CHAPTER 9

Regional Medical Geology

There are two ways of organizing work on medico - geological study of a given territory. *In the first place,* medico - geological investigation can be initiated by isolating geological units and then clarifying the diseases that characterize those units. The *second way* is to establish the geographic distribution of diseases and pathological states from reliable data and then characterize certain medico - geological regions (comples) after comparing this information with the geological properties of a location.

For the time being, it is difficult to say which of these ways is the more rational. Use of either the first way or the second can doubtless be justified in practice. The most important thing is to answer the question as to whether certain diseases and pathological states are linked with the geological (natural) environment.

The goal of the chapter on regional medical geology is more in keeping with the first of the two indicated approaches. To be specific, geology can make a considerable contribution in the event that geotectonic units of the first or lower orders are singled out and studied. It is certain that such a method can make it much easier to assess a geological environment from the medical standpoint and draw valid conclusions based on that assessment. Many examples from the practice of research conducted to date indicate the great promise of such an approach. This is especially true because the geological framework of a territory in greater or lesser measure dictates the position and characteristics of pedological, climatic, biogeographical, floristic, geomedical, and other types of ranges.

In further text geotectonic (geomedical) units of the first and second order, are discussed.

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GEOTECTONIC UNITS OF THE FIRST ORDER INTERESTING FROM THE GEOMEDICAL STANDPOINT

Many geological bodies and various structures - geotectonic units - have been formed in the Earth's crust that gives it the features of a complex edifice of mosaic nature. *By geotectonic unit, we mean a geological body, unit, or part of the Earth's crust that in its composition, structure, origin, and geological age stands apart and represents a geological environment that is distinct in space and time from other neighboring bodies and stuctures.* Some geotectonic units are large, extensive, and all - inclusive (extending over the entire surface of the crust and embracing continents and oceans), while others are spatially limited and even local in extent.

Because of the complexity of tectonic relations prevailing in the Earth's crust, it has always been difficult to isolate its structural units. It is understandable that the geological literature and terminology reflect many views on the origin of geotectonic units and contain numerous divisions and terms that are mutually incompatible and subject to different interpretations. Still, the first glance at a geological map of the world reveals isolated units of interest to us from the geomedical standpoint. We shall rely on the modern views synthesized in the book "**The Earth, Plate Tectonics, and Magmatism**" by D. Milovanovic and B. Boev (2001). Geologists in their research today for the most part create models based on the *theory of plate tectonics* as a foundation of geology. That theory explains many geological forms and processes: mid - oceanic rifts, island and volcanic arcs, collision of continental plates, location of volcanoes and earthquakes on the Earth, creation of mountain systems, etc. The plates themselves were discussed in the chapter on geological factors.

On the basis of geological and geophysical forms, the continental crust can be divided into several typical formations: continental and pre - Cambrian shields, continental platforms, Paleozoic orogenic belts, Mesozoic—Cenozoic orogenic (mountain) belts, and terrains (Fig. 9.1.) (Table 9.1).

1. *Continental* and *pre - Cambrian shields* represent stable parts of continents built of pre - Cambrian (metamorphic and acidic magmatic) rocks with or without a thin sedimentary cover. They are from 500 million to 3.5 billion years old. Regions of shields exhibit slight variations of relief and are tectonically stable over longer periods of time. They occupy about 12% of total volume of the continental crust. The largest among them are the African, Canadian, and Antarctic shields.
2. *Continental platforms* are also stable parts of the continental crust. Like shields, they are built of pre - Cambrian rocks, but differ from shields in being covered by a layer of sedimentary rocks up to 5 km deep.

TABLE 9.1.
Geotectonic units of the Earth's crust.

Categories of the units	Geotectonic units	Main geological features
1. Consolidated areas of the Earth's crust	*1.1. Continental shields* African, Canadian, Antarctic, South-American, Fine Scandinavian, Indian, Australian, Chinese, etc.	Very old stable parts of the continent made of Precambrian metamorphic and acid magmatic rocks. Number of shields is predominantly covered by moraine material or postglacial lacustrine clays. Expressed flatness of relief, with spacious plains or deserts, is characteristics of this type.
	1.2. Continental platforms Eastern European platform (Russian plain, German-polish plain), Western European plate (plain), Arabian platform, Siberian platform (Western Siberian depression, Middle Siberian plateau), Saharo - sudanian platform, Northern American platform, etc.	Stable parts of the continents made of metamorphic rocks, covered by 1-5 km thick (or more) sedimentary rocks. Spacious covers of glacial formations, with expressed flatness of relief and deserts. Huge artesian basins with mineralized waters. Parts of platforms on the northern hemisphere with developed criolite - zone (permanently frozen soil and eternal ice).
2. Relatively consolidated areas	*2.1. Paleozoic orogenic belts* Central massif (France), Rhaina-middlegerman mountains, Czech massif, mountains of British isles, Scandinavian mountains, Altai-Baikal mts., Mongolian - Chinese plateau, Manjuria - Korean area, etc.	Mountainous massifs made predominantly by metamorphic and magmatic rocks. Intensive tectonic sinking and uplifting of block and long-term erosion processes resulted in low and vaulted enormous mountains, with troughs and erosion surfaces.

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3. Mobile areas of the Earth's crust	*3.1. Active continental margins* 3.1.1. Alpine high-mountain ranges: Andes, Cordilleras, Alpine - Himalayan system (Pyrenees, Alps, Apennines, and Carpathian - Balkan mts., Dinaridic mts., Atlas, G. Caucasus, Tian-Shan, Tibet - Himalayan mts.), Urals, mountains of NE Asia, Appalachian mts., mountains of Eastern Australia, etc.). 3.1.2. Spacious plateaus: Tibet, Colorado, etc...	Mountains formed in places of two plates bordering. Made of thick deposits of sedimentary, magmatic and metamorphic rocks, very disturbed tectonically; among intrusive rocks, granodirites are predominant, and among volcanites - andesites. Formed chains of high marked mountains. Expressed volcanic and seismic activity. Outcrops of low - mineralized, mineral and thermal waters are numerous.
	3.2. Rifts and rift valleys 3.2.1 Inside of continents: African - Arabian rift (Syria - Lebanon, Dead Sea, Ethiopia - Kenyan or Eastern African), Niassa - Tanganyika, rift of Rhine, Baikal rift, rift of Southeastern Australia, Rio Grande rift, plateau basalts of Paranna (eastern part of Southern America), Yellowstone park (USA).	Basalt flows and plateau basalt; numerous volcanic structures (domes); intensive uplifting and sinking of tectonic blocks; high heat flow.
	3.2.2. Middle - ocean rifts, that is - horsts. Iceland, Galapagos, etc.	Islands marked by volcanic domes made of basaltic lava. Hydrothermal occurrences are numerous.
	3.3 Island arcs: Japan, Fillipines, New Hebrides, New Guinea, Indonesia, New Zealand, Antilles, Curile arc, Isu - Bonin arc, Mariana arc, Tonga arc, etc..	Islands predominantly made of basalt and andesite. Marked domes of active volcanoes. Very strong earthquakes. Outcrops of high - thermal waters overheat gas and steams are numerous.
	3.4. Basins in back of arcs: Mariana islands, Tonga and Isu - Bonnin in Pacific, Scotia in Atlantic.	Islands made of basalt and sedimentary rocks. High heat flow from the Earth's interior.
	3.5. Oceanic islands and plateaus: Volcanic chain of Hawaii (more than 2,000 km long) and Tahiti in Pacific; Canaries and Azorean islands in Atlantic; islands in Indian ocean.	Islands present volcanoes under the water surface, partly over sea level. Ocean plateaus are existent, also of volcanic origin. Expressed recent volcanic activity. High heat flow.

NOTE: Geomedical features of distinguished units presented in the text.

3. *Paleozoic orogenic belts* are several hundreds to several thousands of kilometers long. They are built of various kinds of magmatic, metamorphic, and sedimentary rocks. These belts are deeply eroded mountain ranges with weakly expressed relief and relative tectonic stability.
4. *Mesozoic—Cenozoic orogenic (mountain) belts* are similar in size and pattern to Paleozoic orogenic belts. Being younger, however, they are tectonically unstable and geomorphologically much more diverse. The three greatest Cenozoic orogenic belts are the Cordilleras, the Andes, and the Alpine—Himalayan belt. Blocks and present - day plateaus (Colorado and Tibet) that have not undergone the deformations characteristic of orogenic belts occur in them.
5. *Terranes* are tectonically limited segments of continents that have a geological structure, history of formation, composition, and pattern different from those of the surrounding region or surrounding terrains, with which they are in contact in most cases. Fused terrains indicate great movement from their primary position, which is confirmed by paleomagnetic investigations.

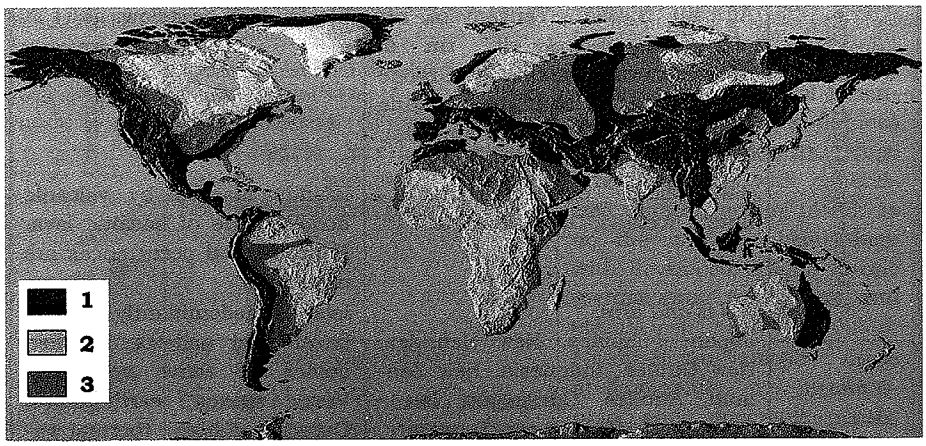

Fig. 9.1. Position of Alpine orogenic belts(1), continental shields(2) and platforms(3) in the Earth (D. Milovanovic, B. Boev, 2001).

The most intensive geological processes take place on the boundaries of plates (Fig. 2.12.). In addition to complex tectonic activity, formation of the majority of magmatic rocks occurs there. This applies to mid - ocean - rift basalts; basic and alkaline rocks within continental rifts; volcanic and intrusive rocks of island and volcanic arcs; and basalts of basins behind the arcs. Plate boundaries are also zones of current volcanic activity and earthquakes (Fig. 2.20.). The next part of the text will therefore be devoted to these interesting boundary regions (Figs. 9.2. and 9.3.).

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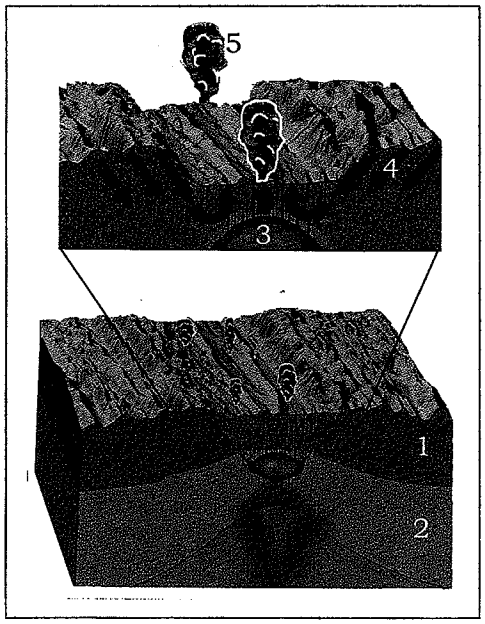

Fig. 9.2. Origin of "black chimneys" in rifts with fast plate opening. 1 - Oceanic crust; 2 - Oceanic lithosphere; 3 - Warm sea water; 4 - Cold sea water; 5 - black chimneys (D. Milovanovic, B. Boev, 2001).

Plate Divergence Boundaries or Rifts

Divergence of two plates in the ocean (in a *mid-ocean rift*) results in the outflow of a large amount of basalt, creating a *mid - ocean* ridge. Representing enormous underwater mountain ranges built of basalt, mid - ocean ridges are more than 20,000 km long (in the Atlantic and Pacific Oceans) and 1,500 to 2,000 km wide. They reach a height of 2 to 3 km above the ocean floor and are marked by numerous volcanic structures, which very rarely rise above the surface of the sea (as in the case of Iceland). Also characteristic are hydrothermal occurrences formed by sinking of seawater along fissures and faults near rifts, heating of that water, and the appearance of hot springs rich in dissolved sulfur and metals separated from basaltic lava with hydrothermal solution temperatures of up to 350°C and more (Fig. 9.2.).

Rift valleys are formed if divergence along rifts occurs within continents. Basaltic magma flows out along faults, resulting in the formation of a basaltic dome or volcanic plate (plateau). Together with intensive volcanic activity, considerable heat is generated due to rising of the ground, and weak earthquakes with foci at shallow depths occur. The rift can be hundreds of kilometers long and several tens of kilometers wide. The greatest structure of this kind on Earth is the African—Arabian Rift, which extends from Mozambique to Turkey over a length of about 6,500 km. Rifts of high volcanism occur in Kenya and Ethiopia (the East - African Rift, which is a constituent part of the African—Arabian Rift) and North America (the Rio Grande Rift).

In contrast to continental rift basalt (which is effused in the rift itself), *continental plateau basalts* are formed due to an overflow from the given structure

(rift valley) of material that covers large surfaces of continents and builds volcanic provinces. A volcanic province is composed of subhorizontal to horizontal outflows or plateaus of basaltic lavas with an area of from several tens to several hundreds of square kilometers lying on the Earth's crust.

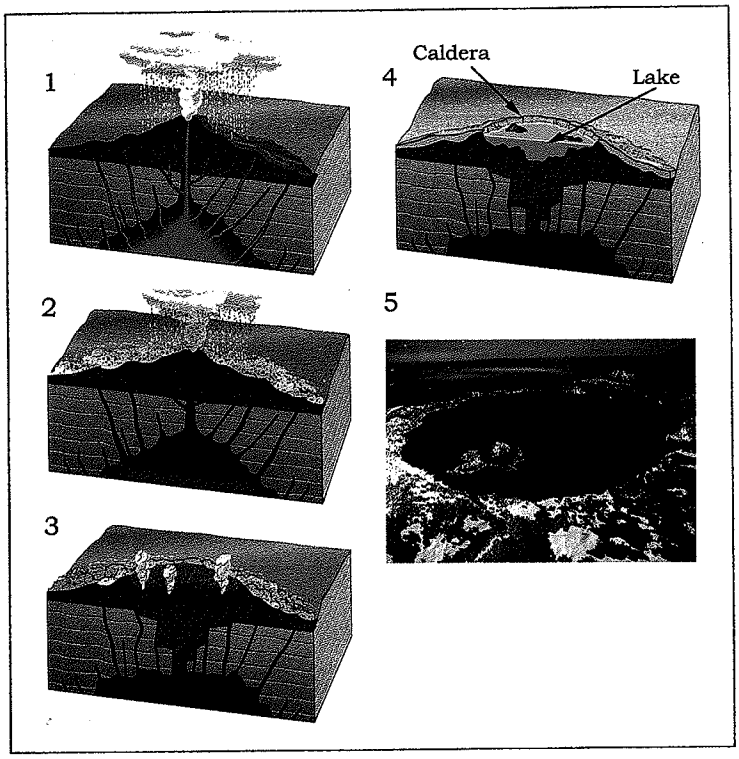

Fig. 9.3. Formation of caldera (Milovanovic, Boev, 2001).

Boundaries of Undertow or Subduction

Zones of subduction (the process of one plate descending beneath another) represent the most complex tectonic regions on Earth and one of the most significant phenomena of global tectonics. About 80% of active volcanoes are found in regions of plate subduction, in island arcs, and on active margins of continents; about 15% of them are found in regions of plate divergence (rift formation); and only about 5% occur within plates. The majority of powerful earthquakes on the Earth are also linked with the edges of subducted plates.

Island arcs are formed by the descending of one oceanic plate beneath another one. Due to conduction of heat from the surrounding layers as well as mutual friction, subducted rocks are progressively metamorphosed and in the end become melted material. Being lighter, this material emerges on the surface to

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form an island arc. Among volcanic island arcs, it is possible to distinguish ones that are young (Tonga), "middle - aged" (New Hebrides), and old (Japan, the Philippines, etc.). Volcanism linked with subduction zones usually begins suddenly and powerfully, a volcanic front of basaltic and andesite magma forming at a distance of 150 to 300 km away. Volcanoes themselves are built of lava and pyroclastic material, while collapse of their walls leads to the formation of calderas (Fig. 9.3.). Volcanic ash and dust can be deposited as far as 100 km away from the volcano.

Even before appearance of the tectonic plate theory, the Andes were regarded as an example of mountains formed by subduction of an oceanic plate beneath a continental one, i.e., as an *active continental margin.* The structure of a volcanic or magmatic arc formed in this way is very similar to that of an island arc. In exceptional cases, if subduction is subhorizontal, great nappes and a complex tectonic area are created without the formation of a volcanic or magmatic arc.

Because the great majority of active volcanoes are found in zones of plate subduction or divergence, *oceanic (volcanic) islands* are very numerous in these regions, especially in the Pacific. More than 2,000 km long and built exclusively of basalt, the volcanic chain of Hawaii represents the most thoroughly studied of oceanic islands (Fig. 9.4.).

An oceanic phenomenon, *marginal basins* are formed behind island chains. They are built primarily of basalt.

Collision of Two Continental Plates

When two continental plates collide instead of undergoing subduction, a contact zone is created with intensive tectonic, metamorphic, and magmatic activity. The area becomes a zone of crust thickening marked by great mountain ranges such as the Himalayas, Alps, Appalachians, Urals, etc.

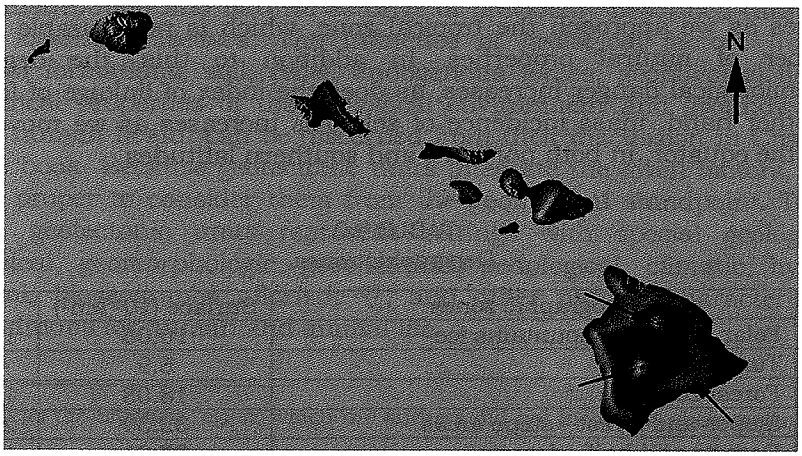

Fig. 9.4. Volcanic chain of Hawaii (D. Milovanovic, B. Boev, 2001).

BASIC GEOMEDICAL CHARACTERISTICS OF FIRST - ORDER GEOTECTONIC UNITS AND THEIR EXTREME ZONES

Geographic zonality is generally known. At the boundary of the atmosphere and lithosphere, horizontal and vertical zones are a result of effects and mutual influences among many factors, viz., solar heat, rocks, soil, water, relief, vegetation, animal life, and man. The areas of these zones on the Earth are given according to A. Maksimovic (1955) in Table 9.2.

Generally speaking, climatic characteristics in large measure determine the natural conditions for development of life, and several latitudinal zones are discernible from the pole to the equator:

- The *arctic region*;
- A *zone of temperate humid climate*;
- A *zone of desert climate*; and
- The *equatorial zone.*

Hydrological zones correspond to the geographical zones listed in Table 9.2.: the zones of the tropics, forests, and tundras are humid and excessively humid; those of steppes and semi - deserts are variably humid and semi - arid; and desert zones are arid.

Specific vegetation and animal life develop in the given conditions, which are largely determined by soil and morphology. All of this dictates the appearance of natural foci of disease. For example, it is known that the number of parasitic, transmissible, and other infectious diseases increases as we approach the tropical zone, which is recognizable from a number of natural properties. In addition to this, the degree of epidemiological danger increases, as does the index of linkage of foci. On the other hand, mass incidence of sclerosis increases as we move away from the equator, in both northern and southern latitudes.

TABLE 9.2.
Geographic zones.

	Geographic zones	Surface (10^6 km^2)	%
1	Polar and high mountains ice	16.08	10.8
2	Tundra	5.9	4.0
3	Forest zones	18.08	12.1
4	Stepes and forest - stepe areas	32.39	21.8
5	Deserts and half - deserts	27.21	18.3
6	Mountainous zones	22.62	15.2
7	Alluvial area	4.26	2.9
8	Continental water (excluding Caspian sea)	0.97	0.7
		148.63	100.0

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Keller et al. (1993) created a complex epidemiologo - geographic regionalization on the basis of analyzing the results of studying geographic conditions in the world, the level of incidence and structure of diseases, the degree of risk from infection, and the spatial distribution (endemism) of illnesses. Eighteen epidemiologo - geographic regions, described in the book "**Handbook of Medical Geography**", are isolated. Greater or lesser agreement with geotectonic regionalization is evident. For example, the Canadian—Greenlandic, Eastern South American, West African, Central African, Australian, and European regions[107] for the most part coincide with tectonically passive zones of the Earth's crust (shields and platforms); while the Central American, Western South American, Mediterranean, and Southeast Asian regions, together with certain parts of other regions, coincide with mobile zones.

Already in 1936, A. A. Grigor'ev noted the necessity of creating and using a parallel regionalization based on geological facts. Grigor'ev then indicated that the time was ripe for physical geography to divest itself of its "physical" traditions: "*Illumination and investigation of the chemical aspect of processes must now be raised to the level needed.*" Geochemical factors of the environment were thus acknowledged to be of great significance in what can probably also be considered an unconscious assertion of the advantages of geological (geotectonic) regionalization[108].

Justification for geotectonic (geomedical) regionalization can be found in many facts uncovered in the long course of medico - geographical research. For example, the need for them follows from information about various microelementoses and numerous other illnesses and data on the spatial distribution and natural settings of previously described rare and strictly localized diseases. The influence of geological factors (rocks, geological formations, soil, relief, endogenous forces, geophysical fields, geochemical properties of the geological environment and groundwater, etc.) on human health can be discerned from their discussion in Chapter 2 of the book. Because geotectonic units integrate the given factors, it is entirely proper to consider them from the geomedical standpoint. To be specific, geotectonic units represent settings with special geological, geophysical, geomorphologic, geochemical, pedological, climatic, hydrogeological, biogeographic, floristic[109], and other natural characteristics and conditions for human and animal life.

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[107] As well as the Siberian region, which the authors did not include in their regionalization.

[108] It was completely logical that A.E. Fersman (1922, 1931) indicated the coincidence of *geochemical provinces* - by which he meant geochemically homogeneous regions with a certain association of elements - with geotectonic units (shields, platforms, or mobile belts).

[109] Correlation of floristic and geotectonic regions is evident.

Geomedical characteristics of geotectonic units have not been the subject of special study to date. We rely in our treatment on the geotectonic regionalization presented in Table 9.1. Because the influence of morphological and climatic factors (apart from geological ones) is very pronounced in the case of some expansive units, there are grounds for distinguishing so - called *extreme zones* within the given units. Extreme zones can be particularly interesting from the medical standpoint. For example, the Siberian Platform consists of the West Siberian Lowland (with an area of about 2 million km^2) - the most ideally level plain in the world, which lies predominantly below 100 m above sea level; and the Central Siberian plateau (with an area of 3.5 million km^2), with broadly level watersheds at an average elevation of 500 - 700 m above sea level. Well - known extreme zones, including the tundra, taiga (forests of temperate climate) and steppe zones are developed in both cases, albeit with specific features. Within such expansive zones, moreover, many features significant for human, animal, and plant life are dictated by the type and geochemical characteristics of the lithological substrate and by geochemical characteristics of rocks, soil, and water. It is therefore sometimes expedient to devote special study to such lower - ranking geomedical units.

Geomedical study of the isolated geotectonic units and their extreme zones is especially significant for a number of reasons, primarily because the pathology, physiology, and hygiene of those areas exhibit a fairly great number of specific characteristics, which are largely dictated by geological, geomorphologic, geochemical, hydrogeological, and climatic features. Anyway, it has long been considered necessary to study the influence of extreme environmental conditions on the human organism. For precisely this reason, geographers, doctors, and biologists have organized numerous expeditions into areas of high mountains, polar regions, waterless deserts, and humid tropical regions, thereby enriching the medical and biological sciences with much valuable new information. Not only have new forms and variants of diseases been discovered in this way, but remarkable examples of the adaptive capacity of the human organism have been revealed as well. The arsenal of medical and biological research methods has also been enriched.

Consolidated Regions and Their Extreme Zones

Consolidated regions of the Earth's crust (old shields and platforms) embrace enormous areas with relatively homogeneous geological and geochemical composition, tectonic framework, and hydrological and hydrogeological conditions. The soil is also homogeneous, of predominantly limited fertility, and deficient in many elements important for life

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(Ca, Mg, Na, K, P, Co, Cu, etc.)[110]. Many acidic swamp soils are difficult to drain and unfavorable for plants, animals, and man. In contrast to acidic soil, soil formed on limestone (carbonate) terrains is rich in calcium carbonate and thereby favorable not only for plants and animals, but for agricultural production as well[111].

Several types of extreme zones are developed on shields and platforms: a polar region with tundra zone, a forest belt, and a steppe zone on the Canadian Shield (with the Northeast Platform) and the Eastern European and Siberian Platforms; arid zones (deserts and semi - deserts) on the Sahara—Sudan, Arabian, and Australian Plates; and a tropical belt in equatorial regions, i.e., on parts of the South American, Chinese, and Indian Plates. Human life in different climato - geographical or climato - geological regions of the Earth is characterized by various physiological reactions and adaptations to the given environment. Several geomedical characteristics of extreme zones are singled out below.

Polar (Arctic and Antarctic) Regions

These regions are located north or south of 66° in both hemispheres of the globe. They are typical representatives of extreme zones with geographically isolated populations. The vast Antarctic and arctic deserts are ice - covered and characterized by the polar type of climate (shortage of sunlight, especially severe chill factors in regions of high mountains due to low air temperatures and strong winds), infertile soil, and low content of mineral compounds in water. Polar regions are rightly considered to be harsh and unfavorable for plant, animal, and human life. Apart from the short growing season, high water levels caused by potential ice melting make farming difficult.

The adaptive responses of man in these regions are very diverse. In the area of medical protection, a specific approach is required in dealing with the native population and newcomers. A new branch of science has been developed to meet these needs, namely *arctic* or *polar medicine* (cryo - pathology, epidemiology, and hygiene), supported by geographic pathology and bioclimatology of man under conditions of high latitudes.

The danger of contracting diseases appears especially with the arrival of people from other territories, when the otherwise pure bacterio - viral setting is contaminated by various agents of infectious diseases. In addition to the psycho - emotional stress syndrome described earlier, polar regions are characterized by the following disease structure:

- General cooling of the body with numerous consequences, up to and including death;
- Diseases of the nervous system and senses;
- Chronic bronchitis; long - term and chronic nonspecific pneumonias;

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[110] Calcium deficiency is manifested especially clearly on the organism of animals: animals suffer from skeletal diseases (rickets), birds are poor layers, their eggs have thin shells, etc.
[111] The given regions are characterized by the presence of very extensive artesian basins, mainly with water that is highly mineralized.

- Rheumatism;
- Diseases of the teeth (high frequency of caries) and the oral cavity;
- Diseases of the circulatory system; hypertonic sickness, sometimes in combination with atherosclerosis;
- Anemia due to iron deficiency in the blood; and
- Biogeochemical endemias (microelementoses).

Epidemics of poliomyelitis and influenza have been recorded (in Eskimos of the Canadian Arctic), together with tuberculosis infections (in the Eskimos of Alaska).

The high - mountain terrains of the Arctic and Central Antarctica are characterized by low atmospheric oxygen content in proportion to elevation above sea level, and this causes severe or chronic mountain sickness in the inhabitants of those territories.

The Forest Belt

This belt encompasses vast areas of the Northern Hemisphere with a damp, moderately warm climate. Climatic conditions were exceptionally favorable for development of forests, especially in Siberia. Landscapes of *transitional* (from acidic to calcic) and *calcic classes* were created, depending on the rock substrate. The former are prevalent in areas of the Siberian taiga and deciduous forests of the East European Plain and West Siberian Lowland, the latter in the Central Asian part of the belt.

In contrast to climatic conditions, the properties of soils of the *transitional class* of landscapes are far less favorable for life. Soluble compounds important for plant and animal life are readily leached from soils and transported into river courses by groundwater. For this reason, acidic soils poor in mobile mineral compounds are best represented. Sandy ground often consists of 98% residual quartz. It follows that the transitional type of landscape from the geochemical point of view is poor in elements important for vegetation. Calcium deficiency is manifested especially visibly on animals of these regions, which are shorter in stature, have fragile bones, and suffer from osteoporosis, rickets, and other diseases. Cobalt deficit occurs frequently, with the result that sheep and (more rarely) cattle are subject to the serious disease B - 12 hypovitaminosis. Deficiency of copper also causes a number of diseases in domestic animals. Iodine deficit sometimes leads to breakdown in functioning of the thyroid gland and development of endemic goiter in domestic animals and humans.

Landscapes of the *calcic class* are formed on terrains with limestones and dolomites, as well as in carbonate moraine material. A carbonate weathering crust with its soil cover is formed here. In comparison with the weakly mineralized water of the transitional class of landscapes, surface and groundwater is appreciably richer in minerals and sometimes hard. Generally speaking, calcium is the typomorphic element of these regions: it erts decisive influence on organisms, soil, and local water and causes such landscapes to differ significantly from acidic taigas, for example. The very favorable climatic conditions, fertile soil, and water of good quality have played an important part in making flatland regions of this type suitable for life and agriculture. For this reason, such regions were the first ones in the European Arctic to be opened up for farming, and they have to date been com-

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pletely reclaimed. The diseases of animals and humans characteristic of landscapes of the transitional class are far rarer under such conditions.

Arid Regions

Formation of arid regions was primarily dictated by unevenness in the distribution of heat and moisture and zonation of the globe's geographic envelope. Such regions are widespread on territories of shields and platforms (in the northern half of the African Shield, on the Australian Shield, and on the Arabian Platform), but also in mountainous regions of North America, South America, and Asia at elevations of the order of 3 - 4 thousand m above sea level (Tibet and elsewhere).

Deserts are characterized by high summer air temperatures, small amounts of precipitation, absence of surface watercourses, prevalence of a sandy substrate, salinization of shallower horizons of groundwater, and migration of soluble salts in the soil. In spite of the abundance of heat, light, and fertile soil, a poverty of vegetation is evident.

About 4% of the world's population lives in the harsh extreme conditions of arid regions[112] (Fig. 9.5.). Because water is the basic factor for life in these regions, irrigation of deserts has played a leading role in the history of mankind, and many civilizations with a high degree of culture sprang up on irrigated lands: ancient Egypt, Babylon, and Mesopotamia[113].

Despite many common features, deserts can differ significantly. These differences determine characteristics of regional medical geography (geology) and geographic pathology. Every desert has its own medical geography (geology), determined by its natural (geological) and socio - economic conditions.

In examining the nosogeography of arid regions, Keller et al. (1993) single out the following three groups of diseases:

1. *Diseases caused by the influence of arid climate;*
2. *Diseases linked with the action of geochemical factors; and*
3. *Pathology determined by the existence of endemic vegetation and animal life.*

The *climatically - determined* pathology of arid zones is formed under conditions of high temperatures and dry air, extended periods of their action, spectrally varied solar radiation, and sharp daily and seasonal oscillations of meteorological factors. All of this places high demands on the adaptive system of the human organism. The following diseases are typical:

- *Heat stroke and other forms of overheating of the organism;*

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[112] Arid regions today occupy an area of the order of 28 million km^2 or 18.8% of the world's land (59% of the African continent, 83% of Australia, the whole of the Arabian Peninsula, 22.7% of the Asian continent, etc.). One of the largest deserts on the Earth, Sahara extends for a length of 5,000 and width of 2,000 km. It is characterized by the highest air temperatures (up to 58-59°C) and ground heating (up to 70-80°C), the lowest level of precipitation (up to 22 mm annually), and the greatest oscillations of daily air temperature (even more than 30°C).

[113] In addition to surface watercourses, large amounts of the groundwater of well-known artesian basins have also been used and are being used. For example, the Saharan Artesian Basin occupies parts of the territory of Morocco, Algeria, Tunisia, and Libya.

- *Gastro - intestinal diseases (some parasitic diseases are very widespread);*

Fig. 9.5. Desert ambient.

- *Formation of stones in the upper and lower urinary pathways;*
- *Skin cancer and dermal pathology as a whole; and*
- *Cardiovascular diseases (according to some authors, while others hold that they are atypical).*

In arid regions, a number of characteristics of diseases linked with the action of *geochemical factors* are expressed. The unfavorable action of these factors is amplified by high temperature of the surrounding atmosphere, complex resistance of organisms to chemical substances, and increased permeability of sweaty skin. Let us dwell on the influence of soil and water on human health. In natural conditions, this influence is manifested in the form of the following things (among others):

- *High incidence of goiter and fluorosis due to iodine or fluorine deficiency in some arid regions;*
- *Endemism of arid regions for cancer of the esophagus due to the high share of quartz in desert dust, action of nitrates and nitrites of the soil, specific diet, and shortage of good - quality drinking water and low content in it of mineral substances and microelements (the main foci are in Southeast Africa and the republics of Central Asia, viz., Turkmenistan and Kazakhstan); and*

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- *Urolithiasis (according to certain authors, arid regions represent endemic foci of urolithiasis, depending on the degree of mineralization of drinking water).*

Diseases caused by specific characteristics of the *arid flora* are primarily manifested in the high presence of allergic ailments. On the other hand, the following groups of diseases are caused by specific characteristics of the *arid fauna*:

- *The group of diseases linked with non - living nature (climate, soil, etc.): non - transmissible diseases whose agents must experience certain transformations under prevailing environmental conditions in order to become invasive; and*
- *The group of endemic infections (invasions), which belong to the category of natural - focus diseases and occupy a significant place in the pathology of inhabitants of hot zones of the Earth.*

Tropical Regions

The damp tropics occupy enormous areas of Equatorial Africa (the southern half of the African Shield), South and Southeast Asia (the Indian and Chinese Shields and island arcs of Southeast Asia), Central America, and South America. More than half of the world's population lives in this space. The greatest number of diseases (including the most serious ones) is disseminated here. We shall dwell on territories of old shields marked by extensive lowlands and plains (the very flat lowlands of Amazonian, for example, with an area of as much as 5 million km^2).

A characteristic of the damp tropics is the constant coincidence of a hot climate and high humidity. The presence of great heat and abundant moisture dictates high annual production of living matter, from which such regions are recognizable. Also characteristic is an abundance of plant species[114].

The soil provides diverse food products for animals and man. Differences are discernible here between the *acidic* and *acidic - swampy classes* of landscapes, which are prevalent.

1. Typical representatives of the *acidic class* of landscapes of the damp tropics are formed on magmatic, metamorphic, and sedimentary silicate rocks, where a thick acidic weathering crust is created under acidic soil, the indicated crust being enriched with inert elements such as iron, aluminum, residual quartz, and certain rare elements of the inert group (Fig. 9.6.). Especially characteristic is the low content of calcium, which is sometimes less than 0.1% (in contrast to Fe_2O_3, with 30% and higher, or Al_2O_3, with even as much as 50%). Richness of the soil and weathering crust in hydroxides of iron gives them a red, orangish, or yellow color.

[114] The colossal amount of biological information not only is a consequence of climatic conditions favorable for organisms, but also results from geological circumstances. To be specific, landscapes of the damp tropics belong to regions of old land, where evolution has taken place continuously for many millions of years, starting with the Paleogene and even the Mesozoic.

Characteristics of the soil and weathering crust also determine the geochemistry of soil and groundwater. The water in question is moderately fresh, with mineralization below 100 mg/l. It is understandable that plant and animal life is likewise characterized by a deficit of mineral substances. For this reason, use of nitrogen, phosphorus, potassium, and other fertilizers is necessary to ensure realization of the enormous potential for farming. Use of chemicals in ranching is also effective.

2. Soils of landscapes of the *acidic - swampy class* are formed on plains and in valleys of the tropics. An incomparably smaller number of plant species are developed on them, and biological productivity as a whole is lower. This class of landscapes is characterized by an acute deficit of oxygen in the soil, accumulation of black humic matter in it, and a very acidic reaction of its iron - rich water. Forest mud occupies large areas in the basins of the Amazon, Orinoco, and Congo Rivers.

As stressed above, tropical regions are unique for extreme precipitation and droughts, which lead to strong geochemical responses of elements. Excesses or deficits of certain elements occur, and this has consequences for human beings and their health in both cases. These consequences are magnified by the virtual non - existence of preventive protection of the population, since the countries in question are among the poorest in the world. The great dependence of man on nature permits geomedical studies by provinces.

Fig. 9.6. Intensive colors of tropical birds principally are result of aluminum content in soil.

It is a well - known fact that **tropical medicine** is very highly developed. We cite two groups of diseases by way of illustration: diseases linked with the action of geochemical factors; and parasitic and infectious diseases. It is also important to stress problems connected with high air temperature and very high atmospheric humidity. Chronic diseases undergo worsening in such conditions, the functioning of various systems (cardiovascular, digestive, nervous, and endocrine) deteriorates, skin dis-

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eases with high incidence of skin cancer are recorded (in arrivals from lands with a temperate climate), conjunctivitis is common, etc.

Geochemical characteristics of the acidic damp tropics leave a clear mark on the flora and fauna, agricultural production, and human health [115]. These characteristics are primarily manifested through deficits of individual elements:

1. Sodium content in water and food products is so low that it does not satisfy requirements of the human organism. The deficit of sodium is amplified by sweating, since a man in the tropics daily gives off up to 12 l of sweat. Decline of sodium content in the blood causes exhaustion of the nervous system and reduces the capacity for work;
2. Calcium deficiency is probably manifested in smaller stature of animals in regions where it occurs compared with animals from other extreme zones (for example, the okapi in Equatorial Africa has a height of 1.5 to 2.0 m, whereas the related giraffe from Ca - rich savannas is about 6.0 m tall). Thus, animals in the acidic damp tropics adjust to a deficit of some element or elements by being smaller. Diseases caused by Ca deficiency (rickets) occur rarely in the damp tropics because the strong sunlight favors formation of vitamin D, which stores calcium and phosphorus in the organism, with the result that animal skeletons are fairly strong;
3. Despite the fact that vegetation of the damp tropics contains much iron, this element is poorly assimilated by the human organism from plant food. Owing to the fact that the inhabitants of the tropics eat little meat (the main source of iron), anemia is widely disseminated here;
4. Due to deficiency of calcium and iodine in the soil, dental caries and endemic goiter are widespread in West Africa. Consequences of fluorine deficiency are recorded in some areas.

The extremely great richness of tropical pathology is primarily based on very numerous *infections* and *parasitic diseases* caused by viruses, bacteria, and fungi. Especially favorable conditions for propagation of diseases prevail in lowlands due to high density of the human population, abundance of animal species, increased humidity, high temperature stability, and abundance of vegetation. Lowlands are characterized by the epidemic type of propagation of infectious diseases (jungle yellow fever, etc.), while flatland relief is characterized by the epidemic - focal type of propagation. Among tropical diseases, generally the most prevalent are ones whose spread is accomplished by carriers that are lovers of damp or dry environments (malaria, etc.). Also characteristic are diet - related diseases (pellagra, beriberi, etc.).

Soils of tropical regions play an important role in the propagation of various diseases. For example, the acidic reaction of these soils is favorable for the development of lower fungi, and different skin and fungal diseases are very widespread here.

The very numerous aquatic basins (rivers, lakes, reservoirs, and irrigation canals) represent good places for multiplication of mosquitoes and carriers of various intestinal infections and other diseases. Moreover, irrigation canals are the home

[115] Water of good quality is available to only a third of the population.

of snails in whose bodies the larvae of parasitic disease agents develop, and lesions associated with cancer occur in some forms.

The exceptional wealth of the flora is characterized by a multitude of useful plants, including medicinal species. More than 500 species of tropical plants can be used as pharmaceutical raw material. On the other hand, poisonous plants also grow in the tropics.

The animal life of the tropics is diverse and of extremely great significance to human beings. Many representatives of the animal kingdom serve as reservoirs of the agents of infectious diseases, and many are poisonous (the tarantula, black mamba, cobra and other snakes, etc.).

Paleozoic Orogenic Belts

Paleozoic orogenic belts embrace the central zone of Europe and areas of Northern China, Mongolia, and Southeast Russia[116]. These are mountains formed by thrusting during the Hercynian and Caledonian Orogenies and deformed by strong radial movements during the Tertiary, when the great present - day mountains and valleys were formed. Owing to long - term erosive processes, the mountains are for the most part of low to medium height (with maximum elevation of 4,507 m, the Altai Range represents an exception created by very strong uplifting during the Neogene and Quaternary) and marked by extensive areas. Viewed seismically, they are today relatively consolidated regions.

The natural conditions of *low mountains* in the damp part of Paleozoic orogenic belts ert mainly favorable influence on human health. In exceptional cases, measures are needed to prevent the occurrence of plague, malaria, scrub typhus, woodcutter's encephalitis, and other diseases in certain regions.

The influence erted by natural conditions of *medium - high mountain massifs* in regions with a damp climate - in contrast to the continental variant characteristic of the mountains of Central Asia - is of a positive nature and promotes improvement of vital activity of the organism. At the same time, it is often necessary to increase the energy value of food in conjunction with supplementary vitaminization, especially through the use of wild greens. In many regions, it is imperative that preventive measures be taken against endemic goiter. Especially needed are organizational measures for prevention of gastro - intestinal diseases, worm invasions, malaria, woodcutter's encephalitis, scrub typhus, etc.

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[116]The Altai-Baikal or South Siberian Mountains cover the greatest area (more than 2 million km^2). The neighboring Mongolian-Chinese Plateau for the most part coincides with the extent of the Gobi Desert.

Mobile Regions

In geological structure and many other characteristics of significance to human health, mobile regions of the Earth's crust differ greatly from the described old tectonic units. Above all, the lithological (petrological) diversity of mobile belts is far more pronounced, their structural framework is incomparably more complex, volcanic and seismic activity is constantly present, and geomorphologic forms are represented by striking young mountains. Without question, the geochemical properties of rocks, soil, and groundwater are also different, risks are presented by current volcanic and seismic activity, and the danger of landslides and rock and mud torrents exists in regions with active fault structures. As for groundwater, its distribution in rock masses is complex, and the water as a rule is of better quality in comparison with that of old shields and platforms. Springs of thermo - mineral water, superheated vapor, and gases are numerous. Together with the listed geological factors, the high - mountain relief and harsher climate ert great influence on human health.

We have noted that regional tectonic structures of standard origin are distinguishable within mobile belts (Table 9.1.). These tectonic units must be taken into account in the further development of medical geology. For the present, we note certain characteristics of two groups of such structures: 1) structures of alpine orogenic belts (active continental margins); and 2) groups of other types of boundary structures.

Alpine Mountain Massifs

Mountain ranges of enormous dimensions were created by subduction of one plate beneath another or by collision of two continental plates. Such ranges include the Andes, Cordilleras, Himalayas, and Alps. The Andes Range is 9,000 km long, and a number of its peaks (volcanic cones) exceed an elevation of 6,000 m above sea level. The system of the Cordilleras is about 6,000 km long and climbs to an altitude of 6,193 m above sea level (Mt. McKinley). The Tibetan - Himalayan mountain region is the most extensive and highest in the world: it has an area of about 3 million km^2, Mt. Everest (8,882 m above sea level) being the highest peak in it. The Tien Shan chain is about 2,450 km long with altitudes up to 7,439 m above sea level. The belt of the Carpathian - Balkan Mountains is 2,100 km long and 100 to 35 km wide with elevations up to 2,663 m above sea level... The relief of the given regions is very sharply expressed (with steep slopes), the soil cover is developed in places, the atmosphere is rarified, and the climate of higher zones is harsh. For all of these reasons and for certain positive effects on human health, the regions in question represent a special type of extreme zones (Fig. 9.7.).

The natural environment of high mountains affords predominantly unfavorable conditions for life. Geological, climatic, and biological factors can be distinguished for the influence they ert in this sense.

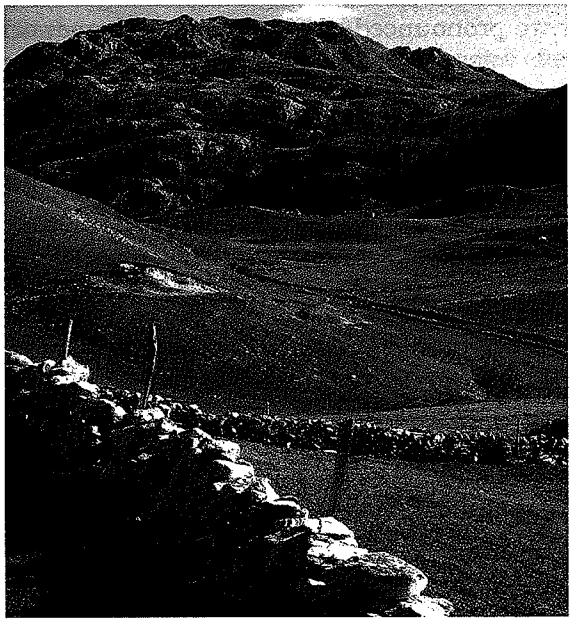

Fig. 9.7. Mountainous ambient.

As we have said, alpine mountain massifs are characterized by diverse **geological factors**. We note the negative and positive action of the more important among them:

1. Risks presented by the destructive force of *faults*, *earthquakes*, *landslides*, and *rock and mud torrents*, followed by various risks associated with *karst regions*, were the subject of the book's chapter on geological factors (Fig. 9.8). To them must be added the potential danger of high - mountain glaciers, snow avalanches, and slope failures. The indicated risk factors of the natural environment, like the positive influence of some of them (faults as pathways for circulation of low - mineral, mineral, and thermal waters, for instance), are primarily characteristic of alpine mountain massifs;
2. Diversity of the lithological composition of terrains, soils, and geological formations strongly affected the *geochemical characteristics* of mountainous regions and is manifested on the environment in different ways. Generally speaking, a higher concentration of vari-

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ous macro - and microelements - with predominantly positive effects on public health - is discernible in the geological environment;

3. Shallow layers of more fertile *soils* of the transitional and Ca classes are distributed on the carbonate rocks widely disseminated in the Alps, the Caucasus, and mountainous regions of Central Asia. These soils have different effects on human health. To be specific, elevated or reduced content of microelements acts indirectly on human health, both negatively (toxic action, endemic goiter due to iodine deficiency) and positively (in the cases of elevated content of calcium, magnesium, and other elements). Because contamination of soils can occur due to leaching from higher regions, conditions are created for occurrence and propagation of gastro - intestinal diseases, while microbic pollution of the soil leads to anaerobic infection of wounds, tetanus, etc.;

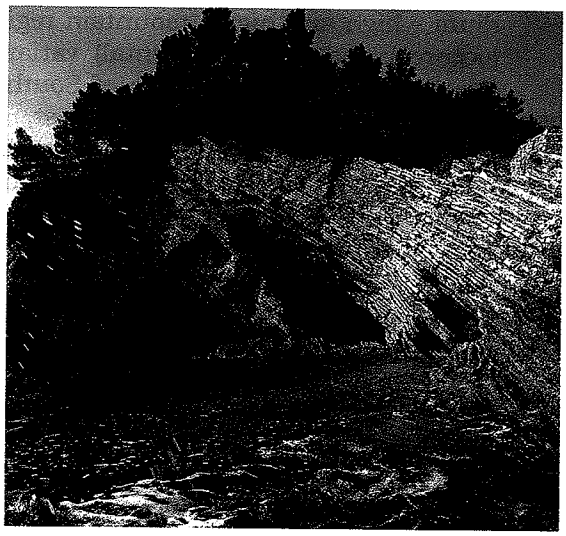

Fig. 9.8. Cliff near to Petrovac (Montenegro).

4. *Waters* of mountainous regions are characterized by a number of properties interesting from the standpoint of their influence on man. Brooks and streams have cold water that is slightly mineralized in regions with non - carbonate rocks. In the event of heavy rainfall, the lower courses become muddy and most often possess a limited capacity for self - purification and unfavorable sanitary properties (under these conditions, they become sources of intestinal and other types of infections). The more mineralized groundwater of karst springs and springs of other kinds is conspicuous for its good quality;

5. With respect to their *elevation above sea level* and the nature of their *relief*, mountainous regions of this geotectonic unit belong predominantly to the category of medium - high (from 1,500 to 2,500 m above sea level) and high (with elevations of more than 2,500 m above sea level) mountains. High plateaus such as the Eastern Pamirs, Tibet, and the Tien Shan Range form separate morphological units. Geomorphologically emphatic relief has an indirect effect on man that can be negative or positive. More will be said about the effects of relief in conjunction with climate in the text to follow. Here we mention increased physical strain and energy expenditure (a consequence of cardiovascular diseases among other things), fear, apathy, mental derangement, and mountain sickness;
6. In connection with *climate* - which in mountains erts especially profound and comprehensive influence on human health - all medium - high and high - mountain regions can be divided into wet (oceanic) and dry (continental) variants. The former variant includes mountainous regions of Southern Europe, parts of North and South America, the Far East, and Southeast Asia; while mountainous terrains of Asia Minor, Central Asia, and southern parts of the Cordilleras and Andes belong to the latter climatic variant. Natural conditions of the indicated types of mountainous regions and the nature of their influence on human health are different. Generally speaking, reduction of atmospheric pressure of the air and oxygen partial pressure with increase in altitude represents the main climatic factor in mountainous regions, which are also characterized by a harsh (sometimes dry) climate, cold and short summers, and strong winds. Disturbance of nervous activity occurs under the influence of climate in high - mountain regions, together with altitude sickness accompanied by headaches, apathy, drowsiness, weakness of the organism, and reduction of working capacity. Changes occur in cardiovascular activity, with expansion of the heart and blood vessels; functioning of the digestive organs is altered; the function of the liver breaks down; fibrose anemia occurs; etc. Sunburns are frequent, due to enhanced solar radiation. At the same time, the potentials of mountainous regions are very great from the standpoint of balneoclimatology, health tourism, and sport;
7. The *flora* of mountainous regions is diversified, but unequally disseminated. On carbonate rocks and poor soil rich in calcium at elevations greater than 2,000 m, extensive pastures are developed with grass rich in nitrogen, phosphorus, and other nutritive elements, but deficient in iodine, sodium, and other ingredients.

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Beech forests grow in the Carpathian and Caucasus Mountains, while the regions of the Tien Shan, Pamir, and Altai Ranges are characterized by broad - leaved forests of ancient origin. A wealth of endemic plant species is also characteristic of the Caucasus region (where nearly 20% of the entire flora is endemic), mountains of the Balkan Peninsula (where endemics can constitute as much as 27% of the flora), and other regions. Environments with such vegetation represent unique natural areas for creation of national parks, tourist zones, and spa facilities. Moreover, the plant life of mountains is rich in resources of medicinal herbs and vitamin - bearing plants;

8. Diversity of the *animal life* of mountainous regions ensures the existence and propagation in nature of many parasitic diseases, infections with natural foci, and transmissible diseases such as plague, leptospirosis of animals and man, malaria, tick - borne diseases, etc.

Other Boundary Structures

This group of boundary structures includes *rift valleys within continents, island arcs,* and *oceanic islands and plateaus* (Table 9.1.). The given structures are largely built of effusions of basaltic lava and are marked by the high cones of active volcanoes (Fig. 9.4.). In addition to common characteristics, each type of structure has its own unique origin and specific petrographic, mineralogical, and chemical composition, as well as its own specific content of microelements and isotopes (especially in regions with strong volcanic activity). Under such conditions, characteristic concentrations of fluorine, boron, and certain other elements play an important part in the evolution of organisms.

Mobile regions of the Earth's crust - above all ones with volcanic boundary structures - are marked by both current and ancient hydrogeothermal occurrences. Such occurrences have been studied most thoroughly in countries where much has been achieved in investigation and utilization of geothermal energy: the USA, Iceland, Japan, New Zealand, Italy, Turkey, and the former Soviet Union. Apart from geyserites (masses of amorphous silica), zeolite, travertine, onyx, quartzite, and other rocks, such regions are characterized by occurrences of mercury and its ores (cinnabarite), hematite, lead and zinc sulfides, and other ore mineral products. For example, ancient and current hydrogeothermal occurrences on the territory of Turkey include a mercury mineralization with the Halikoy - Beydag and Kaymar - ci mercury mines, and mercury is separated from contemporaneous hot springs.

The negative influence of geological factors in the given regions stems for the most part from the danger of *volcanic eruptions* and *strong earth-*

quakes, the most impressive, destructive, and terrifying of natural phenomena (Fig. 9.9.). The effects of these phenomena have already been discussed. We particularly stress the danger to the human population and to plant and animal life presented by poisonous gases, fumes, and volcanic mud currents, which can affect large areas during volcanic eruptions. Volcanic eruptions are often accompanied by contamination of springs and famine. The dangers presented by powerful earthquakes followed by rockslides and the damage they cause are also very great in these seismically extremely active regions. In addition to the danger from movement of masses along faults and rift structures, risks are presented by so - called *gas breathing* of the Earth's crust along such structures. Mercury vapors and elevated concentrations of radon are especially harmful[117].

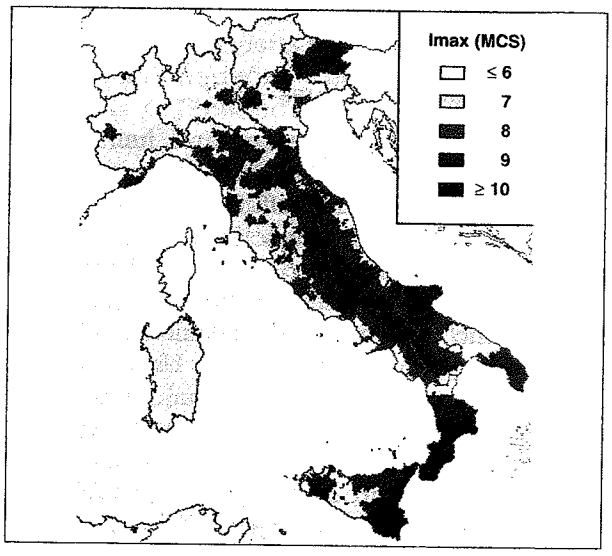

Fig. 9.9. Maximal seismic intensities registered in Italy between 1000 and 2000 (Molin, 2000).

From the other side, because of striking volcanic domes, fumaroles, solfataras, geysers, numerous hot springs and other occurrences, volcanic areas are picturesque and attractive for tourists, convenient for national parks forming. Suitabilities appearing because of volcanic activity are also expressed through emanation of necessary gasses into the atmosphere, forming fertile soil from volcanic ash rich in various trace elements, abundance of groundwater for drinking, etc.

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[117] *Helium breathing*, *argon breathing*, and formation of high concentrations of methane, carbon dioxide, etc., can also occur. It is interesting to note that there is even an ailment known as *rift fever*, a viral disease fatal for animals and man.

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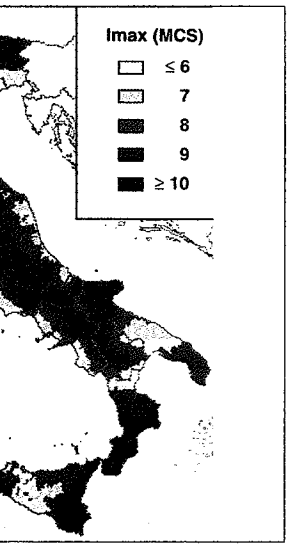

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LOWER - RANKING GEOMEDICAL UNITS

In studying geomedical characteristics of any territory, it is desirable to start with a geologically monotonous region, since it is possible in this case to establish basic regularities prevailing in the region and determine its favorability for human life. Such a region is usually composed of a single formation with definite petrological, geochemical, hydrogeological, engineering - geological, and other characteristics. For this reason, we shall examine lower - ranking geomedical units primarily in terms of the distribution of certain geological formations. It goes without saying that the medical aspect of such lower - ranking units has not yet been systematically studied. This will be one of the next tasks of medical geology and medicine.

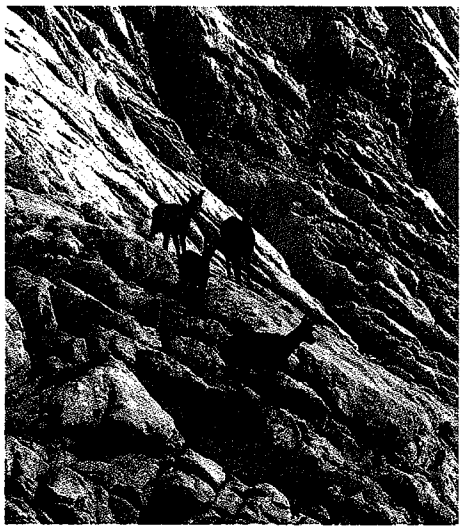

Fig. 9.10. Process of karst erosion in limestones.

The definition of a geological formation as a lower - ranking geomedical unit need not exclude reliance on some criterion used to isolate geomedical units of the first order. For example, a regionalization in which units of the first order are established on the basis of lower - ranking tectonic structures can be completely justifiable. In any event, geomedical characteristics of every isolated region must be examined in connection with general regional regularities.

Let us dwell on several geological formations, which by the way are very numerous:

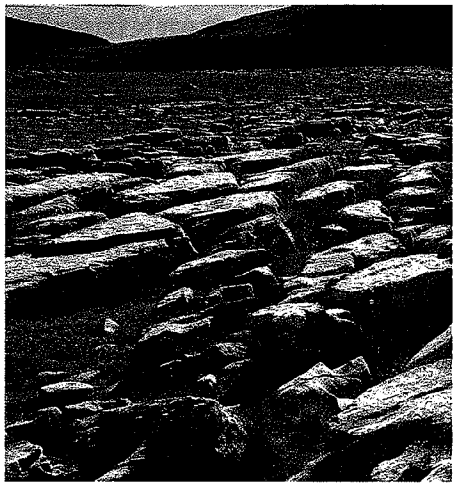

Fig. 9.11. Karst (limestone) ambient.

1. Thick plates of *basalt* cover enormous areas of the mobile belts of continents. For example, the cover in the western part of the Indian Peninsula has an area of about 300,000 km^2 and thickness of 1,600 m (Fig. 2.4.). In the chemical properties of rocks, soil, and water, as well as other geological characteristics, this geological (natural) environment differs greatly from others. For this reason, it can be assumed with high probability that definite geomedical conditions prevail on such a monotonous area. This is all the more likely in view of the fact that such regions with basalt are distinctive for the content and abundance of microlements and rare earths present in them, as well as the frequent negative effects of pronounced current volcanic activity;
2. Formations of *granite* and *granodiorite* are very widely disseminated in the world. These are rocks that can have significant concentrations of uranium and other natural radionuclides, with all possible risks to human health. Such formations include the uranium - bearing Phosphoria Formation on the Colorado Plateau (USA) and the Francevilien Formation in Gabon, both of which cover considerable areas. The problem is further complicated by radioactive contamination of soil and groundwater;
3. Attention was called earlier to the large areas covered by limestone (carbonate) formations (Figs.9.10. and 9.11.). Marked by phenomena created by the karst process (resulting in special morphology), superficially waterless over large areas, but possessing significant deep - lying reserves of good drinking water, such geological formations are characterized by specific organization of settlements and conditions favorable for human life, but also by a wide range of risks to human activity (collapsing sinkholes, risks in the sphere of hydrotechnological construction, etc.). With areas measuring several hundreds of thousands of km^2, such territories unquestionably deserve to be the subject of special geomedical study.

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