CHAPTER 11

Use of Applied Medical Geology Results in Economy and Health Care

By rapid development of the society, because of numerous values, geological environment became more and more important part of the environment, gaining nowadays the first - class significance (regardless if speaking about positive or negative role of geofactors). It is not acceptable to understand protection of the environment as only out - and - out defense of the human body from diseases, but as conservation of all values in the human beings surrounding, making their life more pleasant and to be handed down to next generations. In that way, tasks which can be solved by applied geology and applied medical geology for the sake of well - being of mankind, are noticeably broadened, more complex, different and very important. Subject of the further text are the two groups of practical tasks: - (1) tasks useful for economy and improving of living standard and (2) tasks important for organizing population health care.

USE OF RESULTS OF MEDICO - GEOLOGICAL EXPLORATION IN ECONOMY

Situation, in which the humanity was found at the early beginning of the 21st Century, is very complicated and alarming. Exponential growth of the population, followed by rapid decrease of natural resources reserves and simultaneous increase in various contaminants, are dramatically reminding the mankind to seriousness of the newly created conditions and directing to the necessity of fundamental analysis of our total behavior, activity and strategy of in regard to the surrounding

environment and the whole biosphere. Beside the mentioned, other global ecological problems, as progressive destruction of biodiversity, damaging the ozone layer, global climate disturbances, reducing cultivable soil, global water problem, global energetic problem, waste disposing problem, etc., are also producing worse situation.

In solving greater and greater disharmony between assigning for higher degree of the nature and environment and further progressive development of the modern society, introducing a concept of *coordinated (balanced, sustainable, permanent) development* is not only beneficial, but also only rational solution (I. Savic et al., 2000)[124]. Naturally, if we behave in that spirit. In that domain, geological and medico - geological practice can be very helpful. Some of numerous potential examples of taking measures in order to overcome the cited global problems, regardless tasks of defining and providing sources of raw or energetic material can be support for the mentioned attitude.

Measures for geodiversity conservation. Geological environment is the basic support of the environment. That is why (including other reasons, which were treated later) international behavior related to geodiversity, in other words - to conservation of geological elements (factors) diversity, has to be much more responsible in comparison to nowadays situation. General development of the mankind has to be balanced completely with strategic goal of protecting and improving quality of the living (natural, geological) environment for the future, for next generations. Some trials to attain the goal are performed by geological institutions from a number of countries, becoming engaged in the field of protection of geological heritage (ProGEO).

Measures for erosion prevention and soil recultivation. Soil erosion is one of the main forms of destruction and contamination of the

[124] According to A.I.Perelman (1975), one of important tasks of the science related to landscape is to develop optimization theory of the cultural landscape, that is - determine *optimal cultural landscapes* for different natural rayons. For each rayon, plan of natural resources management, based on complex study of the nature, particularly in evaluating link between integral parts of the landscape, has to be made. One of the ways of perception such links is geochemical study of landscape.

Within an optimal cultural landscape, by use positive geochemical characteristics and additional measures, geochemical conditions which can't be found in the nature can be made. So, after draining peat mud, landscape with significant content of dead organic substances in the form of peat coal uniting with very oxide medium, is formed, this is not possible to be found in the biosphere.

Naturally, optimal cultural landscape must be the most convenient in hygienic sense, and, finally - not contaminated. Modern hygiene defines certain requirements regarding quality of water, food, air, and made optimal standards of consumption for some compounds. Within the cultural landscape, using natural resources of not only studied rayon, but also others, very often of distant rayons, forming optimal conditions for life of the whole human population is possible, fulfilling standards of medical science.

environment, particularly within the process of intensive agricultural activity, felling of trees and destroying vegetation cover in general, constructing and mining activity as well as urbanization (Fig. 11.1). Result of erosion process is losing of the most fertile surface layer of soil, water accumulations filling by deposit and their saturation by nutritious elements from soil and fertilizers. For preventing and reducing erosion, various measures, rational and efficient only if planned according to the results of restricted geological exploration and zoning according to degree of rocks and soil cover erodibility, can be performed.

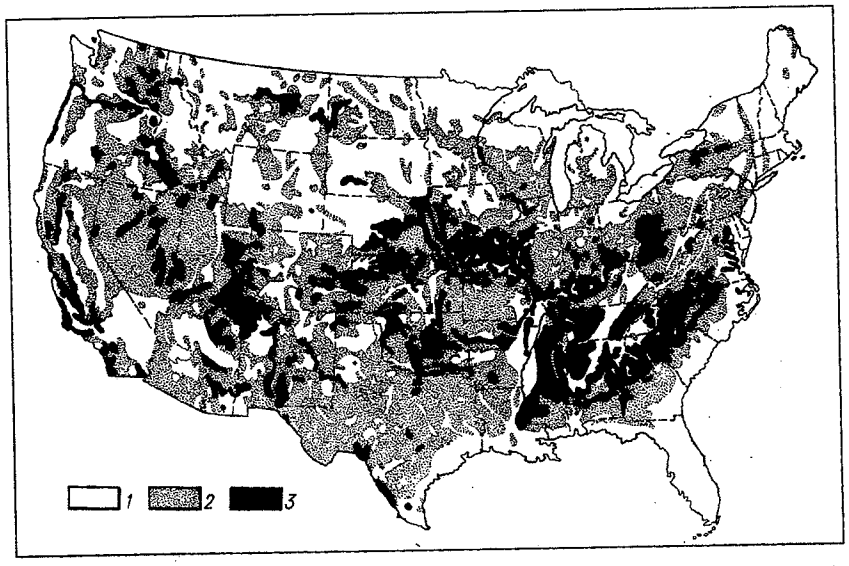

Fig. 11.1. Soil erosion in USA (according to the data of the Ministry of agriculture). 1 - insignificant or absent; 2 - medium (25 - 75 % of surface layer of the ground is destroyed, ravines presence possible); 3 - significant (over 75 % of surface layer of the ground disappeared, numerous deep ravines.

According to historical experiment, increase in biological productivity of soil and geological medium in wide sense was solved by two principally different ways (A.I. Perelman, 1961). *The first way* is based on mobilization of internal resources of the environment, as are: plowing fields (in order to make better conditions for breathing and feeding for vegetation), application of fertilizers (lacustrine sludge, fertilizers, etc.), intensifying oxidation process in swamp soil and their transformation into cultivable soil (with measures of drainaging and desalting, adding dolomite, zeolites, etc.), overcoming problems related to processes of soil erosion and ravining, plant selection. *The second way* means external adding a series

of deficitary chemical elements into the soil, which is performing by: wider and wider range of fertilizers (boric, selenic, manganese, copper, zinc, magnesium, etc.), maximal widening of biological circular process of elements within the soil, and, on the contrary, minimal natural removing of useful elements phosphorus, calcium, nitrogen, etc.), removing harmful elements, optimal moistening of pedological soil (irrigation). To make a right choice of efficient measures for soil recultivation, that is - forming cultural soil cover, with optimal geochemical regime and hygienic conditions, it is necessary to make high - quality geological basis, first of all - pedological, geochemical and hydrogeological bases of the interesting area.

Measures for providing high - quality water. In solving water problem of the mankind, providing high - quality drinking water is, certainly, a primary goal. Two principal directions of the activity are known in this domain - performing *measures directed to water protection from contamination and measures for protection of water resources from overexploitation.* Applied hydrogeology can have a very important contribution in solving the problems; *first* - to study vulnerability of so important groundwater resources from contamination from the terrain surface and define zones of sanitary protection. *The second* to contribute to rational use and regulation of groundwater reserves, by measures of artificial recharge of intergranular water - bearing formations, or by regulating groundwater regime, when speaking about karst - fractured formations.

Other ways of providing high - quality drinking water are also known, as well as modern directions for providing water for irrigation, that is - regulation of moisture regime at irrigated territories (M. Komatina, 1990, 1994). Questions referring to providing drinking water of high quality and for irrigation under desert and semi - desert conditions are specific and difficult for solving, but numerous high - yield deep wells direct us to conclude that even such cases have appropriate solutions. In finding solutions for rational management of groundwater resources, it is recommendable to start from *Basic hydrogeological map*, made for territories of the whole countries, in sheets of scale 1:50,000 or 1:100,000, as well as systematic and stage approach to hydrogeological exploration.

Protective measures from landslides, rockfalls, subsidence and soil breaking. The mentioned exogenous geodynamical occurrences are followed by catastrophic consequences for human lives and huge financial losses very often. Beside in USSR, the most complex national program for reducing losses from *landslides*, was issued by Japan, where, starting from the 2nd World War, planned, legally supported, systematic exploratory and rebuilding works are carried out. In France, on the basis of adopted program for zoning rayons with potential rock sliding, whole

series of map (1:25,000 or larger scale) is present, outlining unstable zones, but also giving instructions for correct distribution of objects in ground where constructing is planned.

When speaking about *rockfalls*, rehabilitation of the process means only prevention. Among the reclamation measures, artificially activation of rockfalls under controlled conditions and anchoring of mobile monoliths for stable foundation are applied most often. Protective measures at the steep slopes in Rio de Janeiro (Brazil) include concrete and stone walls, supporting concrete columns and metal bars strengthening rock masses bended over the slopes (A. Howard, I. Remson, 1978).

Damages of *subsidence* can attain catastrophic dimensions, particularly in cases of groundwater overexploitation, or oil and gas exploitation, when can spread over large areas and cause sinking low sectors of land and cities, destroying buildings and other structures, deformation of irrigation channels, destruction of underground communications, railroad tracks, bridges, etc. Such areas require special approach to engineering geological and hydrogeological exploration as well as to monitoring, in order to make correlation between water or oil exploitation and subsiding process, and to define exploitation regime.

Rayons with *soil breaking* occurrences, however, predominantly belong to karst terrains. Particularly vulnerable geological formations are very soluble gypsum and anhydrite, and that is reason why several dams in the areas characterized by such type of formations, have been abandoned. High quality geological base enables evaluation of latent danger of the mentioned occurrences. Soil breaking alone is very difficult to be regulated, but can be avoided, if the terrain is previously explored in detail and potential sectors for use outlined.

Protective measures from earthquakes. As human victims and financial losses as a result of this natural event can be catastrophic, voluminous engineering geological and geophysical investigations, as well as numerous preventive activities are performed. Two indispensable bases - regional seismic map and map of microseismic zoning, have been treated in the previous text. In the map of seismic risk for the territory of USA, rayons of potential risk were outlined (Fig. 11.2.), and in California, for precise planning and evaluation of potential destruction, detailed seismic maps and plans of seismic risk are prepared, as integral parts of all general plans in California. All mentioned bases offer possibility to evaluate dimensions of potential destruction, but also to plan precisely and define aseismic constructing (Fig. 11.3.).

Protective measures from volcanic activity. As speaking about geological event which is almost unpredictable and enormous risks to live in the areas of volcanic activity, series of unique exploration methods is performed, as well as monitoring and protective measures of distinguished

rayons, in order to mitigate consequences of lava and ash flows. The approach is, first of all, dependent on the type of volcano. Monitoring includes observing potential signals - warning eruptions, earthquakes, changes in slopes of the terrain, occurrences of new hot springs and fumaroles or changes in temperature and chemical content at the existing springs, soil temperature changes, etc., and main monitoring equipment is seismograph (A. Howard, I. Remson, 1978). Among protective measures, let us note lava flow bombing, barriers and trenches for drainaging lava flows, etc. In 1973, experiment was successfully performed on Iceland.

Measures for toxic waste disposal. Factually, almost in all countries of the world, waste dangerous for biosphere, in other words - for its normal survival, is existent. Problem of their disposing becomes more and more important during several last decades; investigations of possibilities are very complex, long - term and diligent, and acquired experiences very different. Water basins are not convenient as disposals, loaded by various unknowns, while in land, each country is looking for solutions within geological structure of appropriate territory - Germany is orientated to salt diapirs, Great Britain to evaporite formations and clay rocks, France - to granites, schists, clays and salt formations, etc. (B.Ciric, 1990).

In any case, good knowledge on geological structure and hydrogeological conditions of interesting areas and potential geological formations is the best basis to choose the most convenient formations and the most efficient measures which has to be undertaken in solving this very responsible ecological task[125]. It is reasonable that approach to finding the most convenient rayon for toxic waste disposing is based on geological and hydrogeological criteria, to which other criteria, required by valid regulations, are merged. The approach has been applied to example of geologically very complex territory, as the territory of Serbia (M. Komatina, 1990, 1993).

USE OF RESULTS OF MEDICO - GEOLOGICAL EXPLORATION WITHIN HEALTH CARE

Among problems with which mankind is confronting during the last decades, caused by contamination and enormous destruction of the environment, *global medical problem* extended into the first plan. All newly created global problems, in fact, are hiding serious dangerous for human civilization, life and health of human beings.

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[125] The most sensitive problem is, certainly, disposal of radioactive waste, where time dimension is very important. That is why among basic conditions which have to be fulfilled, the following ones are included: 1) impossibility of contaminated groundwater circulation into the other rayons and 2) permanent stability of distinguished rock masses.

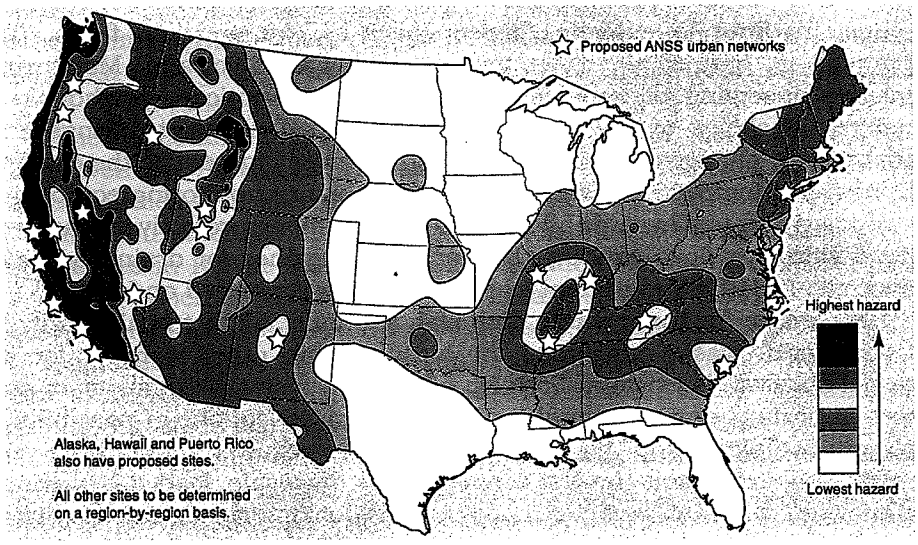
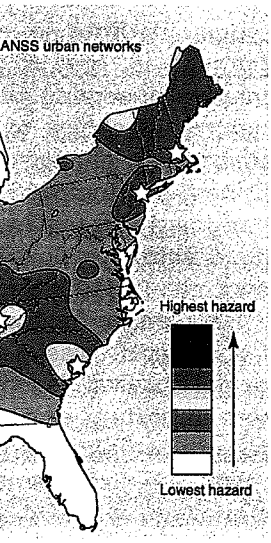


Fig. 11.2. Seismic hazard for the territory of USA (USGS, 2000).

Doubtlessly, ecological problem of protection of the environment formulated very complex and difficult tasks to the contemporary medical science and health care. In that way, within medical science and practice, more and more significance belongs to *global problems of health care*, which is not, according to their character, possible to be solved by individual efforts of the countries, in other words - require united efforts of all countries in the world as well as the international community. After Keller and associates (1993), three following health care problems of global character are known:

1. *programs development and preparing efficient complex systems of health care in countries throughout the world, characterized by different socio - political system and level of economic development, the system capable to provide right of inhabitants to obtain rapid and qualified, urgent and specialist's, prophylactic and medical help;*
2. *organizing fight against such permanent infectious diseases, as plague, cholera, yellow fever, AIDS, or widespread tropic disease, as malaria, for instance;*
3. *problem to fight against cardiovascular diseases, neoplasmes, some chronically and hereditary diseases, widely spread all over the world.*



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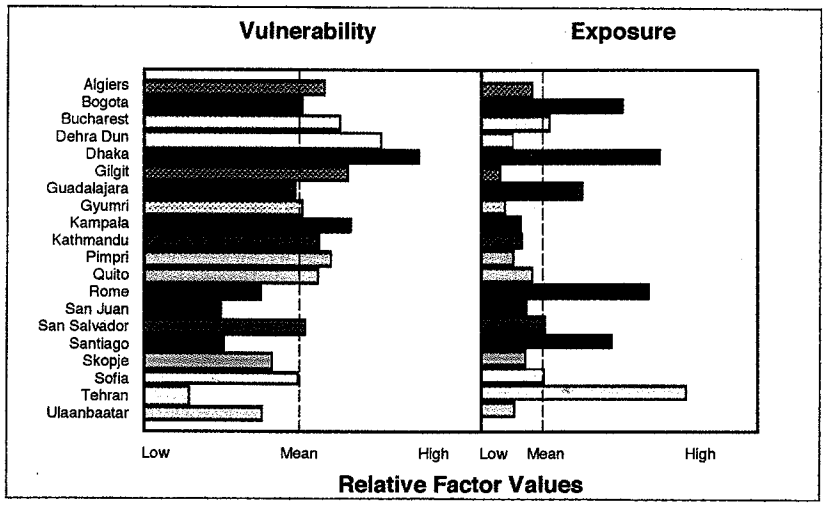

Fig. 11.3. Seismic risks in some urbanized rayons (IDNDR, 2000).

In this domain, significant results have been attained by the World Health Organization, as a leading and coordinating institution in the international activity related to health care. Let us remember successful liquidation of pox during 1958 - 1985, or organized work on prevention, diagnostics and clinical treatment of AIDS patients[126].

Preventive medicine, in other words - performing prompt and rational prophylactic measures, and qualified treatment of sick persons, has very important role within the process of improving level of population health. Conditions of health care in different regions of any state territory can be very heterogeneous, depending on large number of natural and socio - economic factors, among all - urbanization degree and state of transportation network. Unique situation can appear in the territories predisposed to negative elemental natural (geological) occurrences, which can disturb and discontinue all kinds of connections, becoming a source of traumatism and other pathologies (earthquakes, volcanic eruptions, catastrophic mass sliding, rockfalls, stone - sludge torrential flows, floods, fog, etc.).

Further, problem of logical linking of the complex *nature - man (health, health cure) - economy*, as an essence of health care within some country, requires organized multidisciplinary activity directed to development new modern methodology of research as well as ecological approach to health prevention. Medical treatment of the population

[126] The first case of AIDS was registered in USA in 1981, suddenly spreading over the whole Planet in the form of infection pandemy.

cannot be carried out according to a stereotype and over administrative units - it has to be based on geographic and geological features of certain regional types of the country's territory, for which unique standards and requirements of health care are defined.

Nowadays, factors of natural (geological) environment are not studied enough yet, as well as influence of numerous anthropogenic factors on human health are difficult to be predicted. That is why new *nosological forms* and appropriate scientific classification of diseases appears to be a very important task of medicine, task of the highest significance for health care organization. Even in 1972, A.P. Avtsin underlined real benefit from correct outlining nosological units, which is of the same significance for the mankind as discovery of new chemical ingredients or new elementary particles in physics. *"Argumentated distinguishing each new disease, and hence, more disease categories, means not only certain victory of human intellect, but also one of the first real preconditions for successful health care"* - concluded Avtsin.

Role of applied medico - geological discipline, as well as importance of use obtained results and cartography in health care organizing is also noticeable in rapid and efficient solving actual complex tasks of medicine and health care. First of all, contribution of medical geology in affirmation of geological preconditions of diseases, in other words - in distinguishing new nosological forms, but also in clearing up natural characteristics, forces, processes and occurrences; degree evaluation of comfortability, conditions and quality of the environment; making optimal conditions necessary for living activities. Some domains of possible use of geological and medico - geological exploration results for the cited purposes are presented in the further text.

1. Link between natural conditions and human health is noticeable. Nutrition, health conditions, capability for work and vitality are dependent on quality of air, climate, soil, plants and animals. In order to be healthy, strong, alert and persistent, human beings tend to interact with preserved nature. From the other side, natural potential of numerous territories of the Planet, particularly mobile tectonic belts, is still enormous. In order to use and preserve that gift of the nature in optimal and coordinated way, for the well - being of this and future generations, high level of geological knowledge on all potential areas when speaking about treatment, vacation, recreation and tourism; is principally required; starting from zoning and evaluation of potlined rayons[127]. Let us note rayons rich in

[127] It is desirable that all aspects of practical contribution of environmental and health care geochemistry are presented in the maps of medico - geochemical zoning; for example, distribution and prognosis of biogeochemical endemies, other geochemical and geological

mineral and thermal waters, which are very significant resources in numerous countries of the world. Use of the water resources makes the spas to be very attractive tourist destinations with a long tradition, not only in domain of tourist, but also of health care services. For rational management of mineral and thermomineral water resources, high degree of information and protection is required, as well as reliable geological - medical evaluation of quality, quantity and usability of the potentials. According to results of various detailed hydrogeological, hydrogeochemical and balneological investigations, desired basis is possible to be obtained. Special type of applied medico - geological and medico - geographic works is analysis of conditions in various rayons, serving for clearing up capabilities of their use for recreation.

2. In order to solve a series of practical tasks of prophylactic medicine and health care, it is necessary to acquire voluminous material referring to geological (geochemical), medical, biological and other investigations. Geochemistry, for example, has a significant contribution in collecting input data for explaining disease carriers, development of prophylactics and finding the best ways of treatment (eradication of biogeochemical endemies, caused by deficiency or surplus of some elements within the system *rock - soil - water,* etc.)[128], but also forming optimal content of chemical elements in food products and water, providing human body in the best way. Leading role in solving such problems belongs to medical sciences, but geochemical study of each interesting area is also of high importance. Finally, for each area, sanitary - hygienic evaluation of appropriate geochemical conditions, with defined ways of forming an optimal geochemical regime (that is - optimization task solved), is necessary. *"Through capability of forming optimal geochemical regime, mankind obtains a new powerful factor of improving health, vitality extending, improving the whole physical nature of human beings, a factor which was not a characteristic of the nature during several billions of years of life presence in the Earth" (Perelman, 1975).* For example, optimal geochemical regime understands optimal level of selenium, as one of trace elements essential for human body. That is why a problem of population appeared because of deficiency this element in rocks,

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factors of the environment influencing on human health, spa resources of geochemical origin, etc. (A.I. Perelman, 1975).

[128]Numerous diseases of cultivation plants and domestic animals are also caused by deficiency or surplus of chemical elements within the environment.

soil, water and food, determined by preliminary geochemical investigations, can be solved by application of selenium microfertilizers and in other ways, as done (on the basis of program on the national scale) in Finland, China and New Zealand. In that way, important role in prevention of cancer, heart diseases, detoxication during heavy metals contamination is fulfilled; helping also in possible physiological damages caused by diabetes, immunity stimulation, longevity reaching. The situation is similar when speaking about iodine, fluoride and other elements deficiency in food and water as well as their compensation. Problem of fluorine, iodine, boron, and iron or manganese surplus can be also solved by application of some of appropriate technological removing procedures.

3. In the world, areas characterized by extremely high or high content of naturally radioactive elements are known. Outlining such (radioecogeological) areals is of indisputable importance from radiation - epidemiological and radiation - hygienic viewpoint, in order to evaluate radiation risk for human population living in the certain territory or wider[129]. In solving the cited problem, data of geological exploration of nuclear raw materials, as well as radon exploration followed by compiling maps of radon risk, about which we discussed in the previous chapters, and particularly radiogeological investigations of the interesting area intended to needs of medical science and health care, can be of invaluable help.

GEOLOGICAL FACTORS AND HEALTH ASPECT OF STAY IN OFFICE AND AREA OF AN APARTMENT

During their development, human beings expressed tendency of longer and longer stay indoors, office or in apartment. According to available data, nowadays, man spends indoors even over 80% time during a day. By such way of life, he practically deprived himself of all positive influences of the environment in relation to his health and working capability, from one side, and exposed to danger influences present indoors, from the other. Stay indoors, less and less made of natural materials, resulted in consequences on human health, followed by a series of *specific diseases* (allergic alveolitis, fever because of humid air, asthma, allergic diseases of

[129] Of course, consequences of soil and water (and, indirectly, food) contamination by radionuclides occurred after damages of nuclear power stations or during nuclear tests, partly because of use phosphorus fertilizers made of apatite and phosphorite should be also kept in mind.

nose and eye, manifestations on skin), but also various bacterial and virus diseases, mild chronic intoxications. Besides, carcinogenesis as a mechanism of diseases origin means possible harmful effect of asbestos from building materials and, particularly, radioactive radon (Rn_{222}) and its descendants - frequent "inhabitants" of indoor space. Beside mentioned *specific diseases,* health disturbances which are not defined medically as diseases, but expressed through non - specific subjective difficulties, are the centre of attention. Group of such disturbances of benignant character has been studied since 1983, as a *sick building syndrome.* The most frequent symptoms of the *sick building syndrome* are: headache, blocked nose, sore throat, eye itch or tearing, lethargy, painful neck, dry eyes, dry skin (Z. Marmut, 1998).

Specific carrier factors causing in some number of persons symptomatology of *sick building syndrome* can be classified into the following categories: 1) *geological,* 2) *biological,* 3) *chemical* and 4) *physical factors of the environment.* We will focus on the part related to *geological factors* and possibilities of reducing or total eliminating their influence on human health. From that point of view, geological composition and characteristics of rocks and soil within the foundation of the building, tectonic disturbance of rocks and particularly presence of fault structures, groundwater existence in rocks and moisture in soil and used building material, various geophysical fields, radioactive radiation from rocks, soil and used geological building materials, are interesting (Fig. 11.4.).

Starting from a whole series of the mentioned geological elements, it is real to presume that, by exploration results, geosciences and applied geomedicine can contribute significantly to analyze negative effects of the cited and other geofactors, hence - to construct on the suitable terrain and, using biologically qualitative (*"healthy"*) materials, to avoid some bad materials. In other words, geology and geomedicine can be of indisputable importance in providing healthy conditions for life and work of human beings, staying (as mentioned) the greatest part of their lives indoors. In the following text, some of illustrations are presented. According to exploration carried out in Great Britain, in percentual relation of *radioactive emission in the environment,* radiation from the terrain is 47%, from soil and objects - approximately 14%, food and beverages - 12%, etc). The other authors direct our attention to crucial role of natural sources of radioactivity within total radiation of population (85%), of which radon is predominant (49.5%), much less from artificial sources (15%) (I. Petrovic, 1998). On the basis of epidemiological studies of American Environmental Protection Agency (EPA), performed in cooperation with various health centers, radon is at the second place as a carrier of lung cancer (after smoking), highlighting very high risk for smoker staying in apartment with high radon concentration. Radon risks can be extremely increased within

seismic active areas, because it was determined that during intensive repeated earthquakes, content of the gas in groundwater significantly changes.

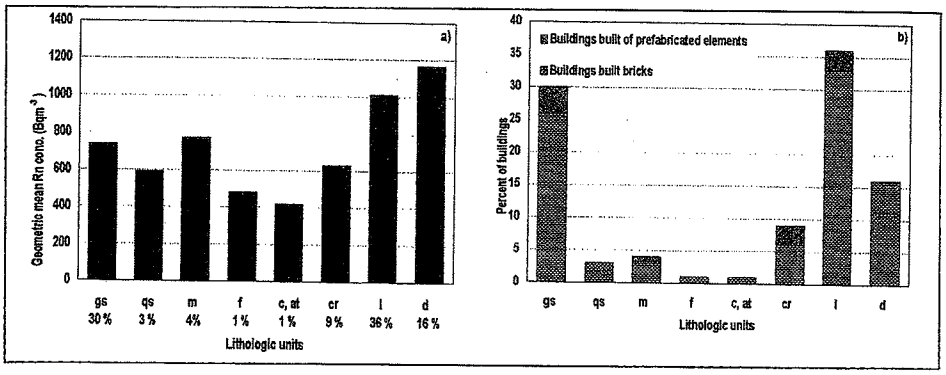

Fig. 11.4. Geometric mean radon concentration on each lithologic unit (**a**); percent of buildings on each lithological unit, constructed of bricks or prefabricated elements (**b**); (gs - glacial sediments; qs - quartz sandstones; m - marl; f - flysch sediments; c, at - claystone with intermediary layers of andesite tuffs; cr - various clastic rocks; l - limestone; d - dolomite (A. Popit and J. Vaupotic, 2002).

Risk of radioactivity is extremely high in the areas made of rocks containing uranium, including their soil cover (granite, basalt, gneiss, tuff, pumice), particularly if the rocks are tectonically damaged and permeable for radon, or contain groundwater as the gas carrier. As a risk factor, geological building materials from the mentioned areas are also known, but also new materials, made of slag from blast furnace, ash from steam power plants, phosphate waste from uranium mines[130, 131, 132], etc. Negative aspect of stay indoors built of such material was presented for the first time in 1972 by the Ministry of science in Germany,

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[130] Main source of radon in the ground floor is gas from geological environment (approximately 60%), while in case of apartments on higher floors, building material has very important contribution (approx. 50%).

[131] At the beginning of the fifties of the last century, alum shale with natural radioactivity (according to summed formula) over 20 (allowed value: 1) was used for concrete production in Sweden; during 1952-1966 period, in Colorado and Ontario (USA), as also in Australia, waste from uranium mines were used; in Japan, until 1974, building industry produced 3 million tons of artificial gypsum, made from phosphorite, etc.

[132] Large number of used building materials can contain chemically harmful - toxic supplements. Consequences of toxin activity can be malignant excrescences or occurrence of carcinogenic diseases. When speaking about negative effects on health, asbestos, which was intensively used in civil engineering, is mentioned very often, as well as other fibrous non-metallic row materials.

recommending that building materials characterized by high natural radiation, particularly when speaking about space where someone stays for a long time, should be avoided (R. Terzic, 1997).

Geophysical (physical) fields of natural or artificial origin, have a significant influence on human beings and other organisms (S. Komatina, 1998). The topic was discussed in appropriate chapter, and potential risks are analyzed in detail by S. Mares and associates in the book **Applied geophysics in environmental engineering and science** (1997).

In the literature, consequences of various fields of underground flow and geopathogenic zones on the human health, based on the results of measuring by pendulum or divining rods, are also presented. The method itself, known as *radiestesial method*, is considered as non-scientific, and is not treated in this book. For example, it is not real to expect presence of hydrogeopathogenic privileged groundwater flows within isotropic intergranular alluvial medium, which are presented by V. Momcilovic and V. Minic (1998) as areas of high importance in occurrence of endemic nephropathy and malignant neoplasms in southeastern Serbia. In this case, possible effects on human health could be a result of geological events in the alluvion footwall (for example, radon migration or of some other dangerous gas coming from the deeper levels along some fault line).

APPLIED MEDICAL GEOLOGY AND LAND - USE PLANNING

Land - use planning is very important task of far - reaching significance for each country, and has to be realized extremely resreliably and thoroughly. As an example of good organizing, land - use planning referring to health care in Netherlands, where, besides all, public opinion was also taken into consideration is presented. Main approach to the land - use planning has to be ecological, based on widely accepted and established ecological principles and regulars in planning, arranging and protection of the space, in accordance with concept of sustainable (coordinated) development. In essence, instead directing to protection of exclusively natural comples, as a basis for their rational use, nowadays, problem of human health protection, recovery (improving) conditions for life, work and rest of population, is at the first place. In that way, number and significance of questions which has to be solved, beside others, by experts for medical geography and medical geology, is increased.

Characteristics of medico - geographical and medico - geological exploration for needs of planning offices depend significantly on geographical conditions, in other words - on geological structure of the interesting territory, uniqueness of a task, dimensions of the studied event,

planning stage, etc. According to Keller and associates (1993), for case of medico - geographical exploration, a series of similar features is the following:

- precise defining of input medico-geographical situation;
- analysis of perspectives of economic and socio - public development of the territory and choice of the most acceptable strategy of the development observed from the position of medical geography;
- development of medico - geographical zoning system of the studied territory, adequately to the task defined in the planning task;
- making medico - geographical forecasts for each distinguished rayon;
- wide use of cartography during all stages of solving the defined task.

The mentioned decisions can be predominantly valid even when speaking about medico - geological exploration for the sake of land - use planning.

It is not so strange if in some of previously made land - use plans, geological environment with appropriate potentials, which are important for health care planning, is not treated enough. For example, Spatial plan of Republic of Serbia, from 1995, predominantly neglected not only mineral raw materials, but also hydrogeological, engineering - geological, pedological, and seismological and geomedical factors. This is the way of underestimating geological wealth or making their rational sustainable use difficult by wrong purpose and space occupying, from one side, and overlooking geomedical factors complicates correct organizing of population health care, from the other. One of the most significant types of collision between geological wealth and space occupation appears during constructing large settlements, cities or traffic arteries in the areas with groundwater sources, cultivable soil, deposits of mineral raw materials, etc. A striking example of collision between town and geological wealth is Tuzla (Bosnia and Herzegovina), with salt deposit, over which a town with over 100,000 inhabitants was formed; the town was endangered by terrain settling over the deposit exploitated by salt water pumping, and value of geological wealth was significantly reduced because of increased expenditures of exploitation (M. Babovic, 1992). Underestimation of geological wealth by urbanization is probably much frequent than it is known, because the ore body under the settlement will be very difficult to be discovered, and much difficult to be exploitated. Just in that, but also on other facts, is significance of some *modern geological base* made for needs of land - use planning, related to management and protection of geological potential.

From the standpoint of planning space use, two basic approaches to classification of geological environment - from the standpoint of danger and from the standpoint of resources - can be distinguished. Dangers has

to be taken into consideration, but man has to be diligent to resources, in order to understand natural processes and adapt to living conditions in the areas of limitations restricted by the processes (Howard, Remson, 1978). Knowledge on features of the geological environment and correct defining is one of preconditions for quality of plans, not only spatial, but also plans of development.

For making plans, cartographic methods are most often used. Three types of base: 1) *bases of general type,* with presented geological structure of the terrain (Basic geological map of the territory and others); 2) *analytical bases,* treating certain relevant features of geological environment (for example, metallogenetic map, hydrogeological map, map of seismic activity and terrain stability, geoecological map, radiogeoecological map, etc.); 3) *synthetic bases,* dedicated exclusively for direct use by planning teams, with content dependent on purpose, that is - of the level of planning.

Geological problems of protection the environment through space planning is not equally treated in different countries. According to J. McCall and B. Marker (1989), various contents of bases are more often stated in the following way:

1. *geological maps of the environment* (geoscientific maps), including geological, geomorphologic, hydrogeological, geochemical, geophysical and other maps as a complete set, sometimes with collective restricted interpretation, as well as some necessary non - geological bases;
2. *engineering geological maps,* referring to problems of constructing the objects;
3. *maps of potentials,* presenting resources of geological wealth;
4. *maps of geological resources,* showing mineral raw materials at the surface and in depth, appropriate dimensions and quality;
5. *maps of pedological potential;* presenting possibilities of soil use or potentials of processes which are underway;
6. *thematic maps,* related to special problems;
7. *documentation maps,* containing field and other data referring to the treated subject;
8. *maps of restrictions,* directing to limitations of soil use;
9. *maps of dangers,* presenting types and degree of different dangers at the explored area (Fig. 10.1.);
10. *risk maps,* related to certain type of danger and presenting probability or dimensions of their effects.

It is noticeable that *hydrogeological and hydrogeochemical maps,* which are important because of presenting distribution and chemical content of groundwater (low - mineralized, mineral and thermal water), nowadays so important resources of the Planet, are not treated.

The first bases of multithematic content dedicated to space planning were made in the former CSSR in 1961, and this manner spread to other countries of Europe and USA. In Yugoslavia, *maps of suitability for constructing (urban suitability)* were made in 1972, and Spanish experts included into the set this base five years later[133]. In USA and Canada, for presenting geological problems for the needs of space planning, term *geological map of the environment* is used, with different contents in various parts of the state territories (in dependence on natural conditions, population density and development plans, but also on subjective approach of geologist; for example, in western parts of USA, very important place belongs to seismicity and terrain stability, but in others, soil recultivation after mining activity is important, in the third ones - groundwater contamination, or salt intrusion in coastal parts, etc. In Great Britain, the first *geological map of the environment* was made at the beginning of the eighties of the last century, for one area in Scotland. In France, detailed bases (with presented geomorphologic characteristics, thickness and type of sediments, erosion, foundation conditions, limestone mines, karst terrains) were made for the area of Paris in 1979, as well as zoning according to geotechnical characteristics. Some time later, *regional maps* (with review of conditions of soil and groundwater use, zones of sanitary protection of aquifers, zones of groundwater recharge and accumulation, near - surface deposits of mineral raw materials, interpretation of pedological soil fertility, limitations in sense of constructing because of unsuitable ground characteristics and needs to protect important geological localities)were made in Western Germany. In the former USSR, problems of land - use planning were gradually entered into the content of engineering geological maps.

In the book **Geology and protection of the environment** (1992), as an example of systematic exploration of the whole territory of one country, M. Babovic distinguished *Geological and realized maps of the natural environment and resources, 1:50,000,* based on the project of Geological Survey of the former Czech Republic, started in 1985 (B. Moldan, 1986). This set contains the following nine maps:

1. *Geological map of traditional type,* presents structure of the ground and cover, including Quaternary deposits;

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[133] *Maps of groundwater protection* were made for the territory of Illinois (USA) in 1968, for the territory of Czech Republic (1:500,000) in 1967 and 1968; territory of France was covered by map of aquifers contamination (1:1,000,000) in 1970, and similar maps were rapidly made for the countries of Latin America. In the former Yugoslavia, the first map of aquifer vulnerability to contamination (1:500,000) was made in 1976, including territory of Croatia.

2. *Map of mineral resources,* presents all types of economic and subeconomic, proved and assumed reserves;
3. *Applied geophysical map,* contains results of all regional and detailed geophysical investigations;
4. *Hydrogeological map,* predominantly oriented to review of groundwater from the standpoint of water supply;
5. *Engineering geological map,* containing information on various natural conditions from the standpoint of constructing and soil use;
6. *Maps of pedological soil,* presenting kinds of fertile soil, as also composition of the soil, including interpretation of soil fertility and other features important from the viewpoint of agriculture and forestry;
7. *Geochemical map,* showing components vulnerable to react with groundwater, supposed velocities of reactions with groundwater, anomalous content of main biological components, as also microelements;
8. *Hydrochemical map,* made for surface waters;
9. *Settled map* (map of natural potentials), contains six sheets: 1) *elements of lithosphere* deposits and reserves of mineral raw materials, mines, main fault zones; landslides and other geodynamical phenomena, seismic rayons, stone ground); 2) *qualitative soil* (endangered by erosion, endangered by floods); 3) *hydrosphere* (activities in water supply, main surface reservoirs, zones of water resources protection, important occurrences of mineral waters, main sources of contamination and identified contaminants); 4) *biosphere* (natural reservations and similar; the most productive forests, important localities with vegetation out of forests - protection against erosion); 5) *areas of atmosphere contamination;* 6) *the most important objects made by man* (settlements, roads, railroads, devastated areas, etc.).

Lack of information regarding *radioactivity and ionization* (which can be related to conspiracy), as well as *geochemical composition of rocks and soil* - geological elements very important from the health care standpoint, is conspicuous (Fig. 11.5).

In the text referring to cartographic methods, we concluded that very informative atlas important for medical geology can be made. In the form of example, **Geochemical atlas of Slovak Republic** (1997) made of maps in scale 1:1,000,000 and legend referring to groundwater, soil, rocks, distinguished elements from the forest ecosystem and natural radioactivity in rocks and water, was discussed.

From the standpoint of space use, natural environment is consumed the most efficiently, if planner takes into consideration entire forms of relief making landscape, but also natural processes causing its application. Besides, he is obliged to know in which cases element of relief as a resource or a danger has to be treated. Further, resource as soil is should be cultivated in why which provides maximal benefit for society; from the other side, it can present a danger swelling, rackfalls, sliding

along a slope - processes followed by destructions of different degree). Let us analyze geological risks and their influence on human life. According to Howard and Remson, there are five types of reactions to geological dangers:

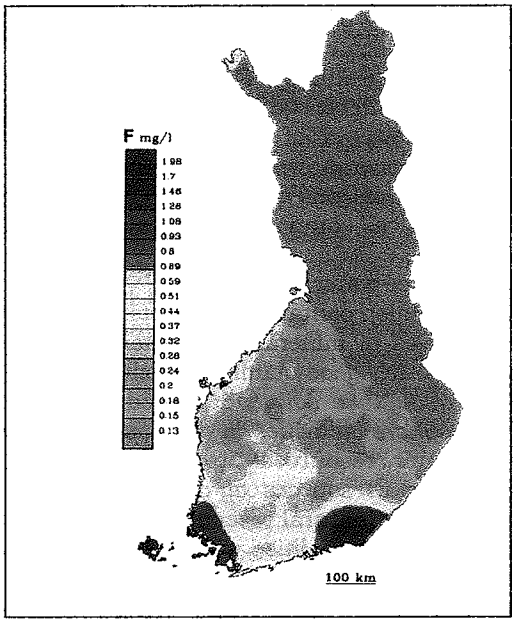

Fig. 11.5. Fluoride concentration in groundwater at the territory of Finland. High values of fluorine correspond to area of Rapakivi granites and other magmatic rocks, while water in crystalline schists are with very low content of that element (P. Lahermo, B. Backman, 2000).

1. *Danger avoiding,* as the most frequent reaction to the present danger (constructing on the territories exposed to floods and landslides, also rayons with active faults);
2. *Stabilization* is related to some geological dangerous which can be stabilized by economical investments;
3. *Providing measures of safety during constructing;* for example, measures of aseismic constructing, with economically justified expenditures;
4. *Introducing limitations in space use and its settling,* that is - possible regulation for agricultural or urbanization needs in accordance with degree of danger;
5. *Making informing system* for some dangers which can be prognosed and where urgent measures can be performed (floods, hurricanes, some parts of volcanic activity).

If there is enough soil for anthropogenic activity, one of the better ways is danger avoiding, that is - reclaiming safe (from that pooint of view) territories. However, many large settlements have already been constructed in the rayons with present geological dangers, and in such

cases, the mentioned ways of reactions and measures have to be considered. For example, a lot of houses, hospitals and schools in the state of California (USA) are constructed directly on the active faults, and so dangerous situation was reason why local authorities introduced a law related to geologically dangerous zones in the state (which was previously discussed). Or, use of land vulnerable to sliding, as a very difficult problem, was solved in town Portola - Vella in California by strict use of geological stability map, as a manual for activity and town jobs management (Howard, Remson, 1978).

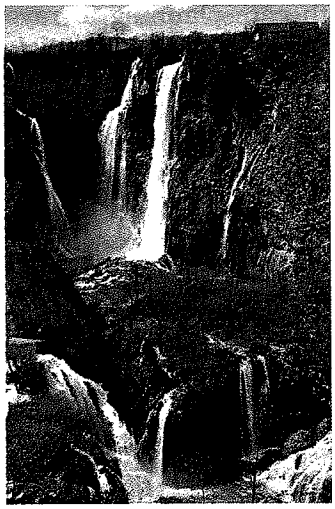

Fig. 11.6. Plitvice lakes, Croatia.

Regarding plans of environmental protection, approach to making part of general plans of towns and districts in California, concerning reserved areas, is interesting. According to the approach, the following spaces are distinguished: 1) *spaces reserved in order to preserve natural resources* (territories necessary for preservation plant and animal world, for ecological and other investigations, then rivers, brooks, bays and estuaries, beaches; coasts of lakes, rivers, aquifers), 2) *spaces reserved for exploitation of natural resources* (forest regions, pastures, plowed fields and territories of economical significance for food production; areas necessary for groundwater recharge; water objects used for fishing regulation; territories of basic deposits of mineral raw materials); 3) *spaces reserved for making recreation zones in the nature* (picturesque localities or localities with historical and cultural significance (Fig. 11.6.); territories necessary for parks and recreation zones, etc.); 4) *spaces used for needs of health care and population safety* (territories requiring special attention because of possible earthquakes, sectors with unstable land, water tapping, zones

necessary for water quality protection, places necessary for protection and improving air medium, etc.)

When speaking about terrains of mobile belts of the Earth's crust, wide range of tasks is put for geology and applied medical geology. Solving the tasks can contribute significantly to land - use planning and protection of agricultural and constructing land from erosion, sliding, rockfalls, settling, cracking; planning water supply and health care in karst terrains; geological heritage protection (Fig. 11.7.); planning protection human lives in the areas with earthquakes and volcanic activity (Fig. 11.8.); outlining potential areas and objects of health recreation; preservation of population in rayons with high radiation risk; health care planning in rayons with geochemical anomalies (deficiency or surplus of certain essential macro - and micro elements in rocks, soil and water, indirectly in food products), etc. Part of the mentioned elements of geological environment is particularly interesting in health care planning, and that is why some of them are discussed in the further text, keeping in mind that they have been already analyzed.

Fig. 11.7. Sjenice exsurgence, Western Serbia (Photo: D. Mijovic).

1. *Providing high - quality drinking water and protection of groundwater resources* for public needs is of varied health significance, and reserving space with practically interesting water reserves and performing measures of sanitary protection is one of principal tasks of the planners. Similarly is valid for relation to pedologically interesting *soil cover*, the second precious gift of the nature, nowadays exposed to erosion, chemization, exhausted in the sense of macro - and micro elements, salinization, degradation and other ways of anthropogenic activity.
2. During exploration of one or other territory, and planning use of natural resources, not only negative characteristics (factors) of

the environment has to be kept in mind, but also *"health stimulators"*, and on that basis - to make a choice of zones planned for rest and treatment. Land - use planning in the areas of *health recreation* often had negative effects on the space, and because of insufficient hydrogeological and balneological knowledge, important resources of mineral and thermal waters, gasses and medical non - metals (peloids) were not used enough or were endangered by various contaminants. For example, in the country marked by over 1,200 springs of mineral and thermal waters, as Serbia is, the already discussed Spatial Plan even doesn't mention that natural wealth (with outstanding variety according to chemical composition and usability); only 30 occurrences is used for needs of spas, and only five of spa centers possess Detailed urbanistic plan.

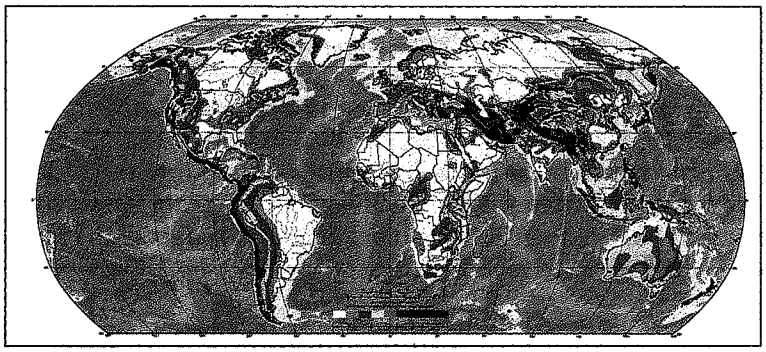

Fig. 11.8. Global seismic hazard map (produced by the Global Seismic Hazard Assessment Program - GSHAP) (USGS, 1999).

3. In planning health care, because of indisputable significance for human health, distinguishing *geochemical anomalies* have to be subject of much greater attention than until now[134]. That is also referred to *rayons characterized by high radiation risk*, first of all - with high risks of radon presence, which should be known in defining locations for new settlements (objects) (Fig. 11.9.). In both cases, main precondition for making optimal plan present detailed restricted geochemical or complex radioecogeological exploration.

[134] Numerous diseases of biogeochemical nature, as we already know, are dangerous for domestic animals and plant cultures.

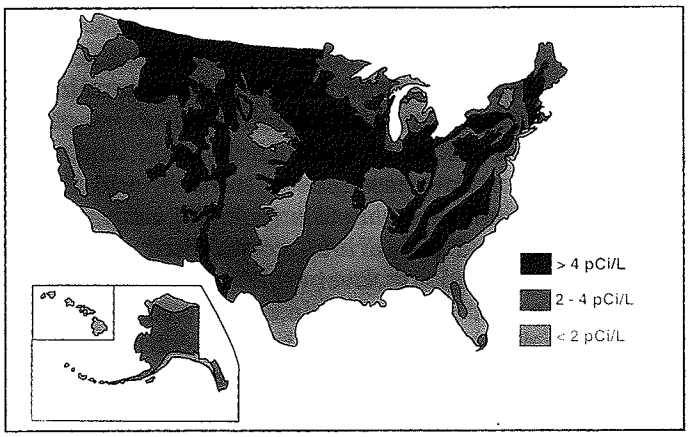

Fig. 11.9. Radon distribution in USA and Hawaii for Sept. 1992 (USGS, 1996).

4. Land - use planning in *areas of volcanic activity* requires unique approach, followed by accepting geological (volcanological) features of the concrete volcanic rayon. Problem of human adaptation on living conditions in such areas is complicated because of outstanding difficulties in domain of forecasting volcanic eruptions in the future (Fig. 11.10.). That is why such terrains are classified into specific zones, used for recreation or as picturesque national parks.

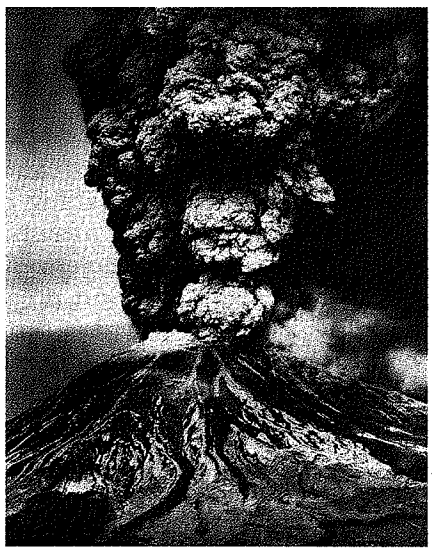

Fig. 11.10. Eruption of St. Helena volcano in the western part of USA at noon, 18th May, 1980 (R. I. Tilling, 1999).