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(RESEARCH ARTICLE)

Environmental impact of weathering and soil formation in geomorphological research

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Abstract

Weathering is a part of geomorphic processes leading to the disintegration and decomposition of rocks and minerals on the earth's surface as a result of physical and chemical action that leads to the formation of soil being a most vital natural resource of rock weathering. Development of soils in an environment enhances plants dependence on it for growth, and man depends directly or indirectly on plants for food, thus the functions of soil as a fundamental interface, providing an excellent example of the integration among many parts of the earth system. Hence, geomorphology research being based on processes of the earth's surfacing that result into most of the physical features seen on the face of the earth.

Keywords: Climate; Environment; Geomorphology; Soil and Weathering

1. Introduction

The systematic study of the earth relief features is known as geomorphology, which explains the definition given by Don (1969) that the concept of geomorphology relates to the origin and evolution of topographic features by physical and chemical processes operating at or near the earth's surface.

Each geomorphic process imparts to the landscape (environment) distinctive features and develops characteristics assemblages of land forms through some identified processes that impact the environment such as;

- Running water that make-up surface flow, sculptures the landscapes to bear characteristics features which differ from those developed by other processes;
- Glaciers carrying large quantities of materials derived by erosion from valley sides and bottoms produce land-forms markedly different in form;
- Ground water, promotes solution and forms of chemical weathering that leads to the development of unique land forms.
- Waves and currents are more active along shorelines of oceans, seas and large lakes modifying the surrounding landforms.
- Wind is a process that is most active in arid and semi-arid regions and therefore an important topography producing agent in such an environment.
- Weathering which is both mechanical disintegration and chemical decomposition of rock results into different landforms formation depending on the resistant nature of the rock forms.
- Volcanism which sometimes causes eruption of lava on the earth's surface, producing very distinctive types of landforms.

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- Diastrophism which is the deformation of the earth's crust by tensional and compressional forces may produce initial landforms or alter the special relationships of rocks differing resistance in such a way as to cause certain landforms to develop under differential weathering.

The development of these characteristics assemblages of landforms can therefore define geomorphology as "the systematic study of the earth's relief features, and these relief features promotes some environmental landmarks noticed in the areas identified.

Weathering being part of geomorphic processes is the disintegration and decomposition of rocks and minerals on the earth's surface as a result of physical and chemical action. The rate of weathering is not constant everywhere, but varies according to differences in intensity of processes going on at any given point, and at the same time, the kind of weathering which predominates on the surface also varies from place to place. Hence, the types of weathering classified into mechanical or physical weathering which involves disintegration or break-up of rock by physical processes without changes in chemical or mineral compositions, and then chemical weathering which refers to the decomposition of rocks by chemical processes which involves chemical or mineral changes.

It is also observed that soil has been of particular interest to man since the beginning of organized agricultural production, and thus, soil being defined as the medium for plant (crop) growth. To the geomorphologist therefore, soil is an important aspect of the land (environment) on which man lives and studied in relation to the other aspects of the earth's surface that affects the climates, landforms, plants and animals.

2. Weathering

Denudation is a useful term for the total action of all processes that exposed rock of the continents is worn away, and the resulting sediments are transported by the agents of erosion.

Denudation is made possible by certain processes by which rock is physically disintegrated and chemically decomposed during exposure to atmospheric influence, and these activities are collectively referred to as weathering processes, classified into physical and chemical weathering.

Tarbuck and Lutgens (1997) define weathering as "the response of Earth's materials to a changing environment." It is also stated that mechanical (physical) weathering is the physical breaking up of rocks into smaller pieces, while chemical weathering alters a rock's chemistry, changing it into different substances, and these two processes usually work simultaneously in nature. Similarly, Bradshaw and Weaver (1995) said that weathering is "the breakdown and decomposition of solid rock and rock fragments in response to atmospheric processes

It has also been observed that climatic factors particularly temperature and moisture, are crucial to the rate of rock weathering, and these climatic elements largely determine the weathering rate and strongly influence the kind and amount of vegetation present in the environment.

2.1. Physical (mechanical) weathering

- The breakup of rock through mechanical processes, without chemical change occurring is what is referred to as physical weathering, and the processes of its occurrence includes;
- Frost action, it is the repeated growth and melting of ice crystals in the pore spaces or natural fractures of bedrocks, which are broken into blocks.
- Temperature change, a process that rock forming minerals expand when heated, but contract when cooled. This expansion and contraction processes of the mineral grains tends to break them apart.
- Plant roots growing between joint blocks and along minute fractures between mineral grains, exerts an expansive force tending to widen those openings leading to rock break down.
- Gravity in weathering is an indirect process because blocks loosened by freezing and thawing or other processes may tumble down slope and break-off additional rocks upon impact on the way down. The loosening of blocks by the force of impact falling material contributes to mechanical weathering.

2.2. Chemical weathering

This is also known as mineral alteration, involving a number of chemical reactions. The presence of atmospheric gases of oxygen and carbon dioxide dissolved in natural water is a matter of great environmental importance in reshaping rock structures of the earth surface through the following processes.

- Solution, whereby minerals composing the common rocks of the earth's crust are soluble to varying degrees in water and are readily dissolved in water, an example is rock containing the mineral halite.
- Carbonation, this occurs when dissolved carbon dioxide reacts with water to form carbonic acid (H2CO3), which is capable of dissolving many compounds more readily than pure water.
- Hydration occurs in chemical reactions where water is added to a mineral or compound. An example is the weathering of feldspar to clay.
- Oxidation is the presence of dissolved oxygen in water in contact with mineral surfaces, which is the chemical union of oxygen atoms with atoms of those metallic elements.
- Hydrolysis occurs when water combines with certain mineral compounds resulting to dissolution. An instance is when hydrolysis breaks up clay mineral into Kaolinite, illite and montmorillonite.

3. Soil

Soil like water is man's most vital natural resource (environmental resource), and from an economical point of view, the production of soils is the most significant result of rock weathering. This explains the definition of soil as a natural body of mineral, organic and nutrient constituent which result from the interaction of the country rock with environmental factors of climate, topography, plant and animal life. Soil is therefore a dynamic system, which if detached from its environment, would become an inert mass of weathered material.

Hence, the assertion of Cunningham et al (2005) that soil is a complex mixture of weathered mineral materials from rocks, partially decomposed organic molecules, and a host of living organisms, such that soil can be considered as an ecosystem by itself, making soil therefore an essential component of the biosphere that can be used sustainably and even enhanced under careful management.

SOIL FORMATION: There are five major factors that condition the development of soils, and these include.

- Parent material, which is remarkably differentiated by the texture and structure of the material as well as its mineralogic and chemical composition. It is characteristically unconsolidated (classic) material without any marked profile differentiation, such as beach sand.
- Climate, particularly temperature and the amount and kind of precipitation. Climate promotes directly the production of soil water and soil warmth, which constitute the most important agents of soil formation; and indirectly acts through vegetation and other forms of organic life.
- Topography affects both external and internal drainage as it controls the rate and nature of rocks weathering, removal and deposition (redistribution) of the soil parent material along the angle and length of slope.
- Soil biota includes both vegetative cover as well as organisms within the soil. As organic matter decomposes in the soil, it produces organic acids which intensify a number pedogenic processes.
- Time is mostly associated with the duration of the operation of soil formation that is whether or not the soil has had sufficient time to form mature profiles.

Soils are therefore the product of chemical, biochemical and physical processes acting upon earth materials, under various topographic and climatic conditions, they reflect as much as do landforms the climatic and geomorphic history of the region in which they evolve, and these varying histories are reflected in the soil profiles.

The physical and chemical properties of soil tend to change when flood occurs regularly over a place. Translocation of materials is so frequent in some cases, while in the other hand cracks and joints may be filled with impermeable materials, which will accentuate flooding.

4. Human activities

In the tropics man is becoming more active than other natural agents of denudation. The clearing of forest, uses of heavy machines for construction and quarrying, dredging of sand and drilling or mining of mineral resources, deforestation, etc. are responsible to deformation of parent rock materials.

The platform created by man allows other agents of denudation to accentuate and quicken denudation activities. Man has also learnt how to compact soil to suit whatever he wanted of the soil.

Human activities have led to flooding and desertification, these in one way or the other affects weathering over an area.

5. Relationship between weathering and soil

It is obvious that soil is a continuation of the study of weathering, since the study of soil serves as an end product of weathering processes. Perhaps, the most important effect of weathering is the development of soils, such that plants depend on soil for growth, and man depends directly or indirectly on plants for food. Aloni, Alexander and Oteh (2015) also observed that our environment provide sources of our food, the resources for our shelter, clothing, industries, constructions, health care and treatments, local craft and implements and for satisfying most of our basic needs and many of our exotic needs. The nature of soil changes with the factors which control the rate and character of weathering, and in addition the composition of a soil generally changes with depth in a systematic manner.

Hence, Ukpong (2009) assertion that the principles of soil science is important to the environmental manager because soils influence vegetation distribution; population distribution, types of raw materials and food. Soil is identified as a dynamic layer in which many complex chemical, physical and biological activities are adjusted to conditions of climate, landforms and vegetation, and will change when these controlling conditions change. Distinguishing a soil as having certain distinctive physical, chemical and biological qualities which permit it to support plant growth and which differentiate it from the infertile surface layer or infertile substratum which may consist of overburden or solid bedrock.

Soil is therefore observed to be composed of mineral and organic particles, while the underlying material usually consists of only mineral matter. Also, immature soils may reflect the composition of the material from which they were derived, as exemplified in a soil developed on granite which may differ from a soil developed in limestone.

Climate appears to play a major role, as a most important factor in the development of soils as noted by Dokuchaev, a Russian Scientist who advanced the idea that similar soils are developed in similar climates more or less independently of the nature of parent material, and that soils developed on the same parent material differ if the climate varies from place to place.

Soils on a steep slope are usually different from soils on a flat ground in the same area, and soils formed under a forest cover is different from soils formed under a cover of grass. These processes account for the importance of the mineralogical composition of rocks, their textures and structures, as well as the effect of different climates which affect the course of weathering, and explains the complex phenomenon involving a variety of processes and being influenced by a number of factors, the most important of which are lithological and climate.

Time also affects soil formation, soils formed very recently show differences from soils developed over a long period of time. A mature soil is one in which a series of zones having well defined characteristics has been produced by weathering processes. In such a soil, there is a succession of distinctive zones from the surface downward to the parent material.

It is a known fact that weathering leads to the formation of soil, and soil is being described as “the bridge between life and the inanimate world”, as noted by Tarbuck and Lutgens (1997).

All life, which is the entire biosphere, owes its existence to a dozen or so elements that must ultimately come from earth’s crust. Once weathering and other processes create soil, plants carry out the intermediary role of assimilating the necessary elements and making them available to animals including humans. Tarbuck and Lutgens (1997).

Soil is dynamic and sensitive to almost every aspect of its surroundings, thus when environmental changes occur, such as climate, vegetative cover and animal (including human) activity, the soil responds. Soil therefore functions as a fundamental interface, providing an excellent example of the integration among many parts of the earth system.

6. Conclusion

The study of geography focuses on the various interactions that take place within the earth’s surface, hence geomorphological research being based on processes concerning the earth’s surfacing, therefore resulting into most of the physical features seen on the face of the earth.

Geomorphological processes therefore explains how features on the earth’s surface are brought into existence, and this is mainly through weathering activities, thus, geomorphology being defined as an applied subject that deals with the impact of causations on the earth’s surface, and that, most research works are on drainage systems and weathering processes.

The environmental importance of weathering processes are felt in diverse ways, hence weathering being referred to as the process that changes the earth's surface due to the influence of atmospheric conditions on rock surfaces. A comprehensive study of geomorphology therefore will touch climatology, hydrology, biology and chemistry.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest. As this is the contribution of the aforementioned authors.

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