m	696m

Location of sediment samples

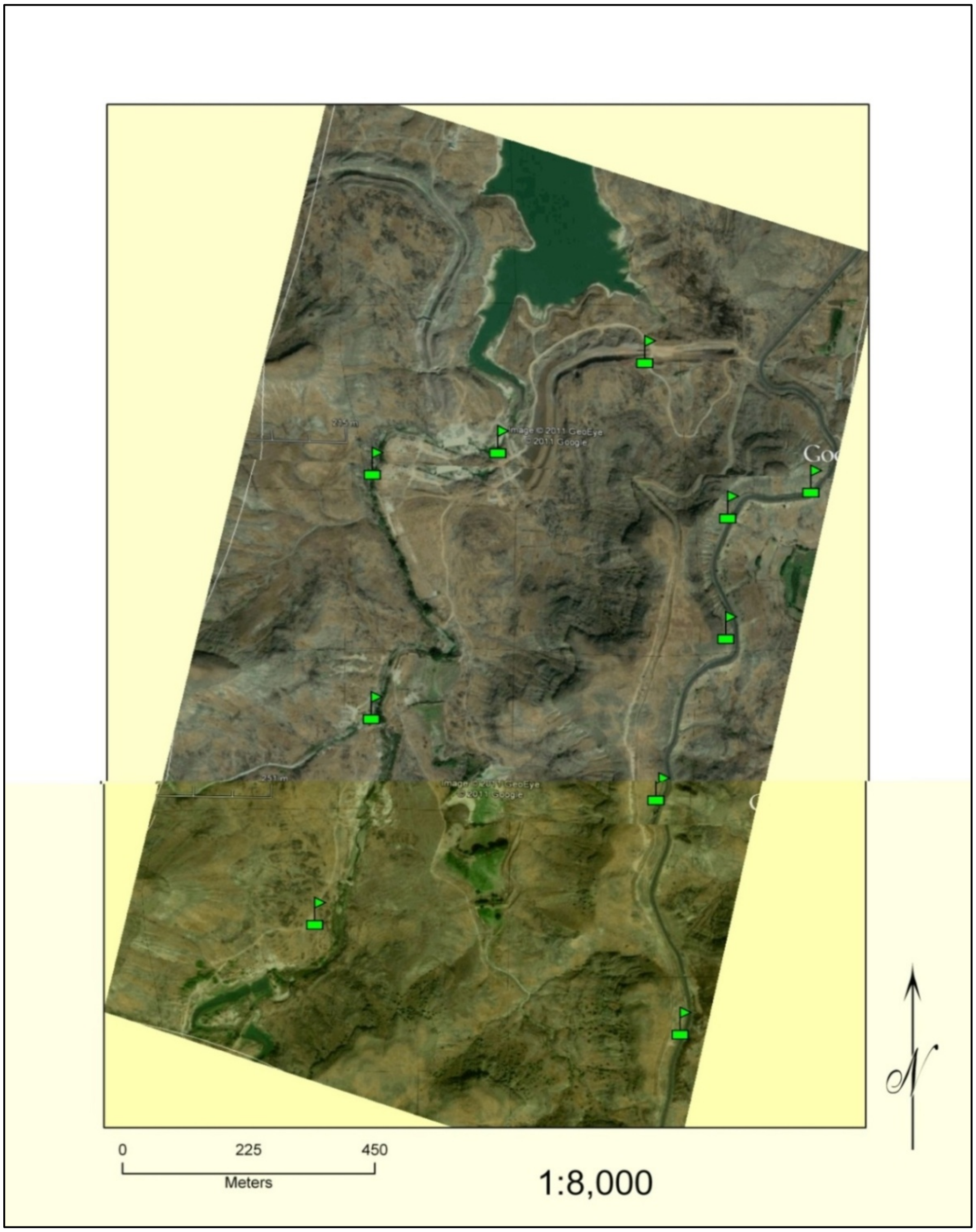


Figure - 20

Distribution of sand

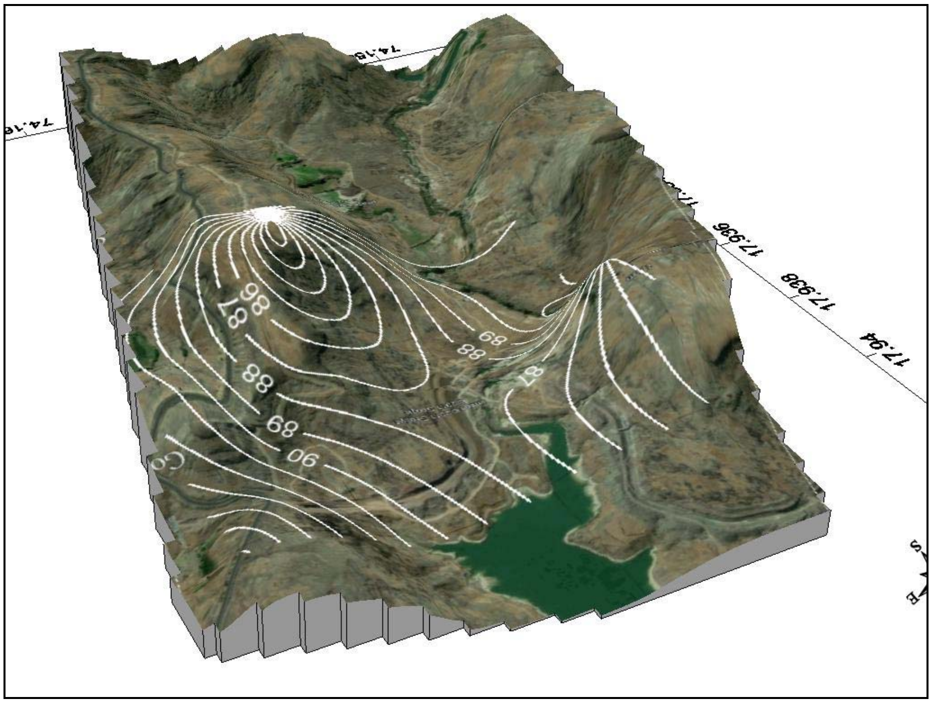


Figure - 21 .

Table – 6 Distribution of sand

Sample	% of Sand	% of coarse sand	% of Medium sand	% of fine sand
1	96.1	83.9	10.1	2.1
2	80.8	53.0	18.7	9.1
3	90.9	74.4	12.6	3.9
4	90.0	68.8	14.1	7.1
5	81.8	55.5	16.7	9.6
6	91.4	69.8	15.3	6.2
7	97.7	87.1	9.1	1.5
8	98.1	90.9	6.2	1.0

All sediment samples are sandy. The percentage of sand ranges between 98.1% and 81.8 %. It is maximum 98.1 % on the western slopes of salpe ghat. The proportion of coarse sediments goes on decreasing towards the western slopes and it is maximum 98.1% on eastern slope due erosion and transport of fine material from the hill slopes. The western slopes of the Salpe ghat also have considerable proportion of coarse sediments. It is between 81.8% and 90%. (Table 6) (Figure 21)

Distribution of fine sediments

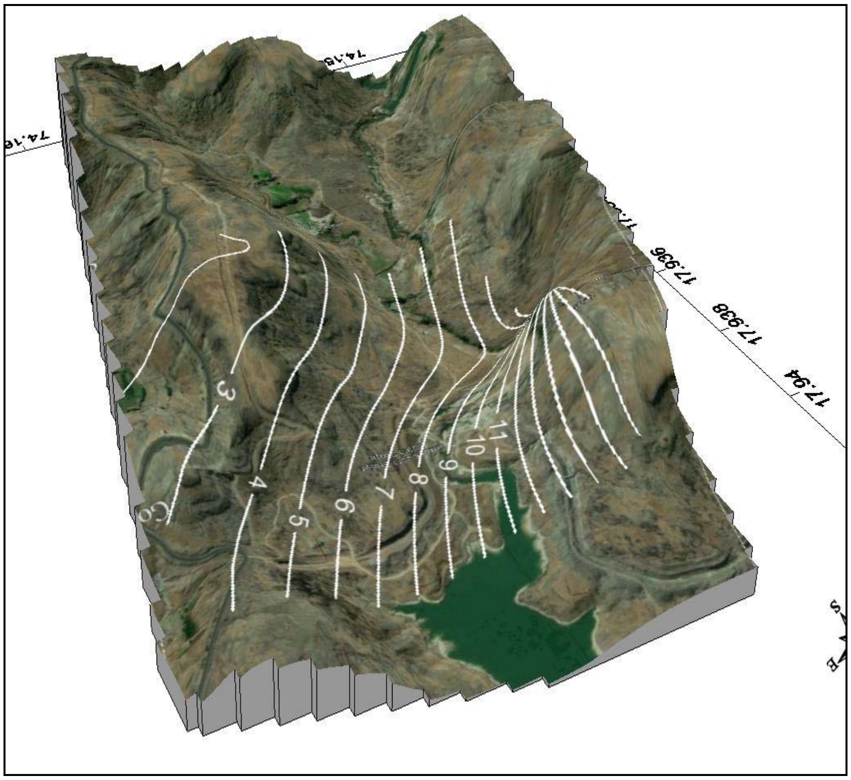


Figure - 22

Table - 7 : Distribution of fine sediments

Sample no	% of fine sediments	% of very coarse silt	% of medium silt	% of coarse silt	% of fine silt	% of very fine silt	% of clay
1	3.6	0.6	0.6	0.6	0.6	0.6	0.6
2	19.2	3.2	3.2	3.2	3.2	3.2	3.2
3	9.1	1.5	1.5	1.5	1.5	1.5	1.5
4	10.0	1.7	1.7	1.7	1.7	1.7	1.7
5	18.2	3.0	3.0	3.0	3.0	3.0	3.0
6	8.6	1.4	1.4	1.4	1.4	1.4	1.4
7	3.2	0.4	0.4	0.4	0.4	0.4	0.4
8	1.8	0.3	0.3	0.3	0.3	0.3	0.3

The percentage of fine sediments ranges between 1.8% and 19.2 %. It is maximum 18.2 % on the western slopes of salpe ghat. The proportion of fine sediments goes on decreasing towards the eastern slopes and it is maximum 18.1% at valley floor due accumulation of transported fine material from the hill slopes. The eastern slopes of the Salpe ghat have very negligible proportion of fine sediment. It is between 1.8% and 3.6%. (Table 7) (Figure 22)

Table - 8 : Textural analysis of sediment samples at Salpe ghat region

Sample no.	Sediment	Textural group	Sample type	Mean	Type	Sorting	Type	Skewness	Type	Kurtosis	Type
1	M.W.S.C.S.	Sand	U.M.W.S	0.409	C.S.	0.629	M.W.S.	0.823	V.F.S.	2.728	V.L.
2	F.S.C.S	Muddy Sand	T.V.P.S.	1.872	M.S.	2.192	V.P.S.	0.713	V.F.S.	1.171	L.
3	P.S.C.S	Sand	U.P.S.	0.684	C.S.	1.315	P.S.	0.903	V.F.S.	2.495	V.L.
4	F.S.C.S	Muddy Sand	U.P.S.	0.926	C.S.	1.520	P.S.	0.916	V.F.S.	1.595	V.L.
5	B.V.P.S.	Muddy Sand	V.C.S.C.S.	1.740	M.S.	2.138	V.P.S.	0.778	V.F.S.	1.167	L.
6	P.S.C.S	Sand	U.P.S.	0.731	C.S.	1.328	P.S.	0.900	V.F.S.	2.069	L.
7	W.S.C.S	Sand	U.W.S.	0.329	C.S.	0.449	W.S.	0.776	V.F.S.	4.617	E.L.
8	W.S.C.S	Sand	U.W.S.	0.239	C.S.	0.352	W.S.	0.707	V.F.S.	4.313	E.L.

Table - 9 : Abbreviations used

B.V.P.S.	Bimodal, Very Poorly Sorted	C.S.	Coarser Sand
F.S.C.S.	Fine Silty Coarse Sand	E.L	Extremely Leptokurtic
Lk.	Leptokurtic	M.S.	Moderately Sorted
M.W.S.	Moderately Well Sorted	M.W.S.C.S	Moderately Well Sorted Coarser Sand
P.S.	Poorly Sorted	P.S.C.S	Poorly Sorted Coarser Sand
T.V.P.S.	Trimodal, Very Poorly Sorted	U.P.S.	Unimodal, Poorly Sorted
U.W.S.	Unimodal, Well Sorted	V.C.S.C.S.	Very Coarser Skewed
V.L	Very Leptokurtic	V.F.S.	Very Fine Skewed
V.P.S.	Very Poorly Sorted	W.S.	Well Sorted
W.S.C.S	Well Sorted Coarse Sand		

Textural statistical parameters, such as mean-size, standard deviation (sorting), and skewness (symmetry of the curve) are sensitive to environmental processes (e.g. Boggs 1987). Statistical parameters were calculated using the Folk and Ward method.

Sand fraction is dominated by coarse sand but also includes medium as well as fine sand. distribution composed with an average of 90.85% sand including 72.93% coarse sand, 12.85% medium sand and 5.06% fine sand, a mean diameter of 0.87 ϕ, standard deviation of 0.352 ϕ to 2.135 ϕ (very poorly sorted to well sorted) and skewness (0.815) (Table 9).Kurtosis measures the ratio between the sorting in the tails of the distribution. If the central portion is better sorted than the tails, the frequency curve is said to be excessively leptokurtic. If the tails are better sorted than the central portion of the distribution, the curve is said to be flat peaked or platykurtic. The distribution of samples collected from different sites show leptokurtic to extremely leptokurtic distribution, means the distribution is unimodal to polymodal (Table 8)

The textural group of sediment samples is a sand and dominant grain size distribution, coarse sand; very poorly sorted to well sorted positively skewed coarser material. The distribution is extremely leptokurtic at lower elevations, middle part and foot hill sediments shows very platykurtic and foot hill slopes it shows leptokurtic distribution. (Table 8) (Figure 23,24,25,26)

Distribution of mean sediment size

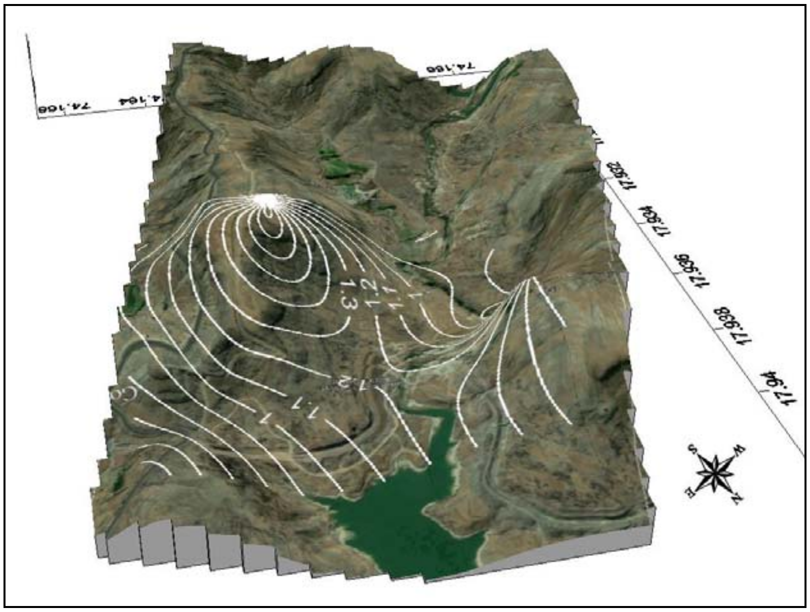


Figure - 23

Index of skewness

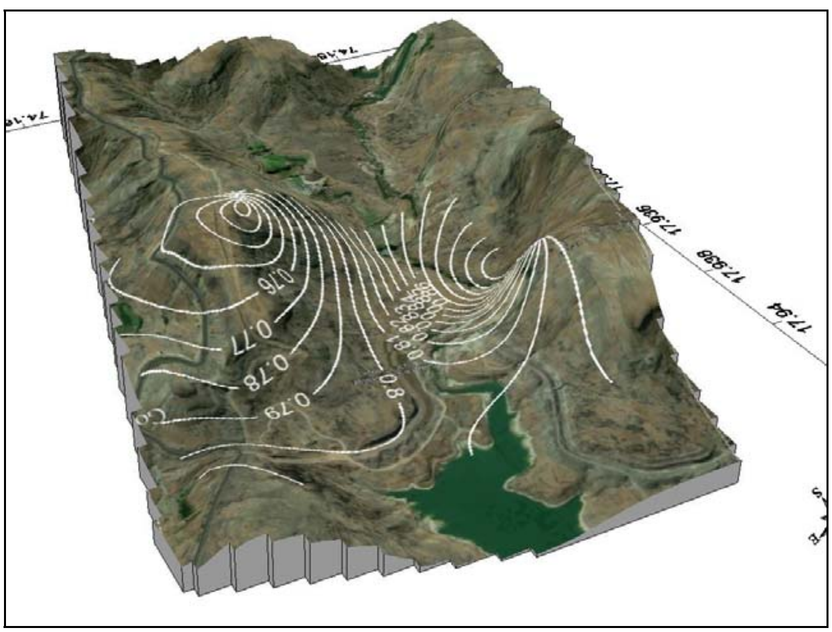


Figure - 24

Index of Sorting

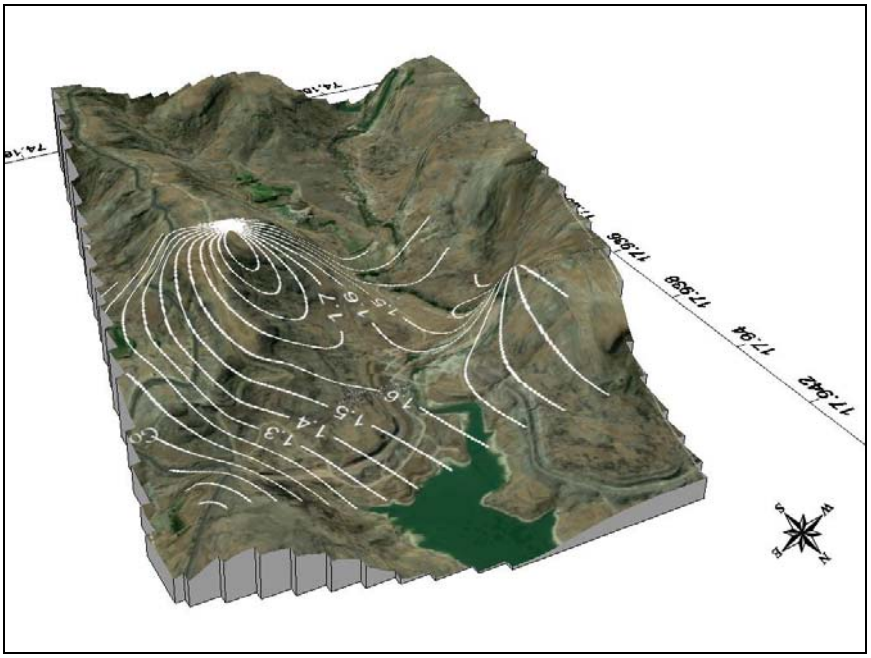


Figure - 25

Distribution of Kurtosis

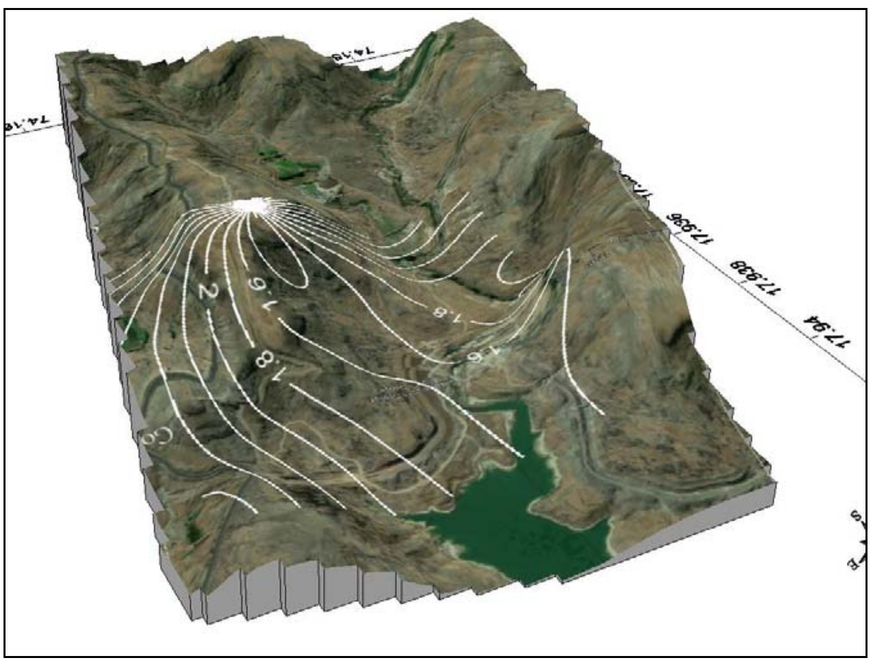


Figure - 26

CHAPTER V

Finding and Conclusions

Weathering is a common process found in semi arid climate area. Deccan plateau is mainly made up with basalt rock. Eastern slopes of Western ghat enjoys dry climate which undergoes weathering process. Depth and weathered material, weathering column is different from place to place. Weathering process also determines occurrence of land slide. As well as soil formation the vegetation cover, outcrop weathering etc.

Daily and annual variation in temperature is very high, the temperature variation in summer April 2008, it was 41.5^0C during day and during night it was 12.3^0C, during winter in January 2008 it was 34.8^0C during day and 7.5^0C during night. it shows that annual and daily temperature variation is very high. This is a major cause for physical weathering at Salpe ghat area.

Annual rainfall at Khandala Dist Satara was observed 76 cm in 2006.most of the rain fall is in the month of June to September. Rainfall varies from 91 cm (1993) to 21.8 cm (2003). This alternate dry and wet season and variation in rainfall lead to physical weathering in salpe ghat area.

The combine effect of origin and weathering can be seen on Salpe ghat weathering. At seven weathering profiles, various zones were identified, sampled and studied like unweathered basaltic rock (parent rock), slightly or moderately weathered basaltic rock (crusts of basaltic boulders or coarse fragments), Red/khaki bole, and weathered basaltic rock with block weathering and migratory layers (soil aggregates). Each zone of weathering profile varying in width as elevation and site differs.(Table 3) (Photo)

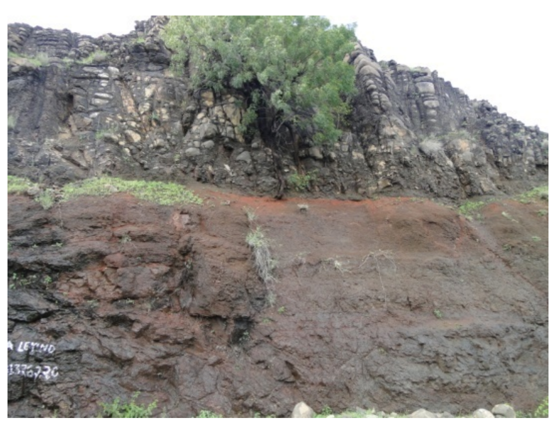
In weathering profile one different zones are identified. The basal zone of unweatherd rock or parent rock material is exposed of 1.96m in depth. The zone above parent rock is of red bole and khaki bole they are in situ or transported clay-rich (soil) horizons that may have formed by oxidation of the lava flows. Alternatively, they represent altered (lateritized) pyroclastic material; attain a thickness of 0.96m and 0.35 m respectively. The upper part of this zone shows column weathering of 2.3m depth. The upper weathering column shows core stones, largely rectangular and interlocked with average depth of 1.3m. (Table 3) (Figure 13)

Profile six shows ten distinct zones lower 1.5m column of unweathered rock is headed by rock outcrops of 0.3m depth. The zone above this is weathered rock of 1.15m depth. Due to change in slope there is a migratory layer of regolith of 4.5m depth. The upper part of this layer is composed of pebble lines centered by rock outcrops of 0.5m depth. Second weathered rock upper layer with depth of 0.3m headed by second migratory layer and block weathering of 1.5m and 1.4m respectively. (Table 3) (Figure 18).

The total depth of weathering profiles varying between 7m and 13m. Maximum 10 and minimum 4 distinct zones were identified. Unweathered zone (parent rock), weathered zone and block weathering is more common all over the region.

The zone of red bole and khaki bole varying in depth between 0.5m to 2m is prominently observed in the study are.They are in situ or transported clay-rich (soil) horizons that may have formed by oxidation of the lava flows. Alternatively, they represent altered (lateritized) pyroclastic material.

The pyroclastic component of the Deccan province is represented by bright red to green to khaki to brown horizons that occurs between successive lava flows at Salpe ghat area.



Moderately weathered basaltic rocks are heterogeneous and present evidence of spheroidal weathering, leading to centimetric pebbles. These pebbles are surrounded by mixed phases, with colors varying from yellow to brown, where the intensity of fractures is greater. The core of the pebbles remains quite unweathered, whereas the outer parts are largely transformed. The initial texture is conserved, but numerous interconnected fractures and cracks affect both phenocrysts and matrix and cross all the samples. Some fractures and cracks are empty, whereas others are partly or completely filled with very fine yellow to brown material coating the walls of the cracks. Similarly, part of the primary minerals is replaced by very fine-grained mixture, also yellow in colour.

Layer in the regolith composed of gravel-size angular to subrounded fragments of weathering-resistant rock, commonly quartz, and normally occurring at a depth between 0.3 and several meters below a gently sloping ground surface. Stone-lines have been variously interpreted as marking an unconformity, as the base of bioturbation, or as the boundary between in-situ weathered parent rock (saprolite) below an originally residual soil layer gradually moving downslope. Weathering profiles of the study area shows distinct layers of stone line overburden by weathered rock or migratory layer.

Sand fraction is dominated by coarse sand but also includes medium as well as fine sand. distribution composed with an average of 90.85% sand including 72.93% coarse sand, 12.85% medium sand and 5.06% fine sand, a mean diameter of 0.87 ϕ, standard deviation of 0.352 ϕ to 2.135 ϕ (very poorly sorted to well sorted) and skewness (0.815) (Table 9).Kurtosis measures the ratio between the sorting in the tails of the distribution. If the central portion is better sorted than the tails, the frequency curve is said to be excessively leptokurtic. If the tails are better sorted than the central portion of the distribution, the curve is said to be flat peaked or platykurtic. The distribution of samples collected from different sites show leptokurtic to extremely leptokurtic distribution, means the distribution is unimodal to polymodal.

Weathering and ground water - Once water has infiltrated the soil, the water moves downward into the profile by the process termed percolation. In many soil profiles, the soil horizon may differ markedly in terms of texture and hydraulic conductivity; such stratification may greatly affect the movement of water through the soil profile.

Weathered rock holds groundwater. The zone of groundwater saturation is topped by a water table which separates an upper oxidised zone from a lower, reducing zone. Ground water level was checked in six wells in the study area. It shows the increase in groundwater level towards valley floor. Increase in groundwater level towards valley floor indicates high infiltration rate on hill tops and hill slopes because of weathering and disintegration of rocks in this region.

5. Redbole

6. Stone line

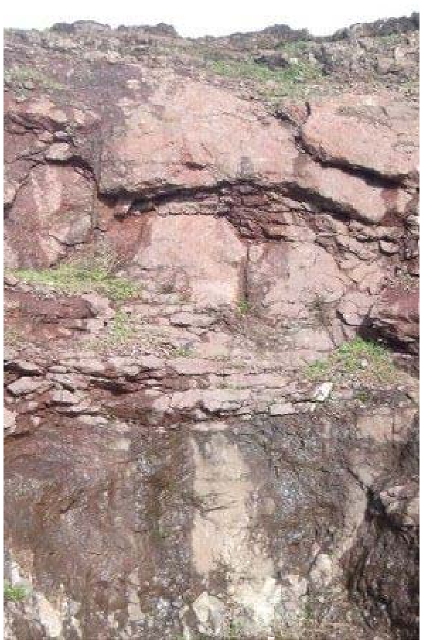
7. Stone line overburden by mygratory layer

8. Block disintegration of basalt

9. Deposition of weathered material on hill slope

10. Stone line and core stone exposed in weathering column

11. Parent rock overlaid by weathered rock



12. Biological Weathering

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