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Component-I (B) - Description of Module

Items	Description of Module
Subject Name	Geography
Paper Name	Geomorphology
Module Name/Title	Economic Geomorphology
Module Id	GEO31
Pre-requisites	Rocks, Terrain characteristics, landforms, drainage
Objectives	To know aboutEconomic Geomorphology, Components of Economic Geomorphology; Hydrology; Mineral Exploration; Oil exploitation; Dam construction; Military; Urban Planning, Coastal zone management, Hazard management
Keywords	oil exploration, economic viability, hazard management

Economic Geomorphology

Introduction

Economic Geomorphology and its significance can be linked to a growing recognition of the practical application of geomorphic principles and the findings of geomorphological research to human beings and the society at large who are influenced by and, in turn, influence the surface features of the earth. Rise in population has led to pressure on land resources, extension of agriculture to hilly and marginal lands resulted in anthropogenic catastrophes like soil erosion, landslides, sedimentation and floods. A proper interpretation of landforms throws light upon the geologic history, structure, and lithology of a region. As geology becomes more specialized there is growing possibility that the application of geomorphology to problems of applied geology will be overlooked. Human beings have over time tried to tame and modify geomorphic/environmental processes to suit their economic needs and at times the natural geomorphology of a place favors economic situation. Geomorphology has diverse application over a large area of human activity while geomorphologist may serve more effectively the need of society so both geomorphology and geomorphologist have economic importance.This can be understood better if one looks at the diverse role of geomorphology and its linkages with other fields.

GEOMORPHOLOGY AND HYDROLOGY

Water either on the surface of the earth or groundwater used by human is available from different sources like streams, lakes and rivers. The human civilizations chose sites based on availability of water. For domestic, commercial or industrial use, the presence of water plays a significant role in the economic development of region. The presence of water is dependent on the different lithological zones with varying conditions of surface as well as groundwater.

Hydrology of limestone terrains

Profound understanding of geomorphology is imperative to comprehend the hydrological importance of the limestone terrain. Availability of water in limestone region depends on the type of rock. On the basis of permeability, limestone rocks may be primary or secondary. Calcareous sediments decide the formation of rock and its primary permeability while earth movements in the form of tension and compression such as faulting, folding, warping, and due to solution or corrosion mechanism decide the secondary permeability.

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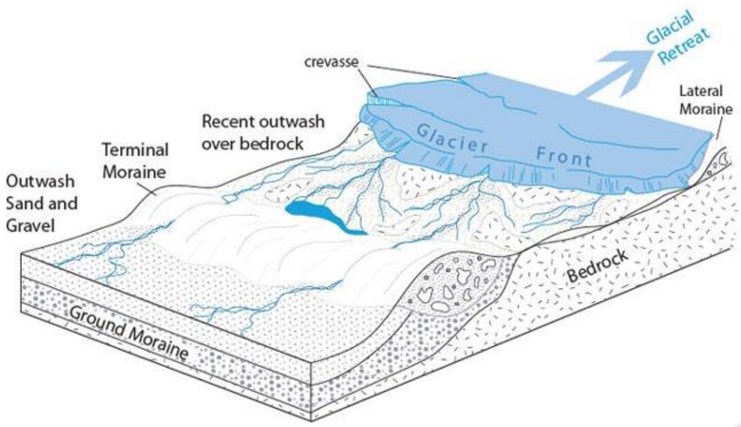
Geomorphology plays an important role to obtain water in limestone region. It may be easy or difficult to obtain water from wells in a limestone terrain. If the limestones have enough permeability and are capped with sandstone layer, the yield of water may be low or inadequate, but subject to contamination. Karst plains lacks filtering cover, and any swallow holes, sinkholes, or karst valleys within an area of clastic rocks should cast doubt upon the purity of the water of springs.

Glaciated areas and groundwater

Preglacial and glacial time history, types of deposits and landforms determine the possibilities of large supplies of groundwater potentials in glaciated regions. There may be yield of large volume of water from Outwash plains, valley trains, and intertill gravels or buried outwash. Due to clay content most of the aquifers are poor, but containing local strata of sand and gravel may hold and supply enough water for domestic needs. The study of preglacial topography and geomorphic history of the area can help detect the presence and absence of underground water.



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GEOMORPHOLOGY AND MINERAL EXPLORATION

Minerals have long been an important resource for economic development of any region. There is a close association of geomorphology, geological structure and minerals deposits. Characteristic of landscapes of specific areas could indicate these geological structures. Economic geologist has not appreciated the exploration of some minerals in the name of understanding of the geomorphic features and history of a region. In search for mineral deposits, these three points may serve for Geomorphic features as:

(I) some mineral have direct topographic expression for its deposits;

(2) the geologic structure and topography of an area have correlation which clue the accumulation of minerals;

(3) geomorphic history clearly indicates the physical condition under which the minerals accumulated or were enriched in a particular area.

Surface expression of ore bodies

Some of ore bodies have surface expression, but many do as topographic forms, as outcrops of ore, gossan, or residual minerals, or as such structural features as faults, fractures, and breccia zones. It is not necessary that all ore outcrops are reflected in positive topographic forms. The lead-zinc lode could be marked by a conspicuous ridge in the case of Broken Hill, Australia.

Quartz veins could stand out prominently as they are much more resistant to erosion than the unsilicified rocks, as in Chihuahua, Mexico. Some veins and mineralized areas may lack conspicuous topographic expression or it may be reflected by subsidence features or depressions. Though no generalization can be made about the exact type of topography necessary for the iron ore accumulation, distinct topographic expression is needed for a particular deposit. Residual iron deposits are the results of concentration of iron due to long periods of weathering, and thus for their accumulation, old erosion and weathering surfaces are favorable sites.

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Weathering residues

Geomorphology can play an important role for several important economic minerals which are essentially weathering residuesof present or ancient geomorphic cycles. Apart from iron deposits, materials like clay minerals, caliche, bauxite and some manganese and nickel ores are of this nature. Recent weathering surfaces may exhibit residual weathering products or it may lie upon ancient weathering surfaces which are now buried.

Peneplain or near peneplain surfaces are most commonly surfaces upon which they form. In general, such minerals are to be found upon remnants of tertiary erosional surfaces above present base levels of erosion. It is not yet clear why the weathering of igneous rocks produces both clay minerals or hydrous aluminum silicates and hydrous oxides of aluminum, such as bauxite. It could be the varying climatic condition under which weathering occurs, that determines the final compound. The residual products from the weathering of igneous rocks are clay minerals found in temperate climates known as kaolinization. It should be recognized that numerous minerals other than kaolin may form in same climate. On the contrary, under tropical climates final weathering products are hydrous oxides of such metals as aluminum, manganese and iron. This type of weathering is known as laterization. The phase of geology which concerns with the recognition and the study of ancient weathering surfaces and soil has come to be known as paleopedology. Though it offers many possibilities but it is still in its infancy in the search for the type of mineral deposits designated as weathering residues of geological phase.

Placer deposits

Placer deposits are mixtures of heavy metals within specific location and distinctive topographic expression. Geomorphic processes are the main cause of placer concentration of minerals. The deposition of placers is affected by the type of rock forming the bedrock floor. There are as many as nine types of placer deposits. They are residual or 'seam diggings',alluvium, colluvial, eolian, bajada, beach, glacial including those in end moraines and valley trains, and buried and ancient placers. The most important among them is alluvial placers.

Residual placers are also termed as 'seam diggings' which are residues from the weathering of quartz stringers or veins, are usually of partial amount, and grade down into lodes. Creep down slope is the main reason for the production of colluvial placers and these are transitional between residual placers and alluvial placers.

Colluvial placers (the koelits) and alluvial placers (the kaksas) are parts of the tin placers of Malaya. About one-third of the world's platinum in Russia, Colombia, and elsewhere, has been obtained from alluvial placers. The most important minerals like gold, tin and diamonds are obtained from alluvial placers. Most of the gold placers of this form have been found in California, Australia, New Zealand, and elsewhere. South Africa's diamonds from Vaal and Orange River districts, the Lichtenburg area, the Belgian Congo, and Brazil's Minas Geraes, are obtained from alluvial placers. Placer deposits have total share of around 20 per cent of world's diamonds. Australia, lower California, and Mexico have yielded gold in aeolian placers. Gold in California and Alaska, diamonds in the Namaqualand district of South Africa, zircon in India, Brazil, and Australia, and ilmenite and monazite from Travancore, India have yielded from beach placers.

Oil exploration

Several oil fields have been discovered because of their striking topographic expression. These oil fields are characterized by anticlinal structures which stand out distinctively in the landscape.In aerial photographs, many of the Gulf Coast salt dome structures are evident in the topography. For the student of geomorphology, it is fairly good working principle to suspect that areas that are topographically high may also be structurally high, where possibilities of topographical inversion at the crest of a structural high may result with weak beds.

In regions of dense tropical forest, topography cannot be seen through the forest cover, an anticlinal or domal structure may outline due to the tonal differences in the vegetation. In search for oil, more subtle evidence of geologic structures favourable to oil accumulation is being made. Aerial photographs are being used for analyzing drainage in typical terrain. Drainage analysis is useful particularly in regions where rocks have low dips and the topographic relief is slight. Permeability may be either primary or secondary in carbonate rocks. Oil yields from limestone may be in high quantity from rocks which have a high degree of permeability produced by solution.

Elongate buried sand bodies are basically shoestring sands. Probably there is no phase of petroleum exploration which can be used to better advantage a knowledge of the in-depth characteristics of specific topographic features than that which deals with the misuse of shoestring sands. Most of the oil and gas sources are associated with unconformities - ancient erosion surfaces; hence a petroleum geologist must deal with buried landscapes.

GEOMORPHOLOGY AND ENGINEERING WORKS

Evaluation of geologic factors of one type or another are involved in most of the engineering projects, amongst which terrain characteristics is most common. A detailed study of the geomorphic history of an area may support the proper evaluation of surficial materials and the bedrock profile configuration.

Road Construction

Topographic features of an area determine the most feasible highway route. Road engineering faces a number of problems due to different types of terrain that includes geologic structure, geomorphic history of the area, lithological and stratigraphic characteristics and strength of the surficial deposits. Areas like karst plain require repeated cut and fill and if not properly carried out, the road will be flooded after heavy rains with surface runoff from the sinkholes.

The presence of enlarged solutional cavities in karst region makes it necessary for the road to be designed in such a way that it is not weakened. Regions like glacial terrain presents a number of engineering problems. Road construction in flat till plain is topographically ideal but other areas where moraines, eksers, kames or drumlins like features exist there is need for cut and fill to avoid circuitous routes. Areas which are characterized by late, youth and maturity of relief will require more bridge construction and many cuts and fills. These types of areas are consistently facing problems like landslides, earth flows, and slumping.

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Landslides and different types of mass-wasting present problems not only in different phases of engineering but in highway construction also. Subgrade or the soil beneath a road surface has become more significant because of its control over the drainage beneath a highway, therefore construction design of highway should be in such a way to carry heavy traffic. Two factors largely determine the lifetime of a highway under moderate loads is the quality of the aggregate used in the highway and the soil texture and subgrade drainage. The type of parent material and the relationships of soils to its varying topographic conditions are more essential in modern road construction.

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The most serious problems encountered by highway engineers is Pumping which means expulsion of water from beneath road slabs through joints and cracks. It is evident that pumping is particularly greater over glacial till than over permeable materials such as wind-blown sand and outwash gravel. Poor drainage in a subgrade is mainly responsible for pumping. Poor and best performance of the highway is characterized by silty-clay subgrades with a high water table and granular materials with a low water table respectively.

Dam site selection

A synthesis of knowledge concerning the geomorphology, lithology, and geological structure of terrains has greatly helped while selecting sites for dam construction. According to Bryan, five main requirements of good reservoir sites depend on geologic conditions**:**

(1) adequate size water-tight basin;
(2) a narrow outlet of the basin with a foundation that will permit economical construction of a dam;
(3) to build an adequate and safe spillway to carry excess waters;
(4) availability of resources needed for dam construction (earthen dams); and
(5) Assurance that excessive deposition of mud and silt will not shorten the life of reservoir.

Constructing a dam in a limestone terrain may prove a difficult one, for instance, the Hondo reservoir was built over limestone in southeastern New Mexico, while the water table was about 20 feet below the surface. Rapid leakage was the cause of abandonment of the reservoir. Building a dam in a valley may not be a good site from the standpoint of the size of the dam. Buried bedrock valleys containing sand and gravel fills are common in glaciated areas, which may not depict adequate picture of surface condition. Making dam on those sites where subsurface topography is not supportive with buried preglacial valley with sand and gravel in it would have a chance of leakage.

https://upload.wikimedia.org/wikipedia/commons/6/69/Karun-3_Dam.JPG

Location of sand and gravel pits

Sand and gravel have more commercial and industrial uses. Evaluation of geologic factors such as variation in grade sizes, lithologic composition, degree of weathering, amount of overburden, and continuity of the deposits are important while selecting suitable sites for sand and gravel pits. Floodplain, river terrace, alluvial fan and cone, talus, wind-blown, residual, and glacial deposits of various types are areas where sand and gravel may be found in abundance. In recent years, there is a great demand of gravel than sand due to decreased use of plaster in home construction therefore knowledge of various grade sizes is more important.

There are high proportions of silt and sand in floodplain deposits which show many variable and vertical gradations and heterogeneous lateral. With their angular shape as well as variable in size alluvial fan and cone gravels are found near their apices. Being angular like talus materials are too large to be useful and are limited in extent. There is only sand in wind-blown sands but have no gravel. Residual deposits are likely to contain pebbles that are suitable for cement work. These residuals are also limited in extent. Favorable sites for pits are terraced valley trains and outwash plains, which are usually extensive and do not have a thick overburden. Due to its large amount of material, kame deposits show a poor degree of assortment because it is discarded on the ground of being too large or too fine.

GEOMORPHOLOGY AND MILITARY GEOLOGY

During wars the military used information that was more geologic than geomorphic in nature. The information regarding digging trenches, mining, countermining, and water supply or other material was not utilized. Topography became more important during World War II with the development of the blitzkrieg type of warfare, because effectiveness of a blitz depends to a large extent upon the trafficability of the terrain. In recent years terrain appreciation or terrain analysis have become more important in military.

For a terrain if geological maps fail somewhere, geographic principles can be applied with advantage to interpreting the terrain from aerial photographs. Little training is required to recognize features like mountains, hills, lakes, rivers, woods, plains or some kinds of swamps. It is important to know the kind of hill, plain, river or lake, and so on, because by knowing this it is quite possible to reconstruct the geography of that region. Aerial photographs are useful for the preparation of terrain intelligence as they provide information on the geomorphology of the area. Terrain has been an important factor in the Korean War and in the fighting in Vietnam region.

GEOMORPHOLOGY AND REGIONAL PLANNING

Geomorphologic information can be utilized at various levels of planning. Combination of topographic information, soils, hydrology, lithology, terrain characteristics and engineering included on terrain maps make it suitable for regional planning. Applied geomorphology has distinct place in regional planning. On broad scale it can be used to delineate areas for forest, mountain, plateau, recreational, rural and urban areas. A balanced growth of a country's economy requires a careful understanding of its natural resources and human resources. Rural or underdeveloped terrain fulfills a variety of recreational needs. There is a transformation from a terrain maps into land-use suitability maps to develop rural and urban areas. Detailed information on topography enlighten regional planners who may then advise development projects best suited for separate region.

GEOMORPHOLOGY AND URBANISATION

There is a separate branch known as urban geomorphology applied to urban development. According to R.U. Cooke, this branch of geomorphology is concerned with "the study of landforms and their related processes, materials and hazards, ways that are beneficial to planning, development and management of urbanized areas where urban growth is expected". Geomorphic features decide the stability, safety, basic needs and even its expansion. That means city or towns entirely depend on lithological and topographical features, hydrological conditions and geomorphic features. Urban geomorphologist begin even before urban development through field survey, terrain classification, identification and selection of alternative sites for settlements irrespective of plain or hilly areas. These urban geomorphologists would be concerned with impact of natural events on the urban community and that of urban development on the environment.

When geomorphological problems are not understood by the planners and engineers then it leads to destruction and damage to urban settlements in different environmental regions. Settling of foundation material in dry or glacial region, weathering process, damages of roads and buildings through floods in many parts of the world occur frequently. These problems arise due to misunderstanding of the geomorphological conditions. In developing countries attention has not been given to the geomorphological conditions before the development of existing urban centres. This leads to haphazard growth of city with squatter settlement and shanty towns with urban morphology.

GEOMORPHOLOGY AND COASTAL ZONE MANAGEMENT

Coastal zones are not linear as boundary between land and water is viewed as dynamic region of interface. The major threat to the fragile coastal zone is its deteriorating coastal environment through shoreline erosion, pollution and extinction of species coastal zone management requires an integrated approach. The most widespread material is beach sand, found mainly in low latitudes. Beach sand and gravel is widely used for construction industry.

Geomorphologists have made some significant contribution towards an understanding of shorelineequilibrium in Eastern Australia where considerable development of sand mining for heavy minerals has been done. Some structural measures have been designed for coast protection such as sea-defence structures - seawalls, breakwaters, jetties and groynes. To protect the sea backshore zone from direct erosion cut, sea walls are designed since these walls are impermeable they increase the backwash and produce a destructive wave effect. Breakwaters can be built either normal or parallel to the coast. It is necessary to monitor and quantify wave conditions, tidal currents and sediment movement in the nearshore zone to evaluate how sea defenses and other human-made structures affect shoreline equilibrium.

In context of coastal zone management Hails emphasizes that applied geomorphology must be concerned with quantitative and not descriptive research in order to obtain relevant and accurate data on (i) natural erosion and deposition rate (ii) at what rates and amount the sediment transport from river catchments to the near shore zone; (iii) variations in sediment composition and offshore distribution; (iv) sand supply sources and shoreline equilibrium; (v) interchange rate of sand between beaches and dune systems; (vi) the effects of constructing sea defenses; (vii) offshore sediment dispersal and the dredging effects of seabed morphology, sediment transport and wave refraction; and (viii) analysis of landform including topography of the near-shore zone, form of the continental shelf and of relict coast lines, particularly in terms of rock outcrops. Above investigation provides relevant baseline data needed for systematic planning process and monitoring programmesand devising land use scheme.

GEOMORPHOLOGY AND HAZARD MANAGEMENT

Hazards can be natural or human-induced where tolerable level or unexpected nature exceeds. According to Chorley, geomorphic hazard may be defined as "any change, natural or man- made, that may affect the geomorphic stability of a landform to the adversity of living things". These hazards may arise from immediate and sudden movements like volcanic eruptions, earthquakes, landslides, avalanches, floods, etc. Faulting, folding, warping, uplifting, subsidence, or vegetation changes and hydrologic regime due to climatic change arise from the long term factors. Areas having past case histories of volcanism and seismic events help in making predictions of possible eruptions and earthquakes respectively. Regular monitoring of seismic waves, measurement of temperature of craters lake, hot springs, geysers and changes in the configuration of volcanoes whether dormant or extinct can reduce the hazard to some extent. A detailed knowledge of topography can predict the path of lava flow and its eruptions points in advance.

The behavior of a river system can be well understood by its geomorphic knowledge through its channel morphology, flow pattern, river metamorphosis and so on. It may help controlling excess water in river and control measures during flood season. Prior knowledge of erosion in the upper catchment area and carrying sediments to its proportion may help in understanding the gradual rise in river bed, which may lead to levee breachand sudden floods. Earthquakes may be human induced or natural geomorphic hazards. Detailed study of seismic waves help in identifying and mapping the zones of high to low intensity to reduce the risk of human life.

With the introduction of aerial photographs and satellite imageries, preparation of specialized maps and interpreting them has become easier and more accurate. Aerial photographs are being used for evaluating landforms and land use for city developmental plans, construction projects, highway etc. Another tool i.e. Remote sensing is necessary for sustainable management of natural resources like soil, forest, crops, oceans, urban and town planning etc. At present Geographical Information Systems (GIS) technology has been used along with Remote Sensing techniques in geomorphic features interpretation.

By understanding the core of geomorphology and its interlinkages with other fields and how this interlinkage influences human beings and further the society one gets to know the important role played by geomorphology in contributing to the economy.Whether it is urbanization, mineral exploitation, oil exploration,water availability, construction of dams, roads, railway tracks etc., or disaster management the role played by geomorphology is immense and imperative.