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Abstract

Geomorphology is the science of studying and understanding the unevenness of the earth's surface. Geomorphology provides the best tool for classifying the forms of unevenness of the earth's surface. One of the outputs of geomorphology is the preparation of geomorphological maps. There have been numerous problems in preparing these types of maps, including identifying and separating geomorphological units, the presence of vegetation, the concealment of features, human activity, and coastal destruction, etc. The preparation of geomorphological maps always follow certain principles and methods. Obviously, in recent years, geomorphological maps have been prepared using new methods and computer manipulation such as GIS. An important issue regarding geomorphological maps is the issue of standardization, which is a noteworthy point. The purpose of preparing geomorphological maps is to record information about the land forms, materials, soils and rocks, land surface processes and in some cases the age of the land forms. In this way, these maps provide a basis for land assessment that is useful in the context of many environmental topics . Therefore, geomorphological maps are considered as a tool for sustainable development and progress in most developing countries.

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Standard for Preparation of Coastal Geomorphology Maps

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Standard for Preparation of Coastal Geomorphology Maps

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Preface

Geomorphology is the science of studying and understanding the unevenness of the earth's surface. Geomorphology provides the best tool for classifying the forms of unevenness of the earth's surface. One of the outputs of geomorphology is the preparation of geomorphological maps. There have been numerous problems in preparing these types of maps, including identifying and separating geomorphological units, the presence of vegetation, the concealment of features, human activity, and coastal destruction, etc. The preparation of geomorphological maps always follow certain principles and methods. Obviously, in recent years, geomorphological maps have been prepared using new methods and computer manipulation such as GIS. An important issue regarding geomorphological maps is the issue of standardization, which is a noteworthy point. The purpose of preparing geomorphological maps is to record information about the land forms, materials, soils and rocks, land surface processes and in some cases the age of the land forms. In this way, these maps provide a basis for land assessment that is useful in the context of many environmental topics . Therefore, geomorphological maps are considered as a tool for sustainable development and progress in most developing countries.

CHAPTER ONE

The Importance and History of Geomorphological Mapping in Iran and the World

Introduction

In many environmental management tasks, the most important and useful contribution of the geomorphologist is the preparation of maps of the unevenness of the earth's surface. The preparation of such maps has been used and benefited in many engineering, planning and land management projects. Due to some practical limitations the implementation processes greatly affect the nature of the map prepared. In this regard, we will focus on the preparation of land-system maps and the preparation of geomorphological maps, because these two types of land maps are most widely used in environmental management. Geographers have considered maps as a means and tool of their investigations from the beginning, and this means that the transfer of some geographical concepts, facts, and ideas was not possible with verbal and written systems alone, or at least did not satisfy geographers (Ramesht, 2006). In geography, a map creates a space for the viewer so that he can understand the spatial relationships between phenomena (Ramesht, 2006). Maps represent landforms or groups of landforms that are more general topographic phenomena and are often created to meet specific needs and may be produced at different scales for planners, geologists and tourists (Clles et al., 1982). The preparation and use of maps in different types and scales is essential and inevitable for the development of any country and is fundamental to our lives and activities. Therefore, knowledge and understanding of this environment, its elements and processes are of great importance for promoting rational development. We can gain knowledge of past and active processes by studying the landscape around us (Gustavsson, 2005). When a regional development plan is proposed, planners must have knowledge of the details of the natural environments of that area (Oya, 1983). A tool that presents the results of studies in a simple and somewhat accurate and complete manner is very necessary (Rajaei, 2003). Geomorphological maps are an ancient source for recording landscape information (Seijmonsbergen, 2008). Geomorphological maps are among the best tools for understanding the dynamic framework of the Earth's surface, allowing the investigator to determine and map the evolution of the current landscapes of the area being studied and to formulate rational predictions about their future trends (Dramis, 2009).

The nature of geomorphology, given that it is a branch of geography, has a systemic approach and always considers two elements: humans and the environment. One of the capabilities of geomorphologists is to prepare geomorphological maps for different regions with different purposes. These maps are a type of research method and can also be a tool for more research by other researchers and sciences. In other words, it can be a scientific foundation for fundamental and applied research.

Geomorphology and geological mapping

Geomorphology is a science between geology and geography and is closely related to civil engineering that studies the interaction between climate, hydrology and tectonic processes of the Earth's surface. Basic concepts in geomorphology include the magnitude and frequency of processes, the scale of landforms and processes, time scales of lag times, reaction times, reflection times, quiet times of adjustment, equilibrium and historical . Geomorphology is the science of quantitative analysis of the Earth's surface, which is a modern and cartographic-analytical method for presenting the topography of bare earth using computer manipulation of elevated features and is an interdisciplinary field that has been derived from mathematical sciences, earth sciences and, more recently, computer science (Bohner et al., 2009). Therefore, geomorphology is the science that studies the surface land forms of the earth and the processes that create and renew their profiles (Gustavsson, 2005).

In many environmental management tasks, the most important and useful contribution of geomorphologists is the preparation of terrain maps. This is especially evident where information about the distribution of landforms, soils and rock materials or features resulting from surface processes is needed. The preparation of such maps has been used and has many benefits in many engineering, planning and land management projects (Kook et al., 1998). The geomorphological analysis of a given area, which geomorphological maps represent spatially, is the key to research related to earth sciences, and in this regard, the maps that are drawn are a scientific document in executive work, because geomorphological maps provide a complete and rapid view of the various forms of roughness of the Earth's outer crust and the processes that cause the emergence of these forms in relation to geological and climatological formations (Rajabi, 2001).

History of Geomorphological Maps

The first maps were produced in Babylon around 4500 BC, using the relief method to describe landscapes, along with symbols for vegetation and hydrology, and were used for several thousand years. Then, in the 18th century, reliefs were shown using hatching. Then, in the 19th century, contour lines were used, to show a specific relief (Gustavsson, 2005). Traditional geomorphological mapping began when aerial photographs became available. The first geomorphological map was prepared in 1914 (Rao, 2002). This map was prepared by the German physician Pasarg Peziz for the Stidermba region at a scale of 1:2500 (Rajaei, 1980). Between 1920 and 1930, several attempts were made to produce geomorphological maps, but this work was stopped (Gustavsson, 2005). However, the main demands for nationwide coverage came from agricultural planners and engineers after World War II. However, a legal mapping system was only started during the 1950s (Rao, 2002).

The preparation of modern maps began in the 1950s by the Dutch, and their goal was more for economic planning (Ramesht, 2006). Development and expansion of geomorphological maps in the post-war period was carried out slowly and without the use of a logical methodology. So that in 1954, Scholey, in collaboration with Boomer, prepared a geomorphological map of the Paris Basin, which is based more on the monograph of the area than on fundamental research. In Australia, organizations such as (o.r.i.s.c.) after World War II, using the physiographic method, prepared maps of geomorphological units (Rejaei, 1980). has succeeded in presenting a classified plan suitable for agriculture. This study system has provided desirable regional criteria for engineering purposes in Australia, and numerous areas have been studied with this method. Geomorphological maps for the development and planning of the Kiras de Rance river basins were prepared by Jean Tricard following the flooding and heavy damage in 1975. This map also includes details and with the scale of 1:5000. Chueca et al. (2008) used aerial photographs to produce a map of the Ribagorza region of the Spanish Pyrenees, which is located in the middle latitudes with very high altitude. May (2008) with a combination of Landsat and Corona satellite images to produce a map of the Cuabradadí Purmamaraca region, Jujuy, in northwestern Argentina.

For the first time, the geomorphological map of Iran was prepared and published at a scale of 1:2500000 in a collection of maps of the Near East region at the University of Tübingen, Germany, (Servati,et al,1990) This map was prepared on the basis available of topographic maps, geology, aerial photographs, satellite images, articles and limited books on geomorphology . This map was translated by Servati and published by the Geographical Organization of the Armed Forces (Servati , 2002). Currently, geomorphological maps are accepted and utilized as a method in evaluating natural resources by UNESCO researchers (Ramesht, 2006). The necessity of producing geomorphological maps and its application is to draw investigate and deposits and to understand the processes of a landscape. Although they are more limited for certain purposes. With regard to, the increase of world's urban population and human population growth, it is important to develop a relationship between land planners and geosciences to prevent the negative feedbacks of this phenomenon Applied geomorphological studies can play a fundamental role in recognizing the risks and crises of incorrect survey in a territory. The presentation of useful long-term plans are very effective tools for scientific analysis and awareness of managers and related authorities. On the other hand, the scientific and comprehensive needs studies of landforms in expanding our understanding of the interaction of surface processes of the Earth and the formation of subsequent landforms (Paron et al., 2008). Therefore, identifying and explaining morphogenesis and morphodynamics is in fact a requirement for any kind of construction project , So therefore, the preparation of geomorphological maps is of great importance (Servati, 2002). Geomorphological maps are the most important sources of information in land use planning, agriculture, forestry, design and rehabilitation of settlements, construction of transportation lines and water engineering. They also play an important role in mining exploration, architecture and landscape presentation and are part of applied landscape planning (Rao, 1978).

Geomorphological maps are prepared in the field of environmental management for three main reasons:

1- To enable the geomorphologist to better understand the landscape before providing a description.

2- To record and mapping the landscape features related to the project in progress.

3- To provide a fundamental basis for preparing derivative maps with a and specific purpose (Cook et al., 1998). Geomorphological maps, if prepared based on detailed studies, are considered a very suitable tool for the reconstruction of damaged or destroyed areas and to prevent the occurrence of natural phenomena such as river floods, earthquakes, etc. Because the origin of the damage is carefully studied and the causes of geomorphology and the mechanisms that cause it are investigated and identified (Rajaei, 2003). Specialized geomorphological maps indicate the course of development and changes in landform over time and will clarify the basic information related to physical and surface properties. Geomorphological thematic maps are prepared for various purposes, such as agriculture. soil science, hydrology, ecology, regional development planning, rural development and urban planning, etc. (Rajaei, 2010) (Ramesht,2006)

Mapping from 1900 to 2000

A wide variety of methods, including simple outline or plan drawings, block or general diagrams, and various types of photography and other imaging methods, both from the ground and from the air, have been used by geomorphologists to describe the surface of the Earth's land forms. Recent efforts by many geomorphologists to develop a graphical representation of the natural features of the Earth's surface have ultimately led to the emergence of various geomorphological maps. These detailed maps are powerful research tools in both theoretical and applied geomorphology.

Throughout the 19th century and early 20th century, the main method of studying landforms was through static descriptive physiography. In Europe and the United States, some researchers had recognized the influence of dynamic forces on the landscape (for example, John Wesley Powell observed the force of water in the erosion process of the Grand Canyon).

In 1899, William Morris Davis mentioned the basic concept of the "cycle of erosion”. He proposed that landscapes are dynamic and always form in a cycle due to the external forces. Although the theory was not initially accepted by the scientists, but Davis's "cycle of erosion" concept immortalized his name in geomorphology.

By 1920, the quality of photography and analysis had reached a high level of development, and so it began to be useful to geomorphologists. Until the early 1840s, when photography was recognized as a powerful tool in the field of topography mapping, there were only a few users of photography in connection with the study of landforms. However, aerial photography was first experimentally introduced as a tool for landscape study by the first photographers and balloonists, Nader and Triboulet. Albert Heim was the first to use aerial photography in geomorphological research, and in 1899 he published his photographs and observations taken during a flight over the Alps Mountains During World War I, aerial photography was used extensively to obtain views of enemy territory and to observe battlefields.

In the early 20th century, before World War II, landscape factors were the focus of most geomorphological research. Gradually, researchers began to focus on depicting regional landscapes using geographical or landform maps. These maps combined elements of topographic maps and geomorphic units. Geographic maps show real landforms from an oblique perspective in the form of block diagrams or overviews.

World War II brought about a revolution in the science of geomorphology that transformed it both theoretically and technically. The highly dynamic style of warfare in World War II, which required fast-moving combat units, rapid thinking, and decision-making, required detailed analysis of enemy territory, which led to a significant technical advance in the use and interpretation of aerial photographs. The ability to study and analyze landforms from aerial photographs increased with improvements in photographic equipment, film, and interpretation tools. In 1957, quantitative analysis techniques originally developed for other scientific purposes were applied to geomorphological research. Geomorphologists, especially in Europe, became interested in a comprehensive analysis of landforms that considered all aspects and features of the landscape.

Over time, it became apparent that the processes of landform development were much more complex than Davis's relatively simple cycle of uplift, erosion to the plain stage, and rejuvenation. Some Efforts were also made to relate past landform processes to current processes. Questions such as how to compare t different landscapes? and how do landforms and unevenness affect the vegetation, hydrology, and cultural development of an area? revealed the need for a new paradigm in geomorphology.

In the 1960s, the science of geomorphology developed into analytical geography of the Earth's surface, and detailed geomorphological maps became the most important geomorphological research tool.

The main areas of research in modern analytical geomorphology consist of five main concepts related to landforms, which are;

• Morphography (or morphology): the appearance, shape, and other characteristics. of the landscape. This concept refers to the qualitative description and geometric elements of landforms and is the main feature of descriptive geomorphological analysis, which must be carried out with the greatest possible accuracy.

• Morphometry: the measurements, dimensions, and slope values of landforms. This concept often refers to quantitative elements such as height, roughness and slope directions, landform boundaries, angles and lengths of longitudinal or linear cartographic elements (faults, branches of drainage networks, etc.), covered surface by plain surfaces, karst and volcanic landforms, etc.

• Morphogenesis: The origin of each landform. This concept deals with the genetic or formation processes, morphogenetic systems and mathematical simulations that form the roughness of an area over time.

• Morphochronology: The age of a landform. Absolute and relative dating, correlation of sediments, classification and correlation of landforms based on their age and location.

• Morphodynamics: Active landforming processes or morphogenic processes that may be activated in the future. This concept refers to all the dynamic processes that form the topography of the surface. The remnants of past dynamic processes are usually known as “terrace” (inherited landforms).

The graphical representation of these five concepts involves a complex and often difficult set of analytical and cartographic procedures. However, there are various and quite different views on the content of geomorphological maps.

Some of the first detailed geomorphological maps were published in 1914 in the Siegfried Passarge’s Morphological Atlas. From then on, and until the end of World War II, a gap developed in this field, and very general local maps being published by European geomorphologists, and geomorphological surveys being carried out only occasionally. Before the 18th Congress of the International Geographical Union (IGU) in 1956 the importance of detailed geomorphological maps was not accepted internationally. Two years later, the newly established Subcommittee on Geomorphological Mapping was given three responsibilities at the IGU Congress in Stockholm;

• To innovate and develop a methodology for the preparation of geomorphological maps.

• To adopt a single international system for the preparation of geomorphological maps in order to ensure consistency.

• To describe the uses of geomorphological mapping in regional economic planning for optimal use of the land surface.

A large number of countries, including Switzerland, the former Soviet Union, Poland, France, Czechoslovakia, Belgium and Hungary, had already begun to produce detailed geomorphological maps before the establishment of the Subcommittee. The methodology and content of these maps varied from country to country, and therefore the maps were generally not comparable and therefore of limited use for the geomorphological analysis of large areas. European geomorphologists recognized the need for a single technique, including a common guide for the preparation of comprehensive maps. In 1962, a Subcommittee meeting was held in Karaganda, Finland, where representatives of fifteen countries developed a set of guidelines for the preparation of geomorphological maps. These guidelines consist of:

• Fieldwork as a basic requirement, with aerial photographs as a recommended tool.

• Preparation of maps at scales between 1:10,000 and 1:100,000; At these scales, "unevenness and its characteristics can be shown ".

• Mapping all aspects of unevenness: such as morphography, morphometry, morphogenesis and morphochronology in order to study the development of unevenness in the past, present and future.

• Using colour and symbols to in maps.

• Determining the chronological order of the leadforms.

• Shownig lithological data.

• Providing a legend in the form of a genesis-age sequence.

• Recognizing that detailed geomorphological maps are an indispensable tool for the future development of geomorphology.

The Subcommittee on Geomorphological Mapping met regularly throughout the 1960s. In 1968, at the IGU Congress in New Delhi, India, the committee was upgraded to the Commission on Geomorphological Surveying and Mapping.

One of the main tasks of this commission was to develop a code of practice for the preparation of detailed geomorphological maps and to prepare guidelines for the International Geomorphological Map of Europe at a scale of 1:2500000. The next map was prepared in collaboration with many European geomorphologists and published in 1971. In 1972, the "code of guidance " was published. which was a collection of articles by twenty geomorphologists.

A new vision on “ecological geomorphology” has linked the inference of landscape topography to human life and activity. New research methods, especially aerial photography, satellite imaging, and radar imaging, became popular, and computer science advanced in the field of automated cartographic analysis and display. Despite the advances made, serious problems remained unsolved. In addition to the problem of content and methodology, the problem of appropriate scales, especially for large areas with small scales, remained and has not yet been solved.

According to Wright, geomorphological maps are divided into two general categories: "landform surveying " and "feature-specific phenomenon studies". The first category consists of various types of detailed geomorphological maps, and the second category includes specialized maps such as the US Army's "Terrain Relief Similarities," which provide an analysis of operational terrain only in terms of its travers ability by military vehicles, or Hammond's (1954) "Small-Scale Maps of Terrestrial Landforms," which, although regional in scope and small in scale, "focus on the actual characteristics of the existing surface rather than on interpretations of the genesis and development of landforms." Hammond's work cannot be included in the category of land surveys because of its limited scope.

The development of geomorphological mapping has followed different directions in different countries, mainly due to the different interests and emphases of geomorphologists and to some extent also due to the real or perceived differences in landforms in different regional complexes. The lithological structure unit was chosen by some European geomorphologists, including French, Czechoslovak and Hungarian researchers, as the basic element in the analysis of landforms. However, some geomorphologists from Germany, Poland, Russia and Romania have considered the form as the main unit. The detailed geomorphological mapping regulations and the International Map Guide of Europe at a scale of 1:2500000 generally follow the Polish, German and Russian agreement. In Great Britain an "empirical system" was developed by geomorphologists based on the division of the landscape into "ranges and plains".

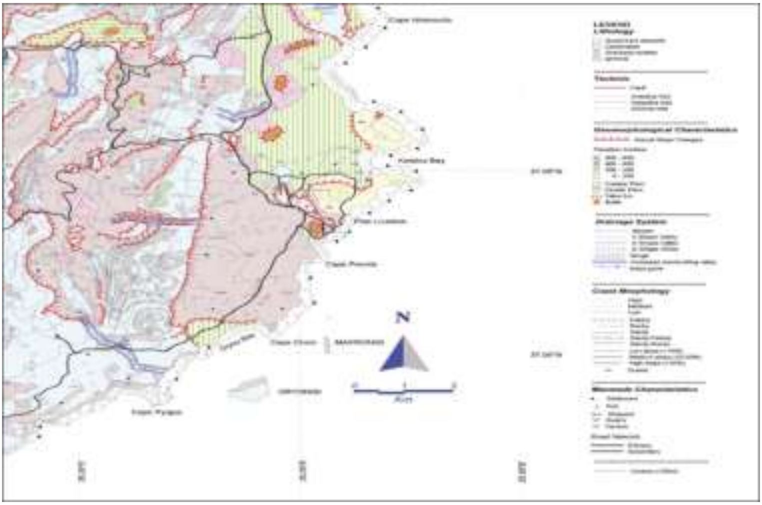


Figure 1- Geomorphological map of Paros Island (Greece)

Belgian and Canadian geomorphologists used similar systems because they could provide quantitative estimates of all landforms generally at the expense of genesis and chronology. Some combined methods have also been followed by some geomorphologists. A system of geomorphological mapping for the survey of reserves based on the concept of land units and land systems was developed by the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia. The terms of reference for this policy were "to establish a basic and functional landscape subdivision". The term land unit was used to describe a land area that had a common origin and now had a common topography, vegetation and climate. The term land system was used to represent "a community of land units that are geomorphically and genesis related".

The development of a "single key", that is an international guide and its application The International Geomorphological Map of Europe is a step forward. This "single key", although not universally accepted, has gained wide acceptance as a guide for use. In 1982, the desirability of a single guide for geomorphological maps at different scales was obvious, but the guides proposed so far have not met all the needs. Despite the many differences, there is a basic unity. The identification of the simplest land unit with little variability and hence the integration of land units into a hierarchy of areas of increasing complexity has been a concern of all geomorphologists.

Geomorphological Mapping in the 21st Century

Even with all available technological advances, geomorphological mapping still begins with the identification of the major units that make up the landscape. Determining the nature and characteristics of these units is crucial to the success of any geomorphological study. However, there is no single agreed upon unit that meets the needs of mapping studies of different types and scales. A geomorphic unit is generally described as a single landform that is homogeneous in origin and development, created by a specific constructive or destructive geomorphic process. Most geomorphologists agree with this definition but disagree about the descriptive characteristics of a homogeneous landform in origin and development. Furthermore, although most landforms may be considered homogeneous in origin and development in terms of current processes, they have their own characteristics that are in some way related to past processes of various types. Every part of the Earth's surface is the end product of evolution dominated by parent geological materials, geomorphological processes, and past and present climate.

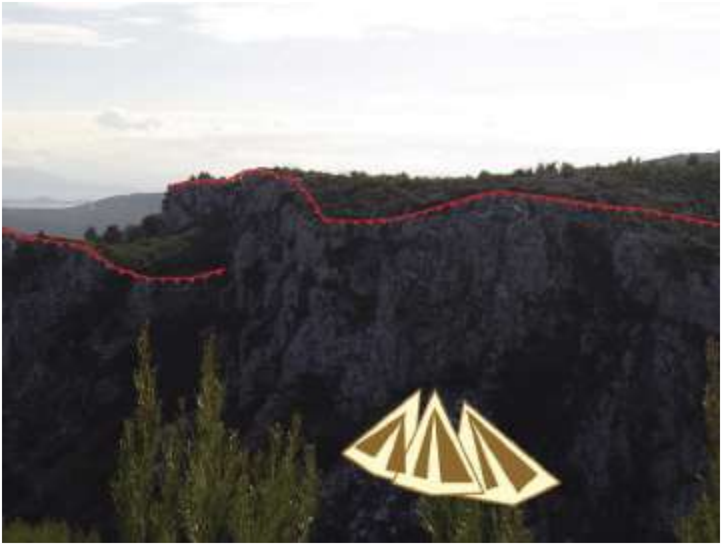


Figure 2- Identifying steep slopes and depositional cones in a landscape

CHAPTER TWO

Techniques for Preparing and Drawing Geomorphological Maps

Method of preparing geomorphological maps

1- Gathering the required information and data.

2- Preparation of the base map and selection of the map scale.

3- Remote sensing.

4- Preliminary visit to the study area and conducting the required sampling.

5- Laboratory operations.

6- Review and analysis of aerial photographs and satellite images and separation of geomorphological units of the study area.

7- Review and analysis of the processes affecting the formation of the study area.

8- Preparation of the preliminary map and final control.

9- Field surveys and finalization of the information obtained.

10- Analysis of the results of the samples taken.

11- Preparation and compilation of the final report and map.

Sampling Techniques and Methods in Geomorphological investigations

In most of the geomorphological applications definitely and descriptive techniques and methods are not sufficient to determine, describe, and analyze geomorphic processes, paleoenvironmental conditions, and paleogeographic evolution with respect to time.

Relatively recent sediments deposited in various environments have "recorded" a set of information that can determine the paleoenvironmental conditions of their deposition as well as post-depositional processes.

Especially for the analysis and study of Holocene and Pleistocene deposits such as clastic cones, alluvial and sedimentary deposits (alluvial cones and pons)), fluvial-floodplain deposits, floodplain and bank (river) deposits, bed and terrace deposits, delta, wetland and coastal deposits as well as human deposits (archaeological layers), sampling of loess sediments or even cohesive sediments along with their stratigraphic description and interpretation is essential.

In order to understand and analyze the chronostratigraphical sequence of sediments and their paleoenvironment, sibling sampling techniques and some sedimentary analyses must be performed. Depending on the context and direction of the research, these analyses refer to mineralogical composition, particle matrix, micro and macro fauna dating, microchemistry, and micromorphological characteristics of the sediments.

Materials and Methods

Based on the equipment used, sampling methods can be divided into the following categories:

• Using hand tools such as geological hammers, drilling bits, knives, spatulas, sanders, etc.

• Using mechanical devices such as drilling machines, vibrating samplers, weight samplers, etc.

In both cases, the goal is to obtain a compact sample of rock or soil with minimal disruption, in a way that matches the conditions prevailing at the sampling site. The sampling method depends on the goal, which can be the determination of composition, physical, chemical, biological, mechanical characteristics, etc.

Types of samples include:

• **Disturbed samples:** Samples that have been subjected to disruption of the soil texture (material composition) during sampling. These samples are suitable only for determining their physical characteristics.

•**Undisturbed samples:** Samples whose collection techniques ensure minimal disruption of the soil texture in order to make them suitable for determining their physical and mechanical characteristics. Undisturbed samples are taken from soft, cohesive (sticky) soils. Shelby or Denison samplers are recommended for this purpose. The following points are essential for collecting undisturbed samples:

1. Use thin-walled samplers to minimize friction between the sampler and the soil.

2. Strict protection and control of equipment.

3. Regular and thorough cleaning of the drill bit with drilling paste or fluid.

4. Move the sampler slowly and carefully, avoiding pressure and impact on it.

5. The penetration of the sampler should be small compared to its length in order to avoid sample compression.

Figure 3- Sampling by vibrating coring machine

The criterion for the desirability or undesirability of core sampling is the percentage of sample compaction, in other words, the ratio of sample length to drilling length (in percent).

The materials that enter the sampler during rock drilling are classified as follows:

• Cores longer than 10 cm.

• Cores shorter than 10 cm.

• Stone chips.

• Materials that are lost when the sampler is pulled up.

When a large portion of the sample core is composed of rubies, it may form a mass with a diameter equal to the diameter of the core and its total length can be measured.

Figure 4- core sampling of the drilling

Solid core recovery is the total length of groups 1 and 2 and is expressed as a percentage of the sampling length.

Rock Quality Determination (RQD) (in percent) = {Total core length > 10 cm/Sampling length} x 100

There are various strategies to reduce core damage during sampling. These factors include;

• **Post-drilling vibrations:** Post-drilling vibrations can be avoided by maintaining the drill in good mechanical condition, reducing the driving force of the rotary rod (axis) and rotation speed, and using rods of the same diameter along the entire length of the drill string.

• **Excessive drilling speed:** This can be avoided by reducing the rotation speed of the core and drilling.

• **Sample destruction due to high water flow:** Sample destruction can be prevented by performing "dry" drilling at selected depths, replacing the circulating drilling paste or fluid, and using compressed air instead of water.

• **Sample crushing (Powdering):** By increasing the water supply, slowly raising the drill string, or pulling it up to the surface it, can prevent the sample from crushing.

The characteristics of crushed rock sampling are:

• The diameter of the drilling is independent from the hardness of the rock.

• No collapse (destruction) of the drilling wall.

• The moving of the rock fragments from the lower part of the drilling should be complete with no water loss.

The rock fragments are collected on the surface, washed with water and, after drying and packaging, sent to the laboratory for further analysis.

Physically supported sampling

This refers to sampling in natural parts of soil materials and loess deposits by hand, or auger. The precise location of sampling as well as its characteristics are necessary for researches. After cleaning the section stratigraphic description and sampling are carried out, and the stratigraphic horizons and their macroscopic characteristics (including thickness, color, composition, constituent materials, etc.) are described as accurately as possible. The depth of the soil from which the sample was taken is also described.

Sampling from a specific location is the next step. Depending on whether the sample is sensitive or reacts to the preservative, a plastic bag or box (plastic or metal) is used. During this step, if the goal is an oriented and intact sample (intact), a method involving plaster badage and perimetrical excavation should be used.

Finally, the sample recording stage comes, which includes characteristics, general information and photographs of the section will be recorded and preserve in a suitable condition.

Topographic Maps

Topographic maps are essential documents in geomorphological studies. Topographic maps in geography are prepared with four methods: highlighting, hatching, color, and contouring technique (Ramesht, 2006).

Usually, researchers use topographic maps as the basis and platform for displaying their geomorphological information.

Geological map

The basic data used in geomorphological maps are taken from geological maps. They include:

- Chronological features, (age of formations and sediments with letters and abbreviations).

- Lithological features, which often deal with lithology and stratigraphy. In this regard, it is more important to show the type of rocks, their hardness or erodibility in the geomorphological map. For this purpose, lithological features show - Structural information such as structural axes, faults and structural slope of layers. are also transferred directly from the basic geological maps.

Geomorphological Maps

Geomorphological mapping is a relatively new technique compared to geological mapping. This is because the technique it is a younger science than geology. A geomorphological map records surface features or landforms that record geological processes on the Earth's surface (Klawon, 2003). Following itmes are shown in a geomorphological map:

1- Land surfaces.

2- Geoforms, land phenomena.

3- Parent materials.

4- Processes that create forms.

5- Time.

In geomorphological maps, the ultimate goal of the researcher is to identify the form-generating systems and the processes (Ramesht, 2006). By drawing a geomorphological map, while identifying the land phenomena and their spatial distribution, the process that causes such forms is also shown in the map, and ultimately the user can delimit the boundaries of the territory of the form-generating systems in the region. An ideal geomorphological map should provide information about the morphology of origin, morphometry, morphography, origin, composition, etc., and show the landscapes, and qualitative description and geometric elements of the landforms.

Morphometry: It shows the dimensions and slope of landforms and basically refers to the quantity of elements such as: height, unevenness and slope direction, landform boundaries, angle and length of cartographic elements faults, surface drainage network, karst and volcanic landforms, etc.

Morphogenesis: It deals with the origin of each landform, expressing the relevant genesis processes, and mathematical simulation morphogenesis systems that show the time of formation of unevenness.

Morphochronology: It shows the age of each landform, including: relative and absolute age, correlation of sediments, classification of landforms and the relationship based on shape and age.

Morphodynamics: It shows the current active processes of landforms, or those that may become active in the future. This refers to all dynamic processes (Pavlopoulos, 2009).

Geomorphological maps can be divided into four groups:

• Surface shape maps.

• Surface material maps.

• Surface process maps.

• Age of landforms maps.

Detailed geomorphological maps are with a scale of 1:10.000, are usually of five types.

Basic geomorphological maps, which record all landforms based on their physical characteristics (morphometric and morphographic), origin and age.

General 1 geomorphological maps, which are general basic maps that are based on the needs of designers.

Detailed basic geomorphological maps, which present the unique characteristics of landforms, group features or individual features.

Detailed geomorphological maps are combined with basic detailed geomorphological maps with special emphasis according to the needs of the designers. Specific geomorphological maps may be a combination of various data mentioned above and are compiled according to specific requirements.

Compiling of detailed geomorphological maps can be divided into four main stages.

1- Design of projects for geomorphological mapping, which includes all the necessary work to determine the activity trends, specify the area to be mapped and a brief summary of the research, define the problems, assessing the existing, topographic maps, accuracy and detail of data, available of subsurface data and a working plan.

2- Preliminary stage: data collection review of the literature, aerial photographs and maps, compiling morphometric and morphographic maps and profiles,

3- Geomorphological mapping method: includes preparing a map of the distribution and individual unevenness forms and determining their boundaries, specifying the formation of the forms, determining the stages of unevenness formation and determining the age of the unevenness.

4- Laboratory details of the materials, which include compiling the map and the final report - analysis of grain size and morphometry (Vozenilek, 2000).

In geomorphological maps, time is usually divided into two periods: the Quaternary and before, because Quaternary climatic changes are more important for geomorphologists (Ramesht, 2006).

Steps in preparing a geomorphological map:

1- Determining the scope of investigation, purpose and scale.

2- Deformation of land surfaces.

3- Geoforms.

4- Parents materials.

5- Processes.

6- Time.

Geomorphological maps can be divided into four groups according to their subject matter:

1- Surface shape maps

2- Surface material maps

3- Surface process maps

4- Age maps of rugged features

The purpose of drawing surface material maps is to record the characteristics of the bedrock and regolith. Usually, the main process is rarely drawn on the map. Often, maps of surface shape or surface material or both are considered. For example, a landslide is not drawn as a process on the map, but can be shown as a resulting phenomenon, or a flood is not drawn as a process on the map, but the upper limits of past floods or the edges of a floodplain are shown on the map. Therefore, in this type of mapping system, the map implies the process, this applies to all morphogenesis systems, including coastal, glacial, preglacial, desert, etc. Determining the age of landforms is one of the most difficult issues in geomorphology, of course, except in cases where there is enough evidence such as determining the age by carbon 14, fossil or archaeological evidence. However, it is noteworthy that for environmental management purposes, which are often studied for this purpose, understanding surface materials and active processes is more important than identifying absolute age, except in areas where there is a possibility of recurring events such as floods. In this case, knowing the magnitude, frequency, etc. of the events will be necessary (Rajabi, 2001). For most practical investigation related to preparing geomorphological maps, it is necessary first examine the site or existing problems in the field. In addition, remote sensing sources, which range from satellite images to aerial photographs, often provide important information Application of satellite data are as follows:

Its functions include:

1) Image of inaccessible areas in the field

2) Recording of temporal changes and historical records of past conditions

3) Preparation of synoptic views

4) Acquisition of data through films or special sensors in the invisible part (Kook et al., 1377)

Useful guidlines for preparation geological maps are as follows (Verstappen, 1970) provided useful guidelines:

1- The method of preparing these maps should be flexible, so that the author has the opportunity to comment on the adoption of the most appropriate symbols for the relevant area.

2- These maps should be as simple as possible to neutralize cartographic problems and to avoid excessive printing costs.

3- The method of preparing maps should be applicable at all scales.

4- General geomorphological maps should be supplemented by functional purpose maps.

5- To determine and show the main and genetic units of the landform, color should be used, (Kook et al., 1998).

Scale in geomorphological maps

Topographic maps that have contour lines are considered the best base maps, and, it is easy to transfer geomorphological data on these maps. In relation to geomorphological maps, there are two main factors regarding their scale type, one of which is the complexity of the landscape and the nature of the topography of the areas, and the second factor is the ultimate goal of drawing and preparing the map. Various classifications have been proposed for geomorphological maps in terms of scale, which is a classification related to the World Society of Engineering Geology by Hansen. According to this classification, the types of maps by scale are:

1- Overview maps 1:100,000 and smaller.

2- Medium-scale maps 1:50,000 to 1:25,000.

3- Large-scale maps 1:5,000 to 1:10,000.

4- Detailed maps: 1:5,000 to 1:2,000.

5- Spatial plans 1:2,000.

Scale plays an important role in the display of geomorphological data and will even affect the type of lines used to display phenomena (Ramesht, 2006). Obviously, as the scale decreases, the display area of the map decreases and the clearness and readability of the features will be lost (Karimzadeh, 2002). Therefore, there must always be a certain proportion between the scale and dimensions of geomorphological phenomena (Ramesht, 2006). In more complex areas, such as those that are highly fractured, the map should be prepared at a scale of 1:10,000. In areas with less fractured, smaller scales can be sufficient to record existing slopes. The choice of map scale depends on the maximum accuracy required, which in turn depends on the thickness of the lines drawn to represent the slope boundaries (Kook et al., 1998). On maps with a scale of 1:50,000 and less, phenomena whose extension exceeds a few kilometers are shown. Therefore, on such maps, shapes that are more related to the structure of the earth are generally shown. Shapes related to the influence of external forces, such as valleys and other shapes such as circuses, etc., are usually not shown on small maps, especially on a scale of 1:50,000 (Rajaei, 1990), while detailed geomorphological maps with a scale of 1:50,000 and larger are prepared with a specific method for many European countries (Rao, 1978). In regional scale studies, the most appropriate scale is 1:500.000 (Ramesht, 2006). Therefore, geomorphological maps are produced at different scales depending on the requirements.

Table 1- Geomorphology Commission classification (IGC) of geomorphological map types based on scale

Map Types	**Topic Sample**	**Scale**
Large Scale	Geomorphology Plans	1:10000 and larger
	Basic Geomorphology Maps	1:10000 to 1:25000
Medium Scale	Detailed Geomorphology Maps	1:25000 to 1:100000
	Synoptic Geomorphology Maps	1:100000 to 1:1000000
	National Geomorphology Maps	A:15000000 to 1:3000000
Small Scale	Continental Geomorphology Maps	1:15000000 to 1:3000000
	Global Geomorphology Maps	1:3000000 and smaller

Signs and symbols in geomorphological maps

The cartographic representation of geomorphological data poses some specific challenges. To improve the readability of geomorphological maps, one approach that reduces the complexity of cartographic elements is the ad hoc approach (question design), which shows fewer processes on a map at a time.

In this way, the map becomes more readable for the user and can facilitate the basic needs for improved land planning and have a more effective impact on land management. It also expresses the need for increased interdisciplinary dialogue between geomorphologists and other specialists. Another approach is the adoption of recent digital analysis and visualization techniques. The increase in computing power of both hardware and software has allowed not only the use of high-level mapping techniques, but also the visualization of the results in the methods, which can create a better connection between the producers of geomorphological maps and their end users. The development of the application of GIS, virtual reality, environmental sensor networks, remote in geomorphological maps, all ground information are shown on the map with special symbols, so that after the completion of the identification, recording and drawing of this data, we will be faced with a specific map (Ramesht, 2006). In general, four categories of information are used as symbols in geomorphological maps, which are:

- Information related to facies and parent materials

- Processes

- Surface forms

- Geomorphic phenomena

In symbolizing information on geomorphological maps, color is also used. Colors are usually used to express processes. For example, yellow is used to represent wind systems, blue is used to represent water processes, etc. (Ramesht, 2006) Digital geomorphological mapping.

Maps can also be easily analyzed and reproduced in digital GIS (Voznilek, 2000).

A GIS database should contain four types of geomorphological data:

1) vector data for representing phenomena

2) raster data for images

3) triangulated irregular networks (TINs) for surfaces

4) addresses for defining geographical locations.

In a GIS database, data is created in two ways:

Layers

The layer method is the most common and has a long history in the legacy of thematic maps that represent different phenomena for an area. In this structure, data is specified in thematic layers, each representation has a feature in similar areas.

Objects

In the object approach, which is relatively new, data structures are like objects and groups of objects. Therefore, data is not specified within layers, but objects are grouped and sorted into classes. The advantage of this approach is that it accurately reflects the real world, but its disadvantage is the problems associated with making a practical GIS.

Depending on the purpose, the selected information in the map can be separated and presented in four thematic maps, each covering a specific type of data. (For example, morphogenic or natural hazard maps). today's GIS software has limitations in drawing layouts, because the drawing is essentially based on the use of cover colors, although a variety of lines and symbols can be used. Software such as MAPLEX ESRI's offers the possibility of designing cover by the selected person and patterns, but the requirements are more extensive before the current combination of data sets is easy. The symbols or lines that cover the areas dduring the geomorphological processes in the map should be presented. For example, small ditches may be shown with polygonal data. Other symbols may be excluded as digitized point data. Hydrological information and the occurrence of infrastructure are also digitized as vectors in the form of polygons, lines and points.

In the new mapping system, separate information on morphometry, morphography, lithology, genesis, processes and hydrology in the GIS database is easily converted into the main map and in the GIS map the data is grouped within its specific data for lithic and non-lithic morphology, genesis, processes and hydrology. Thus, this transition to the GIS environment involves minimal change compared to the field-based mapping system.

Digital Elevation Model (DEM) has been added, which includes digital contour lines or detailed raster data. DEM has the ability to smooth an irregular triangular network that provides an excellent view of the ground surface. For detailed presentation and topographic analysis, they often give the ability to produce approximations and in addition to interpolation of other surfaces, computer graphics or the statistical method KRIGINING will be used.

In this text, the most important thing to keep in mind is that different types of landscapes require different graphics. In addition to the information summarized above, the GIS database is a repository of information about subsurface properties such as stratigraphic sequences and lithological columns. This information added to the database is linked to geographical reference locations and phenomena such as set tables or PO-UP outcrops on the digital map. To provide the user with a comprehensive view of the landscape data, the main geomorphology map includes a raster image, additional raster images such as aerial photographs, which can also include analysis, correlations and trends for, directivity of investigations.

Standardization of Geomorphological Maps

The fundamental issue of geomorphological maps from the past to the present is the standardization of the symbols used in these maps. The lack of standardization of these symbols has had several reasons, the most important of which are the lack of international uniformity of geomorphological terms, the diversity and abundance of geomorphological forms, the lack of development of geomorphological maps as a group of maps discussed in thematic cartography, and more importantly, the lack of use of geomorphological maps as a basic and efficient tool in environmental planning (Yamani, 2005). After World War II, some efforts were made to create international standards.

During the 18th Congress of the International Union of Geographers in Rio de Janeiro in 1956, two ideas for the production of geomorphological maps were proposed, which led to the establishment of a sub-commission of the IGU for geomorphological mapping (Gustavsson, 2005). The principles of the IGU commission were to facilitate geomorphological mapping by establishing close cooperation between the two ideas, which led to the development of geomorphological maps.

The differences in ideas were largely due to the different characteristics of geomorphology and different scientific methods. The French, Czechoslovaks and Hungarians drew geomorphological maps based on lithological building blocks, which gave a lot of information about the relationship between landforms and the underlying layers. But they were almost useless in reconstructing the development of landscapes. On the other hand, the Polish, Russian, Romanian and German geomorphological maps were based on landforms and provided a lot of information about the nature and development of the irregularities, but did not show the relationship with the geological structures. The cooperation and alignment between these two methods resulted in the production of maps that had limited geological information and some structural-lithological information and in some cases also structural information (Gustavsson, 2005). In 1968, the Sub-Commission, prepared the Detailed Geomorphological Maps, based on the experiences of researchers from several European countries, presented at the 21st International Congress of the Union held in New Delhi.

In 1971, the first regulations and manual of geomorphological symbols were published by the Committee for the Preparation of Geomorphological Maps of the International Geographical Union. Between 1972 and 1975, this union continued its activities in standardizing medium-scale geomorphological maps (1:10,000 to 1:100,000). The members of this commission were mainly from Russia, Italy, Germany, Poland, Canada, Switzerland and England. Finally, this commission completed its information and, after reviewing the symbols, presented them as up-to-date information in the form of a set of geomorphological symbols for medium-scale maps. Using these symbols, many European countries have started to prepare large-scale and medium-scale geomorphological maps (Yamani, 2005).

CHAPTER THREE
Coastal Environments

Seawater as a Factor in Coastal Lines

Seawater plays a crucial role in reshaping coastal topography. Waves and tides significantly contribute to weathering and erosion, leading to the formation of diverse coastal landforms. The eroded materials are transported over varying distances depending on the carrying capacity of waves.

Wave erosion depends on multiple factors, such as the type of formations and rocks. The primary factors influencing coastal morphology include time, energy, sedimentation, sea-level changes, and vegetation growth. Time serves as a dynamic balancing factor after any change caused by mentioned factors.

Coasts are constantly subject to wave erosion and destruction. As the coast retreats, an abrasion platform forms, which slopes slightly towards the sea. Weathered materials accumulate in deeper regions, forming marine terraces, which are considered natural extensions of the abrasion platform in geomorphology. The combination of abrasion platforms and marine terraces constitutes the continental shelf. The topography of the abrasion platform includes narrow straits and channels, representing the natural underwater extension of riverbeds and continental valleys.


Figure 5- steep coast. Rhodes - Rhodes - (Greece) (Photo from A. Vasilopoulos, ann. Eulpido

Coastal Erosion and Regression

Waves erode coastal rocks not only directly but also indirectly by forming cavities and notches, weakening the shore's resistance to marine erosion and ultimately leading to coastal retreat.

The retreat of rocky coasts occurs at an extremely slow rate on a human timescale. In rocky shores, indentations and cracks form, which, under the influence of wave energy, expand into coastal caves. Rocky coasts covered with extensive fissure systems display jagged edges extending inland.

In contrast, coasts formed of soft sediments such as alluvial deposits retreat relatively quickly, as they offer minimal resistance to marine erosion processes. Even during stormy periods, coastal retreat can occur rapidly, while sediment movement continues over extended periods when wave carrying capacity is low. These instances represent transient coastal retreat.

Waves

Waves are manifestations of energy transfer from one point to another. They move turbulently within the sea but remain structurally unchanged. Various classifications of surface waves exist, with one of the most prominent being:

Progressive waves.

Standing waves.

Free waves.

Forced waves.

Deepwater waves.

Shallow-water waves.

In progressive waves, each section of the water body oscillates with an identical displacement and duration, but reaches its peak at different times as the wave propagates. In contrast, in standing waves, the displacement of each section varies, but all sections reach their maximum displacement simultaneously.

The emergence and development of sea surface waves depend significantly on wind speed and duration, the distance over which waves develop, and the initial sea surface conditions.

Figure 6- The formation of a coastal rock in the Kineta- (Greece) region, which has been destroyed due to erosional processes, (Photo from Ka. Pavlopoulos).

wave specification

Waves that form in water can be distinguished by the following characteristics:

• Wavelength (L): The horizontal distance between the crest or trough of two successive waves.

• Wave height (H): The vertical distance between the highest (peak) and lowest (trough) points of a wave.

• Wave period (T): The time it takes for the crest of two successive waves to pass the same point, which is approximately constant regardless of changes in other wave characteristics.

Wave speed depends mainly on the depth of the sea, which is a relative relationship. Speed refers to the fundamental component of the wave, however, in nature, a wave is made up of many components that determine the overall speed of the wave.

When a wave moves towards the shore, the speed of the water rotation, especially its horizontal component, reaches a maximum just below the crest. In contrast, when a wave is directed seaward, the speed of the water rotation reaches a maximum just below the trough.

In a stormy sea, it is difficult to accurately assess the wave height, and therefore the initial wave height is used, which is the average of one-third of the wave height of the total wave amplitude. In the case of a coastal area, since the waves break, their breaking height is used as the wave height.

Wave energy is not only dependent on height, but is independent of other basic characteristics.

Coastal Currents

Coastal currents are currents that form when waves approach the shore. Depending on the characteristics of the waves that generate them, these currents can transport sediment to and from the shore. Longshore currents are the most important cause of sediment movement along the shoreline. The constant back and forth of waves towards the shore leads to the accumulation of seawater. The discharge of this water mass is influenced by currents that move either parallel to the shoreline or in a seaward direction (away from the shore). The type of current that forms depend on several factors, the most important of which are the angle of impact of the wave with the shore, the morphological characteristics of the shoreline, and the morphology of the seafloor roughness.

If the wave strikes the shoreline vertically or nearly vertically, a type of cellular circulation occurs due to longitudinal or parallel currents with the shore and rip currents, and if the wave strikes at a different angle, longitudinal currents occur. The activity of these longitudinal currents is limited to the front of the wave breaking zone. The specific characteristics of longitudinal currents depend on the angle of approach of the waves to the shore, and their speed ranges from a few tens of centimeters per second (cm/sec) to more than 1 meter per second (m/sec).

The activity of the tides leads to the movement of sediment from the shore towards the sea, and their specific characteristics are mainly related to the rise of the sea level, due to the accumulation of water mass in the wave breaking zone. The tides are strong and narrow, and their beginning occurs in the wave breaking zone and their direction is towards the sea. The length of these currents can reach 60-750 meters; their speed is more than 50 cm/sec and can often exceed 2 m/sec.

The creation of sea currents is due to various factors, the most important of which are:

• Wind: In addition to its role in creating waves, also carries surface waters in the direction of its blowing.

• Tides: Are another reason for the creation of currents, this factor is of little importance for open sea basins, but when it occurs inside closed basins with a specific morphology (Euripus Strait, English Channel), it can possibly create very strong currents during the phases of high and low tides.

• Hydrostatic Pressure Variation: The presence of different densities causes the movement of a dense water mass towards a low-density mass area.

• Rotation of the Earth: This factor affects the path of sea currents due to the Coriolis force.

Therefore, it is possible that more than one of the above-mentioned factors play a main role during the movement of seawater masses.

Wave activity in the coastal area leads to the creation of four main current systems, which are:

• A closed circulation system consisting of longitudinal and tidal currents.

• A system of coastal currents resulting from the angular impact of waves on the coast.

• A system of diversionary currents. If the wind blows in a fixed direction for a certain period of time, it carries molecules of the surface layer and this movement gradually spreads towards the lower part. If the Earth were stationary, the deviatoric current would be in the same direction as the wind, but due to the Coriolis force caused by the rotation of the Earth, it deflects the spreading surface current up to 45 degrees to the right in the northern hemisphere and to the left in the southern hemisphere.

• A system of oblique currents resulting from deviatoric currents. In fact, when one of these currents causes water to accumulate towards the coast, the accumulated water tends to circulate (roll) in the opposite direction due to the slope created.

Figure 7- A gently sloping beach in the Marathonas area (Greece) consist of of a variety of beach materials including coarse sand and gravel (photo by A. Vassilopoulos, N. Oylpidou).

The direction of the inclined current must be opposite to the direction of the deflected current, but the Coriolis force also deflects the current, which is perpendicular to the coast and the direction is to the right in the northern hemisphere and to the left in the southern hemisphere.

Origin of coastal sediments - sediment balance of the coastal zone

Coastal landforms are formed by materials produced by weathering and erosion of rocks. These materials are transported to the coastal zone by water (rivers, streams and glaciers) or wind.

The formation of coastal landforms (banks, dunes, strips, sand ridges, etc.) is due to the processing and redistribution of coastal zone sediments by various forms of energy acting on a coast. Energy in the coastal zone is explained by waves, tides and ocean currents.

Figure 8- Steep beach at Dunnottar Castle (Scotland) (photo by A. Vassilopoulos, N. Oylpidou).

Erosion in the coastal zone accounts for a very small percentage of the sediments that enter the sea. In 1960, it was observed that even in temperate regions where wave energy is very high, less than 5% of coastal sediments are the result of erosion of coastal cliffs. In 1978, it was estimated that an average erosion rate of 5 cm per year for all the world's coastal cliffs (about 50,000 km long) would provide only 0.04% of the total amount of sediments brought into the ocean by rivers.

Rivers and streams provide more than 90% of the sediments that reach the oceans. The next most important sources of sediment are glaciers and finally biota.

Sediments that are transported in various ways do not directly enter the coastal zone. Instead, they constitute an important part of the sediment budget. Sediments are transported between two places of sediment accumulation, that is the continental shelf and various coastal deposits such as banks, dunes and estuaries.

The movement of sediment from very deep to the coast is mainly due to tidal currents or storm waves, which can reach the necessary speed to transport sediment to the seabed. In shallow waters, waves and coastal currents caused by wave action play a dominant role. Seaward movement of sediment can occur during storms and can also occur through unique “pathways” such as alongshore movement, and carrying sediment to very deep depths. In addition, sediment movement from the coast to great depths can occur through submarine canyons.

The interaction between sediment storage and its movement can occur over a very short time period, such as when summer tides transport sand toward the shore, or over a longer time period, such as during glacial and interglacial periods.

Knowledge and understanding of the origin of coastal materials and the mechanisms of their movement are essential for studies related to coastal geomorphology or for coastal management.

The sediment budget of a coastal zone is the result of the interaction of several terrestrial and marine processes, which can be divided into two main categories:

• Processes that bring sediments to the coast.

• Processes that move sediments away from the coast.

The advancement or regression of the coast is determined by the different processes. When the opposing forces are equal, the position of the coastline remains constant. Artificial structures such as residential and tourist facilities along the coast, hydroelectric and irrigation dams, and protective measures to protect the soil from erosion have led to a decrease in the supply of land materials.

Coastal sediment balance

Sediment is transported between two main areas of deposition, known as "sediment reservoirs", namely the seabed and the coastal zone.

In the study of sediment transport along the coast, where a quantitative assessment of the factors of sediment supply or removal may be required, it is important to determine the lateral limits of the coastal zone section.

It is necessary to specifically examine human facilities on the coast as well as the estuaries of rivers and streams, even if they are located far from the study area. When these estuaries are located near coastal cliffs, which are composed of unconsolidated rocks, their erosion provides a large amount of sediment to the coastal system.

Table 2- Coastal Sediment Balance

Coastal Sediment Balance	
Sedimentation	Desedimentation
Supply of consolidated alluvial (sediment transport by rivers and streams)	coastal movement
Erosion of coastal cliffs	Seaward movement

Sediment transport by the sea	Wind transport of sediments away from the shore (formation of coastal dunes)
Movement of sediments towards the shore by wind (wind transport)	Trapping and removal of sediments through submarine traps
Bio sedimentation	Removal of sediments due to human activity (including sand)
Artificial sedimentation, walkways (human activity)	

Sea level changes

The coastline is constantly changing over time and its development depends on a series of nonlinear factors such as vertical tectonic movements, hydrostatic movements, climatic conditions (atmospheric pressure), tides, waves, sedimentation, wind processes and human activity. It is clear that creating a mathematical model for both coastline and sea level change in the past and future is particularly difficult due to the multifactorial variables and the created disturbance conditions.

For ancient coastal environments and sea level changes, there are a series of "absolute" dating methods (C14, OTL, Pb, U/Th, etc.) combined with micromorphological and micropaleontological sedimentary analyses. These methods are used for sediments (e.g. peats), shells, archaeological finds from sediments and adhesive materials (cement) of coastal and submarine sandbanks. These results are useful in geomorphological and morotectonic analyses, as well as in validating data on the paleogeographic development of a given area. The most common landforms used as "indicators" of sea level changes are: a) sandbars, b) grooves on resistant (hard) rocks, c) sea platforms, d) biological indicators corresponding to marine organisms that lived near the sea surface (a few centimeters above or below the sea surface, including crustaceans, bivalves and corals).

The prediction of future changes in sea level and coastline is made by combining remote sensing data obtained from satellites (Topex, Poseidon, Jason, etc.) with data of seasonal changes over recent decades, measurements of tidal amplitudes on a global or local scale and mathematical models mainly based on climate change (global temperature increase).

Combining scientific methods and approaches in a common database for a specific region can improve mathematical simulation and scientific prediction of sea level changes at local and global scales, and thus simulate reality in the best possible way. The results of this combined scientific approach can provide a valuable tool for planning and implementing decisions related to sustainable and comprehensive development of coastal areas.

Sea Level Changes in the Upper Pleistocene

Sea level has changed several times compared to its current level. In the Upper Pleistocene, four glacial and interglacial periods occurred, which led to sea level changes on a global scale.

Astronomical theory (about glaciers)

This theory was first proposed in 1864 by the Scottish James Carroll and is now often known as the "Milankovitch theory", after the Yugoslav astronomer who perfected it in the 1930s. In the 1980s, it was proven that glacial periods are closely related to the direction of the Earth's axis as it moves around the Sun.

The change in the direction of the Earth's axis is a complex combination of three separate rotations. By combining these three movements, it is possible to find out in which areas, certain parts of the Earth receive little solar heat, that is, those parts where there is a greater likelihood of glacial processes occurring.

• **First rotation:** The precession of the Earth's rotation axis of, according to which the axis's path forms a circle in a period of 19 to 23 thousand years. This is due to the gravitational effect of the Sun and Moon on the Earth's equatorial bulge. The effect of this rotation cannot be traced in short-term changes such as seasonal changes in a century, but can only be followed over long periods of time, in intervals of thousands of years. This rotation is defined as a change in the direction of the Earth's axis of rotation in relation to its orbital plane with a period of 21 thousand years. This period is called the cycle of the axis of rotation.

• **Second rotation:** The obliquity of the Earth's axis (also called axial tilt) decreases slightly over a period of 41 thousand years, the increased. The difference between the two displacements is small, about 3 degrees (from 21.8º to 24.4º), but it is enough to change the amount of solar energy reaching the Earth's surface. Today, this angle is approximately average (º4.23) and decreasing, so we experience slight temperature changes between winter and summer.

• **Third rotation:** Eccentricity: The Earth's orbit around the Sun is not circular but elliptical. The index of this orbit is the eccentricity (e), which is based on the ratio of the divergence between the minor and major diameters, and thus a ratio of zero (0) indicates that the orbit in question is a perfect circle. Periodic changes in the Earth's eccentricity have a frequency of 100 thousand years. Therefore, every 100 thousand years, the Earth's orbit around the Sun changes from being almost elliptical (e: 0.058) to almost circular (e: 005/0). The change in eccentricity occurs due to the gravitational effect of other planets in the solar system.

CHAPTER FOUR

Lake Processes

Lakes

Introduction

In the second half of the 20th century, the famous limnologist Forel defined a lake as a stagnant body of water located in a trough of land and not directly connected to the sea. From a geological point of view, a lake can be considered as a volume of water that appears or disappears in a short period of time.

Today, lakes are found everywhere on Earth. However, they are most abundant in high latitudes and mountainous areas. Lakes are mainly found in glacial and near-glacial regions, especially in the transition zones from glacial environments to very warm and humid environments, as well as along rivers with low slopes and wide valleys, where they connect to other branches.

Lake water can be salty or fresh, which mainly depends on the climatic conditions prevailing in the region. Lake water is supplied directly from rainfall, spring water, runoff or even the sea.

Figure 9- A salt marsh on Samos Island (Greece) (Photo by C. Century)

Although lakes are open systems with respect to materials and energy, they are tested and analyzed as closed systems and are characterized by specific physical, chemical, and biological parameters related to the degree of isolation and geographical location of each lake.

Figure 10- A group of lakes formed by glacial meltwater. These lakes are known for their unusually diverse hydrological and chemical characteristics. Osterseen (Upper Bavaria, Germany) (Photo by O. Bender)

History of Lakes

All lakes have a limited lifespan and generally tend to disappear. In humid areas, the disappearance of lakes begins after the erosion of their barrier (dam), the overflow of water and the deposition of sediments and organic matter on the deltas or underlying deposits (infrastructure). The chemical composition of these bodies does not change much during their short life. In dry areas, lakes disappear due to high evaporation and deposition of materials carried by wind and water. Due to evaporation in dry areas, many lakes have gradually become saline, even if the original lake was a freshwater lake.

Classification of lakes

A lake can be formed by one or more factors. Different proposals have suggested for lakes classifications. For example, one classification is based on the conditions that may have created the basins in question, calling them generative, destructive, or inhibitory. Other researchers have classified lakes according to their formation in bedrock channels, basins formed by natural or artificial barriers, or organic lakes. Both systems can be criticized because they do not include natural, terrestrial classifications. Imnologists dealing with a group of lakes must consider the conditions that led to their formation.

Taking these considerations into account, Hutchison based his classification on the origin of the lakes, in the following conditions:

Lakes of tectonic origin

In this case, the basin in question may have been formed in one of the following ways:

A- By movements of the Earth's crust. This category includes the following types: 1- Residual marine basins that have been separated due to continental movements, such as the Caspian Sea. 2- Lakes formed due to rising sea levels, such as Lake Okeechobee, Florida. 3- Lakes located in areas with gentle slopes that may eventually lead to runoff inversion, such as Lake Kioa, East Africa. 4- Lakes with a central basin, formed due to the average elevation of the marginal areas, such as Lake Victoria.

B- By uplifting of plains during orogenic movements. In this case, basins formed between mountains and can lead to lake formation. In some cases, local faulting forms the lake's margin, such as Lake Titicaca, Andes.

C- Due to mountain folding D- Due to faulting. This is a major category, and many of the world's largest lakes ormed due to faulting.

Lakes associated with volcanic activity

A- Lakes formed in deformed or partially deformed craters.

B- Lakes formed in calderas.

C- Lakes formed in deformed calderas in which local faults play an important role.

D- Lakes formed by lava flows.

E- Lakes formed between barriers (dams) whose origin is lava, volcanic mud, or volcanoes.

Lakes formed by subsidence

Lakes that belong to this class are usually very short-lived.

Lakes Formed by Glacial Activity

Lakes formed by glacial factors are a special class because they were formed during a very short period of Earth's history. Many lakes formed during the Pleistocene glaciation. Some of the prominent types of lakes that resulted from glacial activity include:

A- Lakes behind ice dams.

B- Lakes within glacial rock basins: 1- Cirque or crater lakes form almost at the snowline of glacial valleys. 2- Lakes formed in basins composed of bedrock, beyond the snowline, due to glacial erosion. 3- Lakes formed by continental ice. 4- Lake-like basins formed by glacial melt. Lakes in the latter category are usually small.

C- Glacial lakes. Glacial deposits often create dams to form lakes.

D- Sinkhole or land slide lakes. Lakes in this category formed when small depressions (holes) in the ground fill with water, resulting from the melting of ice fragments buried in glacial floodplain sediments. These lakes are a common type but are usually small in size.

Lakes formed by the dissolution of rocks

A- The dissolution of limestone by water leads to the formation of karst basins with a roughly circular shape. These basins (dolins, ovals) are drained by a series of karst sinkholes or natural drainage pipes. When sediments or other barrier due to the tectonic activity, etc., block drainage paths and then these basins can fill with water and form karst lakes such as doline lakes.

B- Lakes can be formed by the dissolution of rocks in basins bounded by tectonic features (such as faults).

C- Lakes formed by the soil subsidence after the natural dissolution of salts in the layers.

Lakes created by river activity

Some of the reasons that can lead to this type of lake are:

A- River erosion.

B- River deposition: 1- Alluvial fans and deltas that separate existing lakes, 2- Remnants of a main river that blocks an area, 3- Basins formed by abandoned waterways in floodplains.

Wetlands

Wetlands are usually created behind barriers, ridges or sand ridges. The formation of these bodies is enhanced by rising sea levels, so that the river mouth is flooded and the wetlands are fed by seawater. Later, when the sea level drops, this connection is cut off and existed sand barriers (dams) limiting the wetland are stabilized.

Wind-formed lakes

These types of lakes can form in one of the following ways:

a- Basins blocked by wind-blown material.

b- Basins formed between sand dunes.

c- Basins formed due to wind-blown material.

Lakes formed by accumulation of organic materials

This category includes lakes formed in basins that are formed due to the formation of natural barriers by the dense development and accumulation of organic matter, such as, plants. Lake Washington Island in the central Pacific Ocean is a coral reef that is located above sea level and belongs to this category.

Lakes formed by meteorite impacts

Lakes could be formed in craters due to meteorite impacts. Usually, the water in the crater is associated with the accumulation of runoff. If the crater is deep enough, water can drain from the aquifer and form a lake.

Artificial lakes

This category includes all floodplains created by reservoirs and dams.

Lake water: composition, displacements, and characteristics

1- Composition

The salt content of lake water varies greatly. For example, the Great Salt Lake, Utah, USA, contains 12.238 gr/lit of salt, while Lake Geneva contains only 0.1775 gr/lit of salt. The amount of salt dissolved in lake water is a result of the initial composition of the lake, the salts that enter it, and the rate of evaporation.

2- Water movement in lake systems

The movement of water in a lake is usually turbulent. In a lake, water moves everywhere and in all directions. Turbulent movement allows the movement of materials and heat in all directions and increases the apparent viscosity of the water.

Figure 11- A small, marsh-like lake formed after glacial processes. The lake has recently been filled with organic matter. Seewaldsee (Austria) (Photo by O. Bender)

The intensity of wind-dependent currents can also be assessed. The dominant currents are:

A- Currents caused by the movement of incoming and outgoing water.

B- Tidal currents,

C- Density currents caused by temperature differences and pressure under the bulk of the water, D- Currents caused by wind; Wind causes turbulence and small waves on the water surface and also where water flows in the opposite direction. If the energy of the water is lost during the flow, a new flow is created at the end point of the previous flow. In general, this factor creates a periodic displacement or oscillation of the water. In addition, periodic oscillation of lake water can also arise from unequal atmospheric pressure on a lake. The period of oscillation depends on the shape of the lake.

3- Temperature

The temperature of the water in lakes varies depending on the season and condition within the lake. The factors controlling the temperature include the isolation of the lake, the degree of atmospheric temperature, the input of water by rivers and rainfall. Temperature differences within a lake body can lead to layering of the lake water, which can also be caused by changes in salinity or dissolved materials. Lakes without complete water circulation are divided into a region of water circulation at the top, which is quite turbulent and is called the epilimnion, and a relatively calm depth region called the hypolimnion. The two regions are separated by a surface of rapid temperature change called the thermocline.

This pagering can be disrupted when the cool surface water will be denser than the deeper water. When the cold surface layer subsides, the water layers invert. Such inversions are normally seasonal. In lakes where the surface water temperature does not fall below 4°C (the temperature at which fresh water has its greatest density), inversions occur in the fall. In lakes where the surface water temperature drops below 4°C, there are likely to be two inversions per year.

Sedimentation in marine environments

Saltwater and freshwater lakes are distinguished by their different sedimentary deposits. In many cases, in saltwater lakes, the existing deposits are mixed with detrital sediments due to evaporation. The composition of the evaporite deposits may also vary. Sediments of organic origin are rare in these lakes. The sediments of freshwater lakes are very variable, depending on several factors. These factors include the origin of the lake basin, the characteristics of the rocks and land surrounding the lake and its drainage area, the dimensions and depth of the basin, the extension of shallow waters adjacent to the shoreline, the roughness, the percentage and type of vegetation cover of the drainage basin, climatic conditions and living organisms within the lake.

In freshwater lakes, new deposits often contain a high percentage of organic matter. Wasmond (1930) has proposed a term for the organic matter deposits in freshwater lake sediments. According to him, the remains of animals are called furna. Furna, as distinct from the colloidal-sized remains of plants and animals, are called afja. Freshwater mud or gyttja is a type of organic matter deposit under acidic conditions. These organic-rich deposits may grow rapidly in the stagnant water of some lakes, can also be dated by microscopic observation of the plant remains trapped in the sediments. These remains can also serve as an indicator of climatic changes during their deposition in the lake. The dating of organic sediments can be done with high accuracy using the carbon-14 dating method.

In a lake, deposited sediments are rapidly altered by bacterial activity. New sediments are influenced by biological processes caused by microscopic and macroscopic organisms.

Varves are formed in lakes that receive their water from melting glacier caps, or have received it in the past, Varves are the annual result of a sedimentation cycle. Rapid melting of a glacier cap during spring or summer releases large amounts of water. This results in relatively coarse-grained material entering the lake, while very fine-grained material is deposited during winter or glaciation, when the water input is reduced. The layer formed during winter is easily distinguished from the layer formed during summer. The two layers reflect annual deposition and are useful for determining the pre- and post-glacial periods.

Major Lake Landforms
Crater Lake

A lake formed within an inactive volcanic crater or a crater created by a meteorite impact.

Figure 12- Lake Montecchio - Laghi di Montecchio - Italy (Photo by O. Bender)

Doolin Lake

Usually, the bottom of Doolin is covered by silt and clay sedimentary materials that prevent water from penetrating and lead to the formation of Doolin lakes.

Figure 13- Triglav National Park - Slovenia (Photo by O. Bender)

Permanent lake

A lake that has water all year round.

Figure 14- Lake Gusana -Italy (Photo by O. Bender)

Non-permanent lake

A lake that can appear temporarily for short or long periods of time and disappear due to the lowering of the water level due to the opening of a surface outlet or the widening of its subsurface seepage channels. Climatic conditions, including intense evaporation over a long period of time, also play a important role in the drying up of this type of lake.

Salt Lakes

Figure 15- Donana National Park - Hungary (Photo by C. Sentry)

A lake whose water contains less than 5% salt (i.e., NaCl, Na2Co3, CaCo3, CaSO4, etc.). When saline lakes are located adjacent to marine environments, are usually separated from the sea by coastal sandbars or tectonically formed ridges. Sabkha lakes belong to this class. Sabkha is an Arabic term used for flat basins, usually located a short distance from the sea environment and covered by a layer of salt. These lakes are characteristic features of North Africa and the coastal regions of Arabia. Many of these coastal basins are slightly above sea level and are the result of minor mid-Holocene eustatic movements.

Figure 16- Salinas Grandes del Noroeste-Jujuy-Argentina (Photo by Canischidir)

CHAPTER FIVE

Standard of Coastal Geomorphology Map

Introduction

Although coastal areas due to their favorable environmental conditions have historically provided a suitable platform for human economic activities from the view of geomorphology, are known as unstable and dynamic environments in which the uneven surface has always undergone changes and transformations under the influence of relatively high input energy in the form of morphogenesis factors. In the present study, although initially the entire Chabahar coastal plain and the factors effective in its formation and geomorphological evolution, such as geological, tectonic, climatic, paleoclimatic factors and static changes in sea level, were studied, the main goal of this study is to investigate the geomorphology and morphodynamics of the Chabahar coasts. In order to facilitate the study, the coastal area is considered as a system whose input energy is provided through waves, tides, sea currents, and materials entering the coast, and its output is coastal shapes, phenomena and landforms that shape the general morphology of the coasts. However, in order evaluating the energy-providing elements of this system and their morphogenic functioning, static sea level movements (especially in the Pleistocene) have been examined in detail as the dominant factor and controlling factor of all coastal geomorphic processes. Due to the combination of these movements with tectonic movements on the coasts of the region, especially the two phenomena of uplift and subsidence, the analysis of geomorphological issues in this area has been particularly complex. Also, according to the predictions made for the sea level rise in the next century, its effects on the coasts of the studied region have been somewhat predictable. Finally, by examining the formation and evolution of geomorphic phenomena and coastal landforms in the region, such as estuaries, sandy beaches, barrier islands, marshes, lagoons, tidal flats, and sand dunes, and classifying these forms, will be discussed.

Objectives of Coastal Geomorphology

1- Understanding coastal morphology - Classification and description of specific land forms of the area and coastline

2- Determining the factors that contribute to the formation of the area and coastline from the land side and estimating the contribution of each factor.

3- Understanding the effective parameters from the sea that play a role in the evolution and formation of the area and coastline.

4- Studying the role of dominant processes in human exploitation and land use

5- Preparing geomorphological maps of the study area

6- Examining data related to the structure of the land

7- Lithological characteristics and its resistance to erosion

Classification of landforms in coastal geomorphology
Cliffs and rocky shores

morphology of scarps

- Profiles of cliffs and highlands along the riverbank
- Fragmented cliffs
- Caves
- Pools near the sea
- Straits
- Natural arcs
- External lines in the coastal and cliff zone
- Coastal landslides
- Retreat of cliffs
- Coastal platforms

Sandy beach deposits

- Sandy beaches
- Gradual change of sandy beaches
- Origin of sandy beaches
- Shoreline processes
- Sandy beach morphology
- Sandy beach equilibrium

- Sandy beach contours

- Shear and fill

- Sandy beach slope

- Sandy beach morphodynamics

- Sandy beach comparison

- Sandy beach movements

- Effects of Sediment flow on sandy beaches

- Ridges of Sandy beach

- Soft sand beaches

Erosion of Sandy beach

- Decrease in sediment provided by cliffs

- Decrease in sand supply from inland dunes

- Decrease in sand supply from the seabed

- Sand extraction and removal from sandy beaches

- Increase in wave energy

- Change in wave impact angle

- Increase in sediment loss from sandy beaches towards the shoreline

- Abrasion of sandy beach materials

Erosion due to weathering of sandy beaches

Multiple factors of sand beach erosion, effect of artificial constructions on sand beaches:

Sandbar and Costal barrier

- Sand bars
- Paired sand bars
- Elongated sand spits

Tombello

- Sharp sand spits
- Prominent headlands
- Coastal barrier and coastal barrier islands

Coastal sand dunes

- Sand dunes near the sea
- Backshore Sand dune
- Parallel sand dunes
- Sand holes and barchan
- Advanced Sand dunes. Dunes on pebble beaches
- Sand plains
- Sand dunes in humid climates
- Older and newer sand dunes
- Sandy sand dunes

- Sand dune lakes

Tidal landforms, Salt marshes and mangroves

- Source of tidal sediments
- Areas of fine sediments at the mouth of rivers
- Salt marshes
- Salt marsh terraces
- Seaward edges of salt marshes
- Inlets
- Freshwater marshes
- Mangroves

Small bays and lagoons

- Small narrow inlets towards the sea
- Fjords valley occupied by water

Deltas

Coral and algal rifts

Geomorphological Map Standards

The geomorphological feature pattern standards, along with the following special codes, are used for coastal geomorphological maps, which will be used in the coastal and marine geomorphological maps of the Geological Survey of Iran as follows:

Table 3- Continental shelf

Landform	Symbol	Code
Shelf Break		MP001
Reatrating		MP002
Prograding		MP003
Submarine Canyon		MP004
Edge of Canyon		Mp005
Submarine Vall vallies		MP006

Table 4- General shapes of the coastline

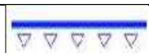
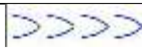
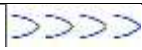
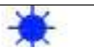
Landform	Symbol	Code
Shoreline		MT007
Reatrating		MT008
Prograding		MT009
costlines		MT010
Rocky Coastline		MT011

Table 5- Rocky shore shapes

Landform	Symbol	Code
Erosional pond		MT012
Pothole		MT013
Solution Pool		MT014
Tidal Notch		MT015
Abrasion Notch		MT016
Erosional Pool		MT012
Pothole		MT013
Solution Pool		MT014
Tidal Notch		MT015
Abrasion Notch		MT016
Erosive Notch		MT017
Sea Cave		MT018
Blowhole		MT019
Stack		MT020
Arc		MT021

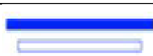
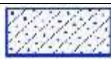
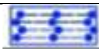
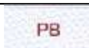
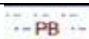
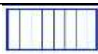
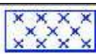
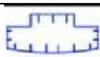
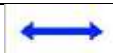
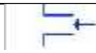
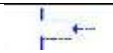
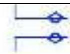
Cliff		MT022
Boulder		MT023
Marine Erosional Scarp		MT024
Simple Coastal Slope		MT025
Complex Coastal Slope		MT026
Wave Cut Platform		MT027
Surf Bench		MT028
Wheathering Paltform		MT029
Bioactivity Platform		MT030

Table 6- Sedimentary and Transitional Coasts

Landform	Symbol	Code
Pebble Beach at Foot Cliff		MT031
Sandy Beach at Foot Cliff		MT032
Sandy EB		MT033
Sandy-Pebble EB		MT034

Pebble EB		MT035
2mm SB< Φ		MT036
2mm SB > Φ > 0.63		MT037
Sandy Gravely SB		MT038
Clay-Gravely SB		MT039
Gravely-Clay SB		MT040
Clay-Sandy SB		MT041
Sandy pocket Beach		MT042
Sandy-Pebbble Pocket Beach		MT043
Pebbble Pocket Beach		Mt044
Cusps		MT045
Beach Rock		MT046
Littoral Barrier		MT047
Tombolo		MT048
Pond, Wetland,Marsh		MT049
Peat Deposits		MT050

Lagoon		MT051
Ancient Lagoon Border		MT051
Lagoon Channel		MT052
Tidal Channel		MT053
Lagoon Mouth		MT054
Tidal Flat		MT055
Salt marsh		
Mud Flat		
Hollow		
Open River Mouth		
Temporary River Mouth		
Wandering River Mouth		
Distributery channel		
Cuspate Delta		
Lobate Delta		
Fingering Delta		

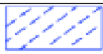
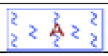
Tidal Delta		
Estuery		
Delta Front		
Prograding Dalta Front		
Retreating Dalta Front		
Submerged Fan		
Mega Ripple		
Ripple Mark		
Single Submerged Bar		
Runnel Axis		
Rip Current		
Washover Fan		
Backwash Fan		
Beach Ridge		

Table 7- Marine Reserves: Landform and Grading

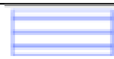
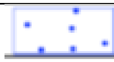
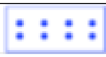
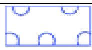
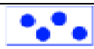
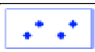
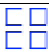
Landform	Symbol	Code
Abrasional Teraces		
Inner margin		
Outter margin		
Silt		
Sand		
Cemented Sand		
Gravel		
Cemented Gravel		
Cemented Blocks		

Table 8- Tsunami and storm surge sediments

Landform	Symbol	Code
Isolated Boulder		
Accumulation Boulder		
Boulder Field		

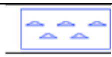
Washover Sand		
Inland Penenteration		

Table 9- Elements due to biological activities

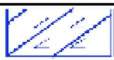
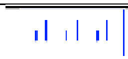
Landform	Symbol	Code
Seagrass Medow		
Sparse Seagrass Medow		
Alga Formation		
Sparse Alga Formation		
Rim		
Dead matte		
coralligenous		

Table 10- Elements due to biological activities

Landform	Symbol	Code
Tubipore Colonie		
Interamatt Deposits		

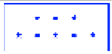
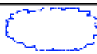
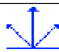
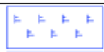
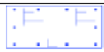
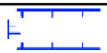
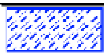
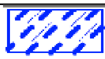
Biogravel Deposit		
Biosand Deposit		
Banquette		
Emission		
Fresh Water		

Table 11- Wind-blown landforms

Landform	Symbol	Code
Deflation Surface		
Blow out		
Deflation Furrow		
Non- evosional (ED)		
Eroding (ED Erosional)		
Eroding Net (PDR)		
Eroding (PDR)		
Eroding Net (SDR)		

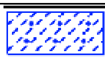
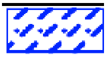
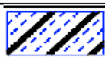
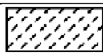
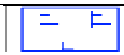
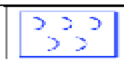
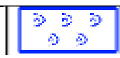
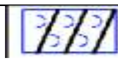
Eroding (SDR)		
Eroding Net (TDR)		
Eroding (TDR)		
Eroding Net (ADR)		
Eroding (ADR)		
Lithified Dune		
Wandering Dune Crest		
vegetated Dune Crest		

Table 12- Wind-blown landforms

Landform	Symbol	Code
Stable Dune Crest		
Sheet Loose Area		
Transgressive Moving Dune		
Vegetated Transgressive Dune		
Transgressive Urbanized Dune		

Transgressive Stabilized Dune		
Foredune Plain		

Parameters studied in coastal geomorphology studies and geomorphology reports

Influential factors and variables analyzed

Subsurface coastal area, lowest tide level: L.L.W Requires preparation of hydrographic maps by relevant groups.

Climatology

The impact, sequence and intensity of storms, rainfall and floods in the watersheds of the region, the specific climatic type of the region play the most important role in the evolution of coastal morphology.

Static changes in sea level

Periodic advance and retreat of water as a result of changes in the location of the coastline and the functioning of coastal systems.

- Salinity and water temperature

- Formation of salt surfaces in tidal marshes,

- Marine currents

- The role of sediment transport and distribution in the seabed

- The evolution of coastal bed morphology has a major effect on the area below the minimum tide. Indirect effect on the coastline

- Land

- Rock type, geology, tectonics

Rock type determines the origin of transported sediments and tectonics is the main factor in changing the base level

Basin hydrology

Basin hydrology is the factor that carries sediment from watersheds and creates water-carved landforms in the area and coastline. Changes in river discharge depend on the morphology and climate of the basin and play the most important role in the development of watersheds and deltas in the region.

Vegetation

The density and distribution of different plant species in the region reduces the effect of water and wind erosion and plays a deterrent role on the morphodynamic developments of the region.

Sediment texture and surface morphology

The vegetation habitat has special morphological forms of loose formations, bad lands, delta morphology, etc. The morphological types of the area and coastline are affected by the specific sediment texture of the region.

Wind transport

The creation of sand formations and their compaction and transport over time are relatively stable factors in the region and depend on the direction and intensity of the wind.

River dynamics

Exploration, location and deposition in the coastal plain zone are the builders of valleys, the dynamics of river meanders form alluvial deposits, alluvial fans and deltas.

It is considered the most active variable in the evolution of the coastal zone and coastline.

Marine morphodynamical processes

Windfall length

- Controls the characteristics of wave structures.

- Coasts with longer windfall lengths have stronger waves.

- Wind direction, general shape of the shore

- The refractive index of the coastline determines the amount of wave impact and the prevailing wind direction determines the main direction of the waves.

- The inclination of the wind direction to the coastline results in the oblique impact of lateral waves on sediment.

The depth of the foreshore

The depth of the foreshore is a factor in the concentration of wave energy. A long length and low slope of the leading-edge cause wave breaking and dispersion, and vice versa.

The tidal amplitude

The tidal amplitude has the effects of the vertical development of the coastline and the distribution of wave energy. The formation of special morphological forms of the coastline, lagoons, estuaries, wetlands, tidal channels is its result. Field surveys, and finalization of the obtained information**.** Analysis of the results of the collected samples**.** Preparation and compilation of the final report and map**.**

Geomorphology of dry areas and wind erosion

The dryness of the environment, smooth topography, strong winds, as well as the presence of fine-grained sedimentary material on the surface of the earth are important factors that provide the basis for the dominance of wind erosion. On the scale of Iran, the coastal areas and central parts of Iran, which are considered part of the lowlands, have an altitude of less than a thousand meters above sea level. These areas are located in the wind erosion area of Iran, and numerous examples of wind erosion features have been formed on their surface during the Quaternary period.

Relationship between wind characteristics and sediment particle diameter

Among the transport factors including glaciers, wind and running water, wind has less power to transport sedimentary materials. However, in dry areas it is considered the most important erosion factor and most of the landforms in these areas are the result of wind erosion.

Land surface characteristics

The topography of the land surface and the length of the windbreak are two important factors for wind erosion. In some rugged and mountainous areas, despite very dry conditions, wind erosion is not very effective. Because the wind cannot achieve the necessary threshold speed and most importantly, the wind is not armed with sand particles and cannot exert its indirect destruction. On the contrary, the smoother the topography and the greater the length of the windbreak, the greater the wind erosion process.

Wind direction and wind frequency

In general, the speed, direction and frequency of the wind play a fundamental role in the volume and dominant directions of sedimentary material transport. In addition to the general morphology, the transverse profile of sand dunes indicates the prevailing wind direction of each region, meaning that the low-slope range of sand dunes is perpendicular to the prevailing wind direction of that region.

Wind-erosion landforms

- Yardang is the most characteristic form of wind-erosion of parallel hills, a specific example of which is the yardangs of the Lut Plain in southeastern Iran.

- Wind erosion holes wind blows on the flat surfaces of the plains, removing fine-grained surface materials and over time creating very wide and shallow holes that lack vegetation. Such holes are called Daq.

- Sand plain it forms in the plains, and alluvial fan in arid areas where the surface sediments are a mixture of fine and coarse gravel, sand, gravel, and clay.

- Mushroom-shaped (Gorz-e-dive) These features are generally the result of the joint action of wind and water.

- Honeycomb-shaped cavities are very diverse. Some of them are formed as a result of the dissolution of soluble minerals in cemented rocks such as sandstone.

- Wind-driven landforms in terms of sedimentology: wind is capable of moving only clay, silt, and sand particles and creates various forms of sand dunes in the wind direction.

Geomorphology of cold and rugged glacial areas

During the Quaternary period, the repetition of glacial and interglacial periods has created important changes in the landforms of adjacent glacial areas and high mountain altitudes in mid-latitudes. It can divide landforms glaciers into two main groups, polar and mountainous. The glacier boundary was lower than today up to 3000 meters on the slopes of mountain peaks in mid-latitudes and even near the tropics. These glaciers have left important traces. The aim of showing these features as a group of major morphogenetic data in geomorphological research is to identify geomorphological landforms, especially the dominant form in Iran, and therefore the emphasis is on mountain glaciers.

- **Dugged glacier exploration forms:** Snow accumulation at the upstream end of mountain valleys and under high peaks and its transformation into crystallized ice and its flow towards the valley slope causes digging and excavation of the glacier passage.

- **Glacial cirque:** A cirque is a circular or semicircular depression at the end of a glacier, and a mountain peak dominates the floor of the cirque with a precipitous slope.

- **Glacial valley:** After the glacial cirque, glacial valleys are the most characteristic form resulting from the excavation of glacial flow. The transverse profile of glacial valleys is U-shaped.

- **Glacial dense features:** They are formed as a result of the accumulation of glacial masses and are more diverse and extensive.

Standard Report on the Side of the Map

This report is actually a compact version of the final report which is located next to and behind the 1:50,000 geomorphological map sheet and shows very little data. Since the geomorphological map provides the most benefit to the readers, it is necessary that the description on the side of it be as productive as possible. The chapters of the report are morphology and geography, description of rock units, tectonics and economic geology, the outlines of which will be given in the final report.

Final Report

A complete report of all the work done and the obtained results, organized as follows.

Title Sheet

This page will include the title of the report (as short as possible), the name of the geomorphologist (preparers) and colleagues, the name of the institution, the series number of the maps, the scale, and finally the year of publication.

Table of Contents includes:

Chapters, subchapters, and their numbers in order

List of Illustrations includes:

Number of photos, with short and concise captions for the photos.

. Introduction

. History of previous studies

. Research methods and stages

. Research tools

In the introduction to the report, the purpose of the study, the duration of the fieldwork, the research methodology, previous works, the scale and number of aerial photographs used, the number of different samples collected and studied, the evidence used, and finally, the problems will be discussed.

Geography

In this section, the location of the area (one guide map), its boundaries, topography, natural state and distribution of the main geographical features (mountains, hills, valleys, plains and deserts, etc.), the climate of the area, human geography, ways to reach the area, hydrographic features (Drainage pattern), etc. will be described.

Climate

Geology

Geomorphology

In this section, the current outcrop and morphology of the area will be described and how they were formed in the area of outcrops and young deposits.

Acknowledgment

In this section, the names of colleagues who have helped and accompanied in some way and appreciation of individuals or institutions who have helped in the project will be stated

Figures and diagrams

References

Conclusion

A map is a picture of all or part of the Earth on a flat surface that is reduced to a certain scale and various features and phenomena are shown on it selectively and with special symbols according to a specific purpose. Maps are diverse in terms of subject, size, content and drawing method. Usually, the output of research and investigation work on regions in geography is displayed in the form of a map. One of these maps is geomorphology maps, which are the result of the efforts, months and even many years of one or a group of geomorphological researchers. Geomorphology maps are generally prepared and, like geological, soil and other maps, are considered to be basic and scientific documents. These maps can also be considered historical documents, because through them, the changes and developments of a phenomenon or a place in a specific time period can be understood.

Geomorphological maps are essentially a type of thematic map whose drawing relies on the skill and technique of cartography. These maps show the anatomical features and shapes of irregularities by means of special symbols. Geomorphological maps are prepared based on information and logical and scientific descriptions of geomorphological practices. These maps are drawn from direct observations on the ground and using aerial photographs and topographic maps and other information obtained from satellite images. Therefore, geomorphological maps are an explanation of the results of fundamental research. Geomorphological maps show the various forms of the Earth's surface and the processes that form them, that is, the product of the action of internal and external geodynamic forces on the ground. In other words, geomorphological maps illustrate the resulting performance of internal and external geodynamic forces on the Earth, which is the uneven surface. Geomorphological, morphography, morphometry, morpho chronology maps display Earth's surface forms, especially the morphogenesis and morphodynamics governing those forms. These maps determine the relationship between morphodynamic phenomena and morphogenesis. Descriptive geomorphological maps provide a sufficient list of observed data from a given space. These data are provided and shown on the map in relation to structural features, spatial and temporal occurrence. Therefore, most geomorphological topics can be inferred from these maps, from statistical analysis and frequency of phenomena to logical relationships between them.

In geomorphological maps, time is usually divided into two periods: Quaternary and pre-Quaternary, because Quaternary climatic changes are more important for geomorphologists. In geomorphological maps, geological facies are reflected instead of geological formations, because the main factor in the formation is facies and their difference in sensitivity to morphogenetic factors Hence the names of the formations, which are usually derived from their recognized location, do not play a role in geomorphology.

The main objective of preparing geomorphological amps, are presenting detail information in all geomorphologucal data, such as lithological characteristics of the earth, structural effects, different surface landforms and their practices, morphological evolution of the different landforms.

Given the increasing development of resource exploitation in the field of land use, land planning and geomorphological studies of watersheds, the use of geomorphological maps is inevitable. Any type of human activity and exploitation of the environment requires the stability of the land on which these activities are established. Therefore, understanding the surface characteristics of the land is obligatory and geomorphological maps are the most important and efficient tools in this field. This issue has become more noticeable in recent years, especially in the context of land planning and watershed studies. Of course, maps produced at different scales are a source for assessing natural hazards and risks. They play a major role in land management and planning, assessing environmental risks and preventing catastrophic events.

In general, it can be said that geomorphological maps are used in scientific research and development, in regional and even national planning. In this regard, the International Geographical Organization established, the sub- Commission for Applied Geomorphology and this commission, particularly its cartography section, was supported by UNESCO.

The outputs of this sub-commission include the compilation of specialized dissertation on geomorphological mapping, the creation of a resource database of articles, a standardization group for cartographic symbols, and relevant GIS tools, and an educational-technical publication on "Application of Geomorphology in Land Planning and Natural Hazard Prevention” In this regard, the sub-commission has also taken steps to publish Map of Journal. Which publishes the result of the field of geomorphological maps in the form of articles. Scale is one of the most important principles in the preparation of geomorphological maps, because it determines quality and content. In other words, scale determines its geometric value index. First of all, the larger the scale, the more details it will show in maps. Also, the accuracy of quantitative information obtained through various measurements on geomorphological maps is directly related to scale. Therefore, numerous maps are prepared with different scales in the field of geomorphology, which differ from country to country in terms of style and preparation plans and even the volume of information. In fact, there is not a single method in the preparation and drawing of geomorphological maps.

Another items that should be considered in geomorphological maps is the issue of using symbols and signs to display its information. The presentation of information by using symbols and signs in geomorphological maps is its greatest advantage, so that if standard symbols are used variety of users will benefit from its information, and it will be easier and more convenient for the viewer to understand and do not require much interpretation. Of course, due to the diversity of geomorphological features and the diversity of maps in terms of scale and different preparation methods, there is still no accepted international standard in this field, and the use of symbols largely depends on the art, taste, and principles of the individual or institution that prepares geomorphological maps. Obviously, by using computer software in recent years as the most basic research tools in environmental studies, geomorphological maps can also be prepared in the form of this software.

Due to the numerous problems in this field, many countries have started to prepare geomorphological maps and have made considerable progress. However, in our country, due to the several reasons such as field work lack of necessary tools in this field, lack of enough support from the center or organization, lack of financial and credit resources, reluctance of other experts to use geomorphological maps in infrastructure and development programs in the country, the geographical extent of Iran, etc., no special work or action has been It is expected that in the near future, the problems related to the geomorphological investigations will be resolved and relevant officials and policymakers should be aware of the importance of these maps as a valuable and useful tool in construction and development works, for the progress of the country.

Appendix

Resistance of soil and rock masses and its relationship with the geomorphology of the region

Compressive resistance is one of the key engineering characteristics of rocks and soils. It plays a critical role in evaluating the condition of soil and rock materials in geomechanical, geotechnical, and engineering geology studies. Higher compressive resistance indicates a stronger rock or soil mass and greater ability to withstand sand tectonic forces or support construction loads.

Compressive resistance provides insight into the internal condition and nature of rock and soil-like materials. It reflects forces such as the condition and amount of cementation between particles, particle interlocking, and the roughness of discontinuities. These aspects together indicate the natural stability of rack and soil masses against tectonic forces and weathering, and inform predictions about future geomorphological changes in the region.

This inherent resistance of rocks and soils significantly influences the description of the geomorphological stability of a region, the rate at which changes occur, and the ability to interpret the future scenarios based on current conditions.

It is well established that greater compressive strength and resistance in rocks and soils correlate with increased resistance to physical weathering. Therefore, higher resistance can generally be associated with greater geomorphological stability and slower rates of landscape change over time.

Determination of Compressive Strength

The compression strength of rocks is typically determined in the field using the Schmit Rebound Hammer Test. This in-site method involves testing rock surfaces at multiple orientations (eg, 0, ±45°, ±90°) for each test location, an average of 15 to 20 measurements is collected. The raw results are then adjusted using a correction table, and the compressive strength (in megapascals, Mpa) is calculated using the Miller and Beverly Formula (Miller and Beverly, 1974).

Following the International Society of Rock Mechanics (ISRM) Standards, the corrected compressive strength values are used to classify the rock resistance ranging from R0 to R6, with R0 indicating the highest compressive strength.

For soils, compressive strength is typically assessed using the Penetrometer Test. This in-situ method is most effective for fine-grained soils such as silt and clay, particularly those with the same moisture content. Portable Pocket Penetrometers are commonly used for this Purpose. A major advantage of this test is that it provides immediate results without any correction. The device directly indicates the soil's compressive strength in kg/cm^2.

It recommends performing between 5 and 10 tests per soil unit at each station. The average of the test values is then reported as the compressive strength of that soil mass.

To better understand the current situation, it is recommended that, in addition to performing the aforementioned tests on rock and soil units, the standard table for determining the degree of rock weathering (recommended by the International Society of Rock Mechanics (ISRM) be used to determine the degree of rock weathering. Based on the ISRM table, weathering can be described from W0 to W5 for rock units.

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