CHAPTER 7

Subject and Tasks of Geological and Medical Disciplines in Defining Quality of the Environment and its Influence on Human Health

SUBJECT AND TASKS OF GEOLOGICAL SCIENCES AND DISCIPLINES

Like all of the natural sciences, geology has developed as a result of accumulation of the data of investigators and experiments and their theoretical synthesis. The current level of development of the geosciences is based on the efforts of many scientists (investigators) whose work laid the foundations for our modern understanding of structure and dynamics of the Earth.

The geological sciences are concerned with the composition, structure, and historical development of the Earth's crust; geological processes transpiring in its interior and on its surface; and forces and factors that cause those processes. The geologist primarily investigates the upper parts of the Earth's crust, i.e., those parts that are accessible to direct investigation. In so doing, he studies the kinds, composition, age, and distribution of rocks; the manner of their formation; and their mutual (structural) relations. He relates the rocks he studies to formations in neighboring districts or other (often very distant) regions. In addition to rocks, the subjects of study include various endogenous and exogenous forces, occurrences, and processes, as well as mineral raw materials and groundwater. Today it can be stated that vast regions have been studied

and the geological structure of great parts of the continents established. Largely owing to constant demands of the economy, the geological sciences are at the present time developed to such an extent that they are able to resolve practically all problems linked with the environment in which man lives and performs his various activities, namely the geological environment.

Knowledge of geology enables us to gain a deeper understanding of everything surrounding man. It helps us to recognize the beauties of nature; makes it easier to overcome our superstitious terror in the face of powerful, sometimes terrible and destructive, geological occurrences; and enables us to make use of mineral raw materials and groundwater. In addition to all this, such knowledge makes it easier to resolve various ecological problems and helps us to recognize positive and negative factors of the geological environment from the standpoint of human health.

With nearly two hundred separate scientific disciplines, geological science has permeated every pore of contemporary civilization.

It is therefore right to ask whether schools as a whole provide enough knowledge from the domain of geology as a basic natural science of broad cultural significance apart from its practical (economic) importance[97]. Does the problem of inadequate education in general partly conceal frequently inadequate treatment of the environment in the framework of medical geography and nonexistence of medical geology?

The *fundamental geological sciences* are devoted to study of the Earth's structure, origin, and historical development. The list of these sciences includes crystallography, mineralogy, petrology, geochemistry, geophysics, geodynamics, historical geology, paleontology, structural geology, and geomorphology, in addition to their various subdivisions (for example, sedimentology as a part of petrology, paleobotany as a part of paleontology, etc.).

Questions of utilization of the geological environment are the concern of a number of disciplines, namely the science of deposits of mineral raw materials, coal, oil, and gas; hydrogeology; engineering geology; pedology, geo - ecology; etc. Each of these disciplines of *applied geology* has developed its own fundamental base.

Fundamental Geology

In the area of fundamental geological sciences, there are three main directions (branches), each of which studies the Earth's crust from a different aspect:

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[97] The conservation of cultural monuments, for example, is today largely based on knowledge of the petrological, hydrogeological, and other geological characteristics of a given locality (S. Dragutinovic, 2000).

1. *Sciences concerned with composition of the Earth's crust*, often jointly referred to as sciences of the geochemical cycle (crystallography, mineralogy, petrology, geochemistry, etc.);
2. *Sciences dealing with geological processes or dynamics of the Earth* (geodynamics, geophysics, volcanism, seismology, tectonics, etc.); and
3. *Sciences that study the history of development of the Earth* (historical geology or stratigraphy, paleontology).

As the science of crystals, *crystallography* treats their external form and internal structure. Because natural minerals are in most cases crystalline bodies, study of their forms and the laws governing their formation is of great theoretical and practical significance.

Mineralogy is the science of minerals. Minerals - quartz, mica, pyrite, etc. - are unique chemically homogeneous bodies formed as a result of various physico - chemical processes transpiring in the Earth's crust. With properties dictated by their chemical composition, minerals are stable under the given geological conditions. Mineralogy deals with the chemical composition of minerals, their physical properties, and natural processes leading to formation of minerals and their associations. Different combinations of minerals form rocks.

Petrology is the science of rocks, of which the Earth's crust is composed. It treats the properties of rocks, their chemical and mineral composition, relationships between different rocks, changes of rocks with the passage of time, and regularities governing their formation and distribution in the Earth's crust. .

Chemical elements and their behavior in the Earth's crust and deeper layers of the planet constitute the subject of *geochemistry*. The geochemistry of processes deals with migration of chemical elements in certain processes transpiring in different parts of the Earth's crust. The geochemistry of systems treats migration of chemical elements in different systems (abiogenic, biogenic, and technogenic) characterized by opposed interconnected processes. The behavior of a certain element in different processes and systems is studied in the geochemistry of elements.

Two major problems of our epoch are closely linked with geochemistry. They are the problem of the environment and the problem of mineral resources. Methods of geochemical research are very important in dealing with these problems. *Environmental geochemistry* can be singled out as a discipline of particularly great interest to us. It deals with the distribution and interrelations of chemical elements and radioactivity in the system composed of rocks, soil, water, air, and living organisms, doing so mainly from the standpoint of human health.

Under modern conditions of diversified geological research, *geophysics* has a special place in both global (regional) and local investigations. In the era of rapid technological progress and high - precision instrumentation, the possibilities of geophysics have become practically unlimited, and it is fair to expect much of geophysical research in the future. The subjects of study of the Earth's physical properties include gravitation and magnetic, seismic, and electrical properties of the lithosphere or parts of the lithosphere.

Geodynamics is the science of processes occurring in the Earth's crust and its superficial zone. Depending on the source of energy, it is possible to distinguish internal (*endogenous*) and external (*exogenous*) processes. Endogenous processes

are linked with internal energy and include volcanism, earthquakes, and tectonic movements. Exogenous processes are in the final analysis linked with solar energy. They include the work of wind, surface water, glaciers, seas, etc. Geodynamics includes *geotectonics*, the science of rock formation and deposition, movements of the Earth's crust, and deformations that arise in it. Geotectonics in part borders on *geomorphology*, the science of relief of the Earth's surface, formation of that relief, and the process of its development. *Structural geology* deals with the structural pattern of the lithosphere's surface layer and that of concrete regions, i.e., the mutual disposition and relationships of rock masses in the narrower sense.

Historical geology (stratigraphy) is the science of the Earth's history. It reconstructs the course of geological events from the oldest times to the present moment. The main historical documents used to interpret the history of changes in the planet's surface are rocks and fossil remains of animals and plants in rocks, which constitute the subject of *paleontology*. Preserved in sedimentary rocks formed in the course of the Earth's geological development, the remains of old organisms and traces of life in general represent relatively reliable evidence on whose basis the stratigrapher can determine geological age of the rocks.

Applied Geology

Geology as a science studies our whole planet, but it also treats in greater detail narrower territories of interest from the practical standpoint. The constant demands of practice have brought about a situation in which today we have a number of very well developed disciplines of applied geology.

The *science of mineral deposits* is concerned with research on deposits of various metals, non - metals, and geological building materials. Energy reserves are the subject of *coal geology* and *petroleum* and *gas geology*.

As the science of groundwater, *hydrogeology* treats its origin, movement and evacuation, physico - chemical composition, and relationship to surface water. This branch of applied geology also considers the possibilities of utilization of groundwater for definite purposes and questions of protection of groundwater. There are a number of subdivions of hydrogeology, namely water supply engineering, mining hydrogeology, the hydrogeology and oil and gas deposits, hydrogeothermics, melioration hydrogeology, hydrogeochemistry, protection of groundwater, etc.

Engineering geology is a geological science concerned with properties and dynamics of the thinner superficial part of the geological environment primarily, its rational use and maintenance, and construction and exploitation of civil engineering works. Special attention is paid to the properties of rocks, engineering conditions at locations selected for construction projects, and the carrying capacity and stability of terrains. Existing parallel with engineering geology are *soil mechanics*, a scientific and technological discipline engaged in studying that part of the geological environment built of sands, gravels, and clays; and *bedrock mechanics*, which treats the properties of bedrock as a medium for construction projects.

Pedology is the science of soils. It deals with the physical, chemical, and biological characteristics of different kinds of soil and other factors of the geological environment connected with the needs of agriculture and forestry. *General pedology* is devoted to fundamental scientific research. In addition to it, today we also have *applied pedology*, whose purpose is to establish the suitability of soils for different uses.

SUBJECTS AND TASKS OF MEDICAL SCIENCES AND DISCIPLINES

The history of medicine is extremely long, and man's striving to discover the causes of disease is as old as his efforts to create religion. The transition from supernatural to natural explanations of disease was made already in Ancient Greece, and Hippocrates in that era suggested that elements of the natural environment are direct or indirect causes of disease[98].

Beginning with ancient medicine, the first stage in the development of medical science lasted all the way up to the 19th Century. The year 1800 represents a turning point after which the scientific approach to study of diseases was adopted much more widely. A number of increasingly notable advances in the area of health protection were made at this time, and at the end of the 19th Century the battle against epidemics became incomparably more effective owing to great achievements in the field of microbiology.

During the 20th Century, the highly developed natural sciences - biology, chemistry, and physics - were of enormous significance for the creation of firm theoretical and procedural foundations of the medical sciences. On the other hand, the sudden technological boom especially advances in electronics, automation, and computer technology, made possible accelerated development of new approaches in the diagnosis and treatment of diseases. In this way, modern medicine has become a very complex and involved system of sciences and scientific disciplines.

A considerable part of medical science is of interest from the standpoint of medical geography and geology. That part is treated in the introductory section, where interaction of medico - biological, geographic, and sociological disciplines in solving medico - geographic problems is presented. An idea of the subject and tasks of medical sciences and disciplines can be gained by dwelling on several of them.

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[98] According to J.R. Paul (1972), this ancient example of observation and conclusion might have laid the foundation of the inductive method of studying diseases. "Had those who came after Hippocrates followed his lead, man's knowledge of diseases might have gained the advantage of several centuries."

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Pathology occupies a central position among theoretical medical sciences. It is engaged in studying basic regularities governing the origin, development, and outcome of diseases in the living organism. The main task of *general pathology* is to learn what we can about the main pathological processes, viz., disturbances in metabolism (dystrophies), circulation (dyscyclias), and growth, as well as inflammations, tumors, and developmental anomalies. General pathology also embraces study of the causes and conditions of appearance of pathological processes (general etiology), as well as study of the origin and course of development of disease processes (pathogenesis). In contrast to general pathology, *special pathology* relies on definite criteria to elucidate basic pathological processes in individual organs and organ systems[99].

Pathology represents a very broad area of science, one in which a number of specialized branches have developed. They include, for example, *neuropathology, nephropathology, psychopathology,* and *biogeochemical pathology.* Of special interest to us is *geographic pathology.*

According to A. P. Avtsin (1972), *geographic pathology* represents an independent science engaged in studying regularities governing the origin, spread, and characteristics of the incidence of human diseases in different geographic zones of the Earth. The term *geographic pathology* was introduced in the medical literature by A. Hirsch in 1856. An especially important moment in the development of this science was formation of the International Geographic Pathology Society at the initiative of M. Askanazy in 1929. From then until 1970, the Society held ten conferences dealing with various questions of geographic pathology.

Study of the pathogenesis of human diseases represents an important scientific task of geographic pathology. Geographic pathology does not simply register some pathology of man in a given region; it also attempts to explain the origin and form of occurrence of that pathology on the basis of those data and data obtained in experiments.

Finally, if we analyze endogenous and exogenous pathogenic factors that have been examined by geographic pathologists throughout the long period of their activity, we notice that many of these factors are referable to the inorganic (geological) environment. Such factors include, for example, the geological and geochemical characteristics of rocks, properties of drinking water, biologically significant concentrations of micro - and macroelements in food (dependent on their content in soil and rocks) causing more serious pathological processes in humans and animals, etc. All this and many other considerations mentioned in Avtsin's 1972 book lead us to conclude that it is justifiable to single out a special branch, namely *geological pathology,* within the framework of medical geology.

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[99] Pathology in the broader sense of the word is not confined to changes in the organism of man and animals (*human* and *veterinary pathology*), but also deals with changes in plant organisms (*plant pathology*).

Physiology is the biological or medical science of vital phenomena and functions of the organism. It studies the functions of cells, cellular organelles, organs and systems, and organisms as a whole[100]. The word *physiology* in its present sense appeared in the 16th Century. In the history of this science, especially great progress was made in the 19th and 20th Centuries, when accelerated development occurred in biochemistry, physiology of the cardiovascular system, respiratory physiology, physiology of the kidneys, and neurophysiology. The latest research in physiology likewise is of a biochemical nature.

General physiology treats general regularities and functions common to all living beings regardless of the degree of their internal organization. Some authors use the term *cellular physiology* in this case, since life is studied predominantly at the cellular level. *Specific physiology* deals with only certain groups of living beings (human physiology, the physiology of domestic animals) or special areas of physiology such as neurophysiology, enzymology, hematology, etc. *Pathological physiology* studies the functions of organisms and their disturbances in states of disease.

Ecological physiology developed in the second half of the 20th Century. It is a branch of physiology engaged in studying the influence of natural environmental factors on formation and performance of physiological functions in the organism. It is logical that this physiological discipline is most directly linked with medical geography and medical geology.

Epidemiology is the medical science dealing with regularities of the epidemiological process and methods of combating infectious diseases of man. As was already mentioned, a turning point in the development of this science occurred in the 1880's, i.e., the era of Pasteur, which was marked by great bacteriological discoveries. A full contribution was later made by *experimental epidemiology*. We also mention *epidemiological geography* and its role in explaining the origin, endemism, incidence, development, and disappearance of various infectious diseases in different parts of the world.

Toxicology is the science that deals with the harmful (toxic) effects of chemical agents on living organisms. Its subject matter includes toxic agents (toxicity), the living organism (as a biosystem that reacts to toxicants), and the toxic effect (the sum of all physiological and biochemical changes). Enormous growth of the chemical industry in the 20th Century was accompanied by rapid development of *professional toxicology*. This discipline has been influenced by modern medical techniques and technology, which enable us in large measure to clarify the processes that occur when a toxin enters the organism. The exceptionally rapid development of biology (especially molecular biology) in the last decade of the 20th Century has made it possible to study the action of toxic substances on the molecular level, which is the subject of *molecular toxicology*. With the task of studying the harmful effects of pollutants on living organisms in the environment, *eco - toxicology* (environmental toxicology) has taken its place in recent years. We note also *aquatic toxicology*, the scientific study of toxic effects of an aquatic environment on its living organisms.

Medical microbiology and **parasitology** are branches of the medical and biological sciences devoted to studying the biological agents of human diseases

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[100] The *physiology of domestic animals* has been developed parallel with human physiology.

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and carriers of the agents of these diseases, as well as their relations with man and the environment in which he lives. These disciplines include clinical microbiology and parasitology, immunology, and sanitary microbiology and parasitology.

As the medical science engaged in studying the influence of environmental factors on human health, working capacity, and life expectancy, **hygiene** elaborates norms, requirements, and various measures designed to achieve the sanitation of settlements and ensure healthy living and working conditions for their people. The branch of hygiene that treats general regularities of environmental influence on human health and the procedures used to study them is called *general hygiene.*

During the earliest stage of its development in the 19th Century, hygiene relied on principles of medicine, physiology, and pathophysiology, which gave rise to the prophylactic concept. The next phase of development was possible only after suppression of the epidemics that carried off hundreds of thousands of lives. The main attention in this phase was transferred to *communal hygiene* and related disciplines, namely the *hygiene of work* and *nutritional hygiene.* In a period of increasing environmental pollution, the main task of the new hygiene is to create conditions in which production does not represent a threat to the environment and does not destroy the optimal ecological equilibrium. In the narrower sense, *environmental hygiene* represents a branch of medical science that elaborates medical aspects of environment protection and scientific ways of preventing unfavorable influence of environmental factors on the population.

Balneoclimatology is a medical discipline that deals with the action of natural physical and chemical factors of the environment on the human organism and the possibility of using them for medical purposes[101]. The natural factors used most frequently are mineral waters, peloids (medicinal mud), carbon dioxide, oxygen partial pressure, heat and cold (mainly in general procedures), and hydrostatic pressure. Depending on which of these factors is used, balneoclimatology is divided into *human bioclimatology* and *balneology.*

Human bioclimatology treats the relationship between the human organism and climate and the direct effect of weather conditions on health and sickness. *Medical meteorology* is a narrower area of bioclimatology dealing with the effect of short - term weather conditions and phenomena on the human organism with respect to a certain disease. On the other hand, study of the effect of long - term weather conditions (climate) on health or sickness is the subject of *medical climatology.*

Balneology deals with the action of balneological factors and the possibility of using them for medical purposes. The list of such factors includes: 1) mineral (medicinal) waters with varying degrees of mineralization, temperature, or radioactivity; 2) peloids of inorganic or organic origin having suitable chemical composition and physico - chemical properties; and 3) therapeutic gases of varying composition, including ones having adequate amounts of radioactive emanations (radon).

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[101] According to the book "**Balneoclimatology**" (Ed. by T. Jovanovic, 1997).

Every medical specialty of a theoretical, clinical, or prophylactic profile has its own *ecological aspects*, whose elaboration is not only desirable, but increasingly necessary. Generally regarded, the ecological approach in medicine involves examination of the interdependence between the human organism and factors of the natural and social environment, and study of environmental influence on the organism. **Medical ecology (human ecology)** - especially ecological physiology as one of its components - has developed rapidly in the last decades.

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CHAPTER 8

Methods of Medical Geology

Nowadays, voluminous and different literature in geosciences, medical science, medical geography, biology, chemistry, physics and other scientific disciplines interesting from the aspect of medical geology is present. Thanks to wide scientific, practical and social activity, particularly in USA, Russia, and EU and worldwide, as well as opportunities of modern technology, numerous research methods to solve various theoretical and practical problems are developed within the mentioned sciences. This is why the range of methods and procedures important for medical geology is so wide but, at the same time, made difficult, while the main selection is expected to be performed during the developing stage of the discipline. Namely, during development of medical geology and solving concrete tasks, not only methodological basis will be improved, but also methods of interest will be developed and applied.

On the basis of experience and scopes of medical geography, here is the preliminary choice (review) of the methods. The concept and methodology of research, like also application of methods, depend on certain scientific discipline, in other words - of the problem stated.

Elements (factors) which have to be known within application of the presented methods are discussed in the Chapter 2.

1. Remote sensing. Series of contemporary, fast, cost - effective, reliable exploration procedures is included. Essence of this methodological approach is based on analysis and interpretation of terrestrial, aero - and space records. From the records, abundance of data related to the environment - relief, lithological content and structure of the terrain, but also surface and (indirectly) ground waters, vegetation, etc., is obtained. This is reason why remote sensing is unavoidable integral part of almost

all sciences and scientific disciplines dealing with the surface of the Earth's crust and appropriate natural values. Nowadays, the method is widely used for solving various scientific and practical goals - within geological, geomorphologic, geographic and biological exploration, in forestry, soil science, land - use planning, environmental monitoring, etc. Note also successful application of the methods of remote sensing in study of the consequences to the environment caused by underground burning of coal at the territory of the northern China (X.M.Zhang, C.J.S.Cassells, J.L.van Genderen, 1999) (Fig.2.34.).

Long - standing application of stereoscopic analysis of aero - snapshots and accumulated rich experience are reason why the procedure is at the leading place among methods of remote sensing. Wide exploration of the environment by material of cosmic records also presented numerous advantages. Satellite records, however, offer a possibility of study large areas and enable new view on the Earth and appropriate geological, geomorphologic and geographic units.

Possibilities of the remote sensing application are neither completely investigated yet, nor recognized in total.

2. Geomedical mapping. This method is irreplaceable way for regional study of characteristics of the interesting natural environment. In practice, majority of geomedical tasks is not possible to be solved without direct link with terrain.

Field exploration for concrete scientific and practical purposes can be planned successfully on the basis of the studied literature and fund documentation, maps obtained according to processing and interpretation of aero - and satellite images, available geological maps, maps and atlases in domain of medical geography and medicine, etc. Goal in this stage of medico - geological exploration is to collect all necessary data related to various appropriate natural factors which could be of negative or positive effect onto the health of inhabitants, zones of high risk and potential natural foci of infection; to analyze and record: rocks and soil, engineering - geological and geomorphologic characteristics of the terrain; to outline rayons with high radioactivity, geophysical and geochemical anomalies; to register used sources of drinking water; to investigate resources of mineral and thermal waters, as well as rayons interesting from the aspect of balneoclimatology and health tourism; distinguish vegetation as indicator of negative effect of biogeochemical factors; to register medicinal herbs; to locate potential and present contaminants of the environment (mining and industrial structures, agricultural contaminants, landfills, etc.). From the medical viewpoint, in the field, among all, the following activities are carried out: polling of the families and medical checkup of inhabitants of study areas, field dispensary investigation; evaluation of diseases of population (data on disease structure, frequency of distinguished diseases,

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their seasonal appearance, etc), dynamics of infections and characteristics of significant endemic diseases; data collecting referring to health care organization. Field investigations are used also for sample collecting of rocks, soil, water, plants and food products for laboratory research.

Acquired information are processed and interpreted in the office. Wide - spread use of computers in research makes processing of huge amounts of data possible. In our case, data on medico - geological and medico - geographic characteristics of the study territory, serving not only for outlining characteristic features, but also for their evaluation, are of special interest. By computing processing, necessary data on different medico - geological, that is - medico - geographic indicators are obtained, making producing different specific purpose maps of the investigated territory easier.

3. Methods of fundamental (basic) geology. Geological factors, as mentioned, have significant role in evaluating degree of suitability for living at a natural environment. That is why research starts with analysis of fundamental (regional) geological characteristics and relationships within the study area, using numerous methods of fundamental geology: *mineralogy, sedimentology, petrology, paleontology and stratigraphic methods, as well as methods of geophysics, geodynamics, structural geology, paleogeological analysis,* etc. Result of application of the mentioned methods and geological mapping is *Basic geological map,* particularly important base for medico - geological analysis of some territory. Such map has been published, for example, for the whole territory of the former Yugoslavia (individual sheets covering approx. area of 1,500 km^2), in scale 1:100,000.

During ***mineralogical exploration***, crystal structure is determined by X - ray method, physical properties - by polarization petrographic microscope, and chemical compounds - by chemical and spectrochemical analyses.

For rock investigations (***petrologic investigations***), different methods are applied. Rock composition is defined by field (with the naked eye or magnifying glass) and laboratory (qualitative and quantitative investigations of samples, chemical and other analyses) procedures. In order to define petrologic structure, that is - structural and texture rock characteristics, grain size and uniformity are investigated.

Sedimentological investigations are useful for determining content, features and genesis of sedimentary rocks. By field investigation, lithological content is defined, while more precise results are obtained laboratory analyses - mineral content is defined by microscopic analysis of samples, and chemical content of carbonate and other sediments is evaluated by calcimetry and dolometry. Data regarding grain size and content of some fractures within a clastic rock are obtained by grain - size investigations.

In order to define geochemical characteristics of the environment, detailed data related to chemical content of elements within rocks, soil, water, air, food products, alive organisms and plants are necessary. That is why the whole spectrum of ***geochemical methods*** is applied: *(1) regional geochemical prospection and geochemical mapping; (2) geochemical sampling and lithogeochemical methods; (3) lithochemical methods; (4) radiochemistry* (exploration of radioactive elements in the nature) *and nuclear chemistry* (exploration of chemical point of view of nuclear reactions and investigation of chemical properties of the obtained nuclides); *(5) methods of gas exploration; (6) chemical and physico - chemical analytical methods and technical analysis of samples:* I classic chemical (volumetry, gravity, colorimetry, etc.); II instrumental (polarography, emission spectrography, spectrometry, atomic absorption spectrophotometry, X ray - fluorescent spectrometry, neutron activation analysis); III methods in geochemical prospecting (fast colorimetric methods, simple procedures of emission spectrography, etc.); *(7) unique instrumental methods* (electron and ion microsonde for determining chemical content of minerals).

Modern analytical procedures are completely useful in solving the mentioned tasks, because of very high sensitivity (Fig.8.1.).

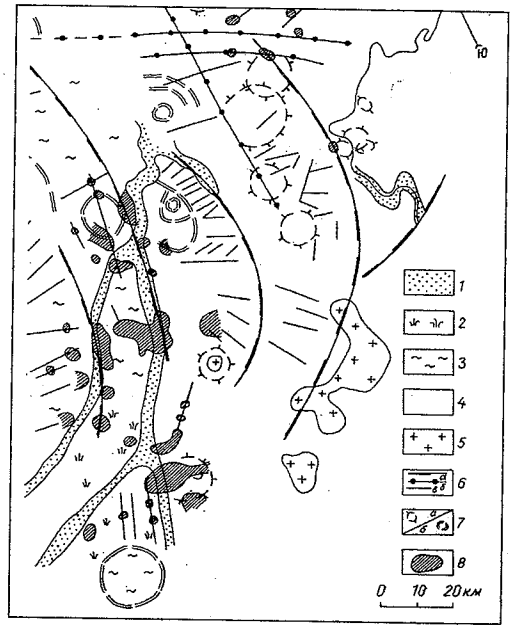

Fig. 8.1. Link between fault and ring structures with hydrogeochemical anomalies. 1 - alluvion; 2,3 - Quaternary clay sediments; 4 - Permian and Triassic sandstones and alevrolites; 5 - granites; 6 - faults; 7 - ring structures; 8 - hydrogeochemical anomalies.

As in other sciences, enormous increase of information in geochemical investigations caused hyper production, particularly noticeable in ap-

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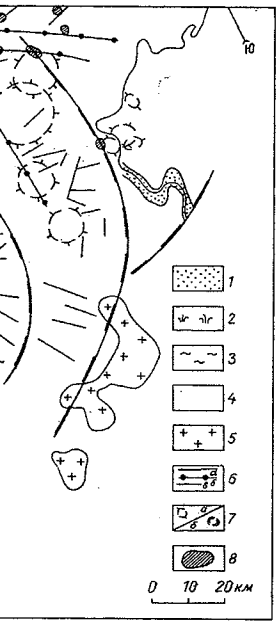

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plied geochemistry. That is reason why highly efficient *information methods* are developed, based on mathematics and computing technique.

By ***paleontological and stratigraphic investigations,*** age and relations among geological formations in the study area are distinguished. Paleontological investigations are based on defining so called characteristic fossils, that is - organisms known by small vertical, and intensive horizontal development. Sediments relationship before important orogenic stages is presented in stratigraphic lines. To determine absolute age of rocks, radioactive isotopes of uranium, thorium, rubidium, potassium, carbon and hydrogen are used.

Various ***geodynamic methods*** are applied to evaluate result of endogenous and exogenous geological forces. Volcanological exploration is particularly used, first of all, in volcanic eruptions prognosis, by monitoring of active volcanoes. Seismographs are instruments for earthquakes registration, while obtained data are useful in seismic regionalization and detailed microseismic zoning of the terrain.

Tectonic investigations exist as inevitable component of practically all geological exploration. Using *methods of neotectonic analysis,* significant material related to the recent tectonic activity (recent uplifting, that is, land sinking) of the territory and active zones (fault structures) is obtained. According to analysis of air - or satellite records, as well as data recorded in the field, all important structural forms: fractures, fault structures, folds, etc., are investigated by *methods of structural geology.*

Formation analysis, as a recent method of geological exploration, is also interesting for medical geology. Subject of exploration are geological formations - occurrences characterized by certain petrologic and geochemical content, metallogenetic, hydrogeological and engineering - geological, and hence, geomedical characteristics.

4. Geophysical methods. In all geophysical methods, procedure of exploration is equal - measuring some physical field at the surface of the terrain and interpretation of measured values in order to collect information regarding distribution of formations with different physical features in the subsurface. For analysis of geological structure (composition and structural fabric, groundwater distribution, ore bodies' deposits, coal, oil and gas deposits, etc.), most frequently used are following quantitative methods: electric methods, seismics, gravity and magnetics. The last decade of the previous century will be famous in the world of geophysics by strengthening of a new discipline of the applied geosciences - ***environmental geophysics*** (S. Komatina, 1996).

Electric methods are based on differences in electric characteristics of investigated geological unit. *Resistivity method* is frequently used, as well as *IP* and *Mise - a - la - masse method.*

Seismic methods are based on analysis of artificially induced elastic vawes propagation. In the practice, *refraction and refraction seismic methods* are used.

Gravity methods are based on different fields of attraction, caused by rock masses. All present methods are classified into two groups: dynamic and static. During dynamic exploration, pendulum or ballistic instruments are used, and during static measuring of gravity relative value gravitymeters.

Geomagnetic methods are useful in defining space distribution of geomagnetic field anomalies, as a result of different rock magnetization. Several types of modern high - resistivity magnetometers are in use. Beside terrestrial, aeromagnetic investigations are also very important, with instruments of higher sensitivity (Fig.8.2.).

5. Geomorphologic methods. Complex geomorphologic analysis includes both qualitative and quantitative analysis of relief. *Quality geomorphologic analysis* means identification of processes and forms. Within the procedure, not only genetic classification of forms is performed, but also determining of their relationship in space and time, and dependence evaluation of the processes intensity and relief on geological structure and the recent tectonic activity of the terrain. *Quantitative geomorphologic analysis* contains numerical parameters of relief through systematic measuring, statistic - mathematical processing, graphic presentation and data interpretation. The first one is carried out by remote sensing methods, and another - by numerous computing techniques.

Main task of ***speleological methods*** is exploration of subsurface karst forms (caves, jamas, ponors) and all other forms into which it is possible to enter, their morphology, speleogenesys and evolution (Fig. 8.3.).

6. Pedological methods. In order to define content, features and quality of soil, various field and laboratory methods are applied: methods of pedo - mapping exploration and sampling; methods for evaluation physical properties of soil; geochemical methods for determining space distribution of trace elements within soil; different chemical and quantitative spectral methods, methods of atom absorption, for distinguishing extraction nutritive substances in soil, radiopedological methods, etc.

7. Hydrogeologic methods. Among geosciences, hydrogeology belongs to disciplines with the fastest development. Reason why dynamics of development and improving extremely numerous and different methods of hydrogeology is, first of all, continual need for drinking, mineral and thermal water. Within the exploration process, methods of fundamental geology, remote sensing, geophysics, hydrometeorology, chemistry, nuclear physics, mathematical modeling and others, are used, as well as sophisticated hydrogeological methods - hydrogeological mapping, tracer methods,

methods of exploratory drilling and testing water intake structures, hydrodynamics, hydrochemistry, monitoring and regime investigations of groundwater methods of groundwater protection, etc. (M.Komatina, 1984, 1986). Thanks to computing processing, need for draft schematization of hydrogeological systems, so often used before expansion of computers, is not necessary any more.

Applied hydrogeology is characterized by different modern approaches of exploration of low - mineralized drinking water, mineral and thermal water; making hydrogeologic basis for drainage of raw mineral deposits; evaluation of hydrogeological conditions and possibility of agricultural soil amelioration. Appropriate methodological procedures are developed within domain of petroleum hydrogeology, engineering hydrogeology, hydrogeothermics, etc. (M. Komatina, 1990, 1995).

Groundwater exploration in discontinual karst medium is very complex task, requiring unique methodological approach. The task is possible to be solved by application of certain geological and hydrogeological methods.

8. Hydrogeochemical methods. Influence of groundwater chemical content and microbiological correctness on human health during the last half a century is studied with particular attention, first of all - because of occurrence of a series of highly - toxic substances, including these in atmosphere (Fig.8.4.). Favorable circumstance is that, thanks to new technical developments and improving numerous laboratory methods of analysis, chemical and hydrogeochemical methods were simultaneously developed. Analytical methods (atomic absorption spectrometry, chromatographic analysis, anode stripping voltmetrics, etc.), as methods of high sensitivity, precision, velocity analysis and automatization, made efficient exploration of micro - and macrocomponents in water possible. Analytical procedure is also useful in easy obtaining of information regarding hundreds of types of organic compounds present in water in micro - and nanogram amounts. Processing and interpretation of obtained results is automatized by computers.

9. Engineering - geology methods. For solving problems in the field of engineering geology (load - bearing capacity of rocks, terrain stability), various field and laboratory exploration works are carried out. The following groups of engineering geological methods are used: (1) *non - geological methods* (climatological, biological, isotope, etc.); (2) *geological methods* (remote sensing, petrologic and mineralogical methods, geomorphologic methods, tectonic investigations, seismological, geophysical and other methods), and (3) methods developed within *engineering geology, soil mechanics, hard rock mechanics and hydrogeology.* In the narrower sense, the following methods of engineering geology are distinguished: engineering - geological mapping, methods of shallow sounding and exploratory

drilling, field and laboratory test of physico - mechanical rock characteristics. By detailed exploration, landslides and unstable terrains are treated, with several special ways of exploration, prognosis and sanation.

Evaluation of soil dynamics (instability) and influence of geological conditions on seismic stability of the objects is subject of various investigations of concrete territories. In order to make enough safe foundation for aseismic constructing at wide areas, *seismic regionalization* is performed, while for the areas of limited extent - *seismic zoning.*

10. Nuclear methods. Nowadays, nuclear methods are so developed that it is possible to determine natural content of stable and radioactive isotopes of the elements within different inorganic materials, plants and parts of organisms. That is why they are successfully used in geological, biological, medical and ecological science and practice.

Radiation defining is performed by gas - , liquid and solid detectors. In *exploration of nuclear raw materials,* gamma - detectors are applied, in other words - gamma radiometric method is used. *Gamma radiometric method* is a basis for uranium exploration, particularly during the stage of field reconnaissance, not only from the surface of the terrain, but also from the air. Simultaneously with prospecting from the air, uranium - hydrochemical prospecting is performed, in order to determine uranium content in water and mud sediments. Collected samples are investigated in the laboratory by *gamma - spectrometric analysis.*

Isotope methods are successfully applied in the wide spectrum of tasks within *groundwater exploration.* In practice, the most often used stable isotopes, are deuterium and oxygen - 18, and, among cosmogenic isotopes - tritium and carbon - 14. In the first case, methods of mass - spectrometer measurements are applied, and in the second one - methods of low - phone radioactivity measurements within samples.

11. Biological and biogeochemical methods. As other natural sciences, biology is at the high level of development. During several decades of development, modern molecular biology, for example, has shown that cancerization, teratogenesis and similar occurrences are result of disturbed function of cell genome of the human organism.

Among biological methods of exploration of the natural environment, the following *zoological - parasitological* and *patho - biocenotical,* as well as *biogeochemical methods* have very important role: methods of floristic regional phitogeography (floristic statistics etc.), biotelemetry (remote sensing method), biogeochemical methods and biogeochemical cartography, radiobiological measurements of radiation, ecological ways, approaches of physiological anthropology, bacteriological water and food analyses, physico - chemical investigations for water quality evaluation, microbiological methods for determining water and food quality, methods of biogenetic engineering, population (biological) monitoring of main animal species.

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Laboratory analyses are based on analytical methods, showing, for example, that atomic prospecting is ideal method for control of metal traces within biological processes.

12. Methods of bioinorganic chemistry. During the last three decades, new, very important discipline was developed - bioinorganic chemistry. Subject of bioinorganic chemistry is study of reactions at molecular level among some elements, particularly biogenic metals with bioligands (proteins, nucleine acids and their ferments, hormones, vitamins, etc.). This scientific discipline could be developed just when research in the field of inorganic chemistry and biology (particularly molecular biology) reached required level. It is clear to expect that further improving of the most sophisticated physical and chemical exploration methods in domains of biology and chemistry as well as other methods, will make possible that, in the near future, our knowledge on reactions between some elements and bioligands, and generally, on physico - chemical foundations of biological activity of some elements, becomes more voluminous.

Nowadays, in solving scientific and practical tasks, sophisticated physical methods of investigation are used, but also, in less extent, spectroscopy and diffraction methods. Obtained results are used in medicine, biology, farming, environmental protection against heavy metals, etc.

13. Medical methods in a narrower sense. Today, medical staff uses practically unlimited number of different methods and procedures[102]. From the other side, although each of numerous medical sciences, disciplines and specialties possesses own system of knowledge and methodology, overlapping in analysis of the problems, but also in application of some methods, is noticeable. That is why more precise overview of methods is difficult, particularly for some sciences and disciplines. Trend of improving and use of part of methodical procedures within medical sciences is certainly visible. That is, first of all, related to:

a) *Experimental method,* which is still, beside use of electronic microscope and new models, unavoidable way in pathology, epidemiology, physiology and other medical sciences. Modern physiology, for example, is known as extremely experimental science. Tests or experiments are performed on experimental animals or their organs.
b) *Use of genetical principles* in applied medicine (medical genetics) is very important. It can be said that genetics and its role in research of vulnerability of humans to diseases is inevitable, while genetic information is considered in pathology, epidemiology and other scientific fields of medicine.

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[102] It is realized that, by better basing on real natural and other preconditions (disease carriers), hypertrophied medical science will reject in the future some part of sufficient methodological procedures and drugs, finding more efficient ways to human health preservation (among all, through efficient prophylactic health cure).

c) *Laboratory analytical methods* are widely applied in numerous medical sciences (Fig.4.4.). Atomic absorption methods, for example, are irreplaceable in analysis of pathological and clinical samples of urine, serum and blood, further, in forensic medicine, but ideal in checking traces of metals within biological processes. Chromatography is, from the other side, procedure for separating of substances from the mixture (liquid chromatography, etc.); spectrometric methods are applied in toxicology (spectroscopy in ultraviolet, that is - visible part of spectrum, infrared spectroscopy, etc.); absorption spectroscopy and colorimetric methods - for determining magnesium in clinical biochemistry (serum, urine, and blood plasma), etc.

d) *Development of computing sciences and information technology* is of invaluable importance for medical sciences. That is reason why enormous development in creating new and improving existing exploration methods occurred.

Wide range of methods used in making diagnosis of some diseases is now illustrated by the example of *endemic nephropathy*. In this case, complex exploration is carried out through the following four levels: 1) perlustration of the terrain (conducting a poll, protein checking of urine); 2) field clinical research (blood picture, urine control); 3) policlinic research (laboratory control; methods of evaluation of functional state of kidneys, an X - ray of heart and lungs; intravenous pieolography, radiorhenogram); 4) clinical research (dynamic scintrigraphy, separate kidney clearance, urine electrophoresis, miction chistourethrography, tethrograde urethropieolography, immunological research, kidney biopsy). During the last two decades, radioisotope diagnostics (rhenography, scintigraphy, radioisotope clearance) has shown numerous advantages. *Present diversity of ways to etiology of the disease is partly a consequence of unsuccessful activities in distinguishing appropriate carriers.*

For the sake of discovering pathological changes and monitoring the process, experts in ***pathology*** use autopsy, biopsy and experiments. Based on recent scientific knowledge in the field of microscope optics, biophysics and biochemistry, modern pathology is able to get to the heart of a problem of processes within subcellular structure (subcellular pathology), reaching molecular pathology. Research in pathological institutes, beside autopsy, pathohistologic and bioptical analyses, includes: autoradiography, fluorescent microscopy, histo - chemistry, and, particularly, electronic microscopy. Various epidemiological methods are also applied, as also methods of pathological anatomy, infection pathology and other clinical disciplines (ophthalmology, endocrinology, oncology, etc.), medical statistics and cartography.

Research in ***physiology*** is predominantly of biochemical character for decades. Numerous physiological problems are studied at the level of submicroscope and macromolecular structures. By application of ideas

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and methods of biophysics and biochemistry, but also introducing new, sophisticated exploration methods and equipment, like electronic microscope, analysis of subcellular and molecular structure of a cell and appropriate compounds is possible. Use of radioactive isotopes significantly contributed to the research. Various modern techniques and methods are applied in study of regulation mechanisms, as well as physiological and biochemical processes of adaptation. Experimental method is still one of basic approaches in physiology.

Infective epidemiology is based on practical tests, experimental method and various abilities of clinical research. Methods of microbiological and parasitological diagnostics are certainly of extraordinary importance among sophisticated methods. By the highest - level precision, serological diagnostics makes high sensitivity and uniqueness in discovering antigens and antibodies or their parts within serum possible. Data processing is performed by biostatistical procedures (distinguishing disease frequency, etc.), and for presentation, different epidemiological graphs are applied.

Medical ecology is characterized by multidisciplinary approach, based on methods of natural sciences, ecological chemistry, biomedicine, medical geography, engineering and technologies, etc. For defining toxic metals and carcinogenic substances, methods of analytical chemistry are applied, and for determining risks of technological procedures - mathematical methods. Effects of toxic substances (alcohol, drugs) on cytological - citochemical, ultrastructural and biochemical features of some tissues and organs are studied. Special attention is paid to radon presence - gas forming the strongest radiation, depositing in bronchi and lungs and causing occurrence of lungs cancer. In this domain, methods of field determination of radon content in soil and air are used and regional and detailed maps of radon risk are made, radon concentration within apartments and offices is measured, as well as epidemiological research method to evaluate risk is applied.

14. Methods of medical geography. Studying general relationships of geographic environment effects on the human health, medical geography deals with factors of geological medium. Numerous methods for evaluation of natural environment are known. That is reason why it is so important for medical geology to use developed methods and available results of medical geography, overlapping each other in scientific and applied domains of exploration.

According to **Handbook of medical geography** (1993), the following methods of medical geography are the most important ones:

- *space - comparative analysis of quantity parameters* (communal feeding; necessary clothes; city and apartment as elements of socio - living environment; work and rest at the open space);
- *medico - geographic evaluation of living environment factors;*
- *medico - geographic cartography* (medico - geographic maps and atlases);
- *modeling in medical geography;*
- *medico - geographical categorization* (taxoning) *of the territories* in unique or hierarchically submitted cells - taxons (zoning);
- *medico - geographical diagnostics;*
- *statistic methods in medical geography;*
- *application of computers in medico - geographic exploration;*
- *Medico - geographic prognosis.*

Information acquired during *expedition visits of the study territory* (medical geographer, biochemist, dentist, radiologist, and pathologist) and *methods developed within basic medical pathology, physiology, epidemiology and climatology* are also of high importance.

In the following text, methods of medical geography which are of interest for our research are presented.

15. Cartographic methods. Importance of medical cartography as one of leading scientific approaches for determining distribution of diseases throughout the world was underlined during fifties of the last century. At that time, prognostic abilities of maps made for epidemic infections, and later for endemic diseases, as geographic map with data referring to distribution of diseases expressing coincidence of certain geographic conditions and studied disease makes possible, were discovered. In the case of making coincidence for several localities, it could be distinguished as general ecological regulation. That is reason why developing of scientific classification of medico - geographical maps, but also way of their making and unification of legends, began. With time, cartography became center uniting almost all methodical procedures, and map was used within medico - geographical exploration beginning from the first stage - acquisition of material, till delivering the report to the customer. Because of continual and complete use of maps, medical geography is different from close medical and biological disciplines.

Now, text referred to methodology of making medico - geographic maps, presented in the **Manual of medical geography** (1993), is cited. Determined goal is to present graphically state and quality of the environment, expressed through: 1) negative influence of geographical factors (natural, social, productive, living, etc.), characteristic for certain geocomples on human health, and 2) presence of health resources, recreation systems and other health stimulators. Because of that, such maps are exclusively of applied nature.

According to the **Manual...,** modern maps are classified into: (1) medico - geographical maps (referring to features of the environment influencing on human health); (2) geographic - medical maps (defining space distribution of diseases at the whole Planet in dependence on some natural and socio - living conditions); (3) maps of health care (as a rule, represent distribution of the network of public health facilities, sanitary and sanatorium facilities, research and other institutes directed to health care. In the following text, the first group of maps will be discussed. According to content (subject matter), within the group, basic (general) medico - geographical maps, maps of medico - geographic evaluation of the environmental, as well as nosogeographic maps are distinguished.

1. ***Basic medico - geographic maps,*** in contrast to other types of maps made on the basis of appropriate thematic maps, are based on data of field exploration and remote sensing. Three kinds of this type are known:
   - *Medico - geographical maps of the environment* (bioclimatic maps, referring to climate influence on the human organism; pedological maps, with pedological soil characteristics of the areas unique from the medico - geographical aspect; geochemical maps, presenting geochemical features of the soil, appearing as biogeochemical endemic diseases; hydrogeochemical maps, defining chemical and other characteristics of groundwater and surface waters and level of their positive or negative influence on the human body; maps presenting features of plants and animals and their influence on human beings, etc.).
   - *Complex (multipurpose) medico - geographical maps* - represent combination of characteristics of natural and production comples of the territory, where integral influence of natural and socio - economical conditions on health of population occurs through qualitative homogeneity and local uniqueness.
2. ***Maps of medico - geographical evaluation of the environment*** are compiled on the basis of thematic maps, made by other experts - geologists, geochemists, pedologists, geobotanists, zoologists, economic geographers, etc. Main advantage of such kind of maps is velocity of their compilation, if a condition that necessary thematic maps are available is fulfilled. Main disadvantage is complete dependence of the maps on credibility of used thematic maps.
   - *Maps of medico - geographic evaluation of the environment* are based on distinguished differences of natural geosystems and effects on health. The following factors are evaluated: climate, soil, geomorphologic forms, surface and ground waters, plants and animals.
   - *Maps of medico - geographical evaluation of socio - economic environment* are made on the basis of exploration of characteristics of production territorial systems and appropriate structural units, level evaluation of the territory organization in accordance with human health. As an example, a map defining consequences of contamina-

tion of the environment in village areas of Armenia, caused by wide application of various toxic preparations in agriculture, is presented.

- *Maps of medico - geographic evaluation of natural - social environment* are referred to relation complex living environment (natural and territorial - production comples) / human health.

3. ***Nosogeographic maps*** outline risky areas with particular disease (nosoareals), their dynamics in time and space. In contrast to basic medico - geographic maps, presenting certain features and states of the environment - assumptions of diseases, subjects of nosogeographic maps are diseases and their distribution.
   - As an example of *maps of geographic distribution of diseases principally caused by natural factors,* can serve maps of biochemicals enemies, maps of allergic diseases or maps of diseases with natural foci.
   - Among *maps of geographic distribution of diseases principally caused by socio - economic factors,* maps of silicosis or maps of professional poisoning are known.
   - In *maps of geographic distribution of diseases with polioethiology,* maps of frequent occurrence of malignant tumors or cardiovascular diseases are classified.
   -

According to the *purpose,* special and universal medico - geographic maps are distinguished.

1. ***Special medico - geographic maps*** are used by certain range of users, for solving concrete tasks.
   - *Cadastre medico - geographic maps* present zoning of the territory according to degree of quality in relation to the state of health in the study area (presence and level of biogeochemical endemics, infective and non - infective diseases, technogenous and municipal contamination of the environment, but also of convenient factors, as well as living and health conditions).
   - *Maps of population health,* as the most reliable integral criterion of effects of environmental features on human body. Basically, three groups of markers are mapped: 1) *demographic;* 2) occurrence of diseases; 3) physical development of distinguished groups of inhabitants.
   - *Sanitary - epidemiological maps* related to sanitary - epidemiologic conditions within geocomples and system of indispensable prophylactic measures for the environment recovery. As an example, classical map made by J. Snow in 1848, in order to outline cholera epidemic in the Soho district (London) is convenient.
   - *Project medico - geographic maps,* made in order to provide medico - geographic information for the needs of planning, use of area for recreation, organizing optimal network of health care institutions.
   - *Operations medico - geographic maps,* applied in solving appropriate medico - geographic tasks (for example, synoptic maps - in order to forecast risky days for weather - sensitive persons).
   - *Recreation medico - geographic maps,* presenting distribution of

zones and places for vacation or natural and socio - economical conditions suitable for recreation and recovery of population.

- *Historical medico - geographic maps* present geographic position of nosoareals of various diseases during the past times. The maps are very important for determining causes, ways and dynamics of diseases distribution.
- *Teaching medico - geographic maps* are used for education, as well as making independent contributions within medical geography and other disciplines (biology, human ecology).

Level of detailed presentation by mapping, that is - highest permitted reduction of some space survey of the phenomenon is dependent on the scale of topographic base. From this point of view, the following types of medico - geographic maps are distinguished: *large - scale* (1:200,000 and larger), *medium - scale* (less than 1:200,000 to 1:1,000, 000) and *small - scale maps* (less than 1:1,000, 000).

According to *the level of markers generalization and features of the presented phenomenon (process),* analytical, synthetic and complex maps are known.

a) *Analytical medico - geographic maps* present individual elements or features of some phenomenon with non - generalized, concrete markers (for example, map of fluoride content in mg/l in drinking water of springs or other groundwater occurrences, or map of soil temperature for some period).
b) *Synthetic medico - geographic maps* contain total (integral) characteristic of cartographic occurrences (processes), with generalized integral parts of the occurrence.
c) *Complex (special) medico - geographic maps* present several different, but, according to their effects, connected, occurrences or several different characteristics of appropriate phenomenon (each one presented by adequate markers). As an example, map of biogeochemical zoning can serve, presenting level of biologically active macroelements and trace elements at the study area. Complex (universal) medico - geographic maps are also used, integrating series of various, but closely connected occurrences within *environment - population - health level* system, as map of complex medico - geographic zoning of the interested region.

At the end, the following classification of medico - geographic maps *in dependence on level of objectivity (reliability)* is presented:

a) *Documentation medico - geographic maps,* fixing concrete facts, processes, occurrences, acquired during field exploration (measurements);
b) *Medico - forecasting maps,* treating scientific forecast of results related to state, distribution and dynamics of uncertain or not yet expressed

processes and occurrences and their influence on health. They present forecasts in time (for example, decrease in population vulnerability to endemic goiter in dependence on applying iodine to food products) or space (reducing areas with potential risk of some infective disease by performing complex of prevention measures), as well as space - time forecast (for example, weather forecast within the *environment - human health* system, as a result of anthropogenic and other factors);

c) *Recommended medico - geographic maps* are important as a finishing link on a chain of system medico - geographic cartography. Complex (synthetic) map of medico - geographic optimization of the environment is an example.

Medico - geographic atlases present systematic collection of organic inter - connected medico - geographic maps, limited by subject and characteristics of the application. Classification of medico - geographic atlases is very similar to that of medico - geographic maps. From the history of medical geography it can be seen that such kind of presentation was used in all stages of development of the discipline.

Three decades ago, **computing geography**, based on huge amount of statistic data and results of concrete exploration, started to develop. The role of this discipline within medical geography was recognized from the beginning, particularly in domain of analysis of space relationships among occurrence of various infective and other diseases. Maps of malignant tumors distribution are made more and more often. For example, **Atlas of cancer risk in USA** published in 1975, containing 65 maps in color, with outlined territories with relatively high coefficient of mortality. Nowadays, technical capabilities of presenting diseases markers in geographic maps are extremely numerous.

Developed approaches to medico - geographic cartography, mentioned in the previous text, are of high importance for **medical geology**, which is at the initial stage of the development. It has to be understood that it is related to the part presenting natural factors. Task of **medico - geological cartography** is to present in space relationships of certain geological factors as disease carriers and medical consequences for human health. Wide range of different compiled geological maps is available, as: photogeological maps and satellite records, basic geological map and various detailed geological maps, geological maps of the territory of the whole country (geological, geomagnetic, geomorphologic, neotectonic, seismotectonic and seismological, geochemical, metallogenetic, hydrogeological, engineering geological, pedological; map with mineral and thermal waters presented), hydrogeochemical, geobotanical, ecogeological, etc. The following examples show how existing cartographic material is useful.

1. *Basic geological map* can be of invaluable use to solving some research tasks, not only in domain of geology, but also medical geology. It presents geological structure of the terrain, tectonic structures (folds and faults), occurrences and raw mining deposits. According to the presented geological structure, preliminary (orientational) evaluation of living conditions in the natural environment (as suitable or not) can be made. It is clear that, from this point of view, each geological formation presented in the map should be analyzed. That is the way of determining medico - geological categorization of geological units.
2. *Geomorphologic maps* present distribution of different sectors of the study area *according* to shape, genesis and age of the relief elements. Content of geomorphologic map is made with the aim of having multidisciplinary purpose - in geology, civil engineering, agriculture, land - use planning, environmental protection, even in medical geology. It should be underlined that geomorphologic factors are of high importance in determining living conditions and treatment of population. Classic type of the maps can be approached in purpose in the case of outlining medico - geomorphologic (geological) types of the territory on the map, with some positive or negative influence on human health and conditions for organizing health tourism and recreation.
3. *Geochemical, hydrogeochemical and biogeochemical maps* offer important information on chemical content of rocks, soil, ground - and surface waters, plants, animals and basic food products. Significant attention has to be paid to trace elements, because of their role when speaking about health of human beings and animals. The maps, adjusted to the requirements of the discipline, can be very important element of medico - geological cartography and to contribute to solving etiology of endemic and other diseases. In order to achieve the goal, a lot of work referring to increasing content of the map and adapting ways of preparing the map to requirements of computing technology is necessary.
4. *Hydrogeological map* is based on distribution of groundwater and their quality. In that sense, according to their permeability, all rocks are divided into categories of water - bearing, poorly water - bearing and practically arid areas (Fig.8.5.), and data on sources of low - mineralized, mineral and thermal waters, their reserves, physico - chemical features and water quality are predominantly presented in the legend or the proposal. On the basis of hydrogeological relationship, level of natural aquifer vulnerability to contamination from the surface can be evaluated. Because of enormous role of water for life of all human beings, hydrogeological cartography is widely used all over the world (particularly during the past two decades). Hydrogeological map is classifies among very important basis in solving various problems - water supply, soil amelioration, exploitation of mineral deposits, constructing sanitary - resort structures, etc., and the similar development is expected in the field of medical geology. For the needs of medical geology, its content can and has to be significantly changed, in other words - to adjust to the principal task, with a main point on

presentation and interpreting chemical content, mineralization, quality and protection of groundwater sources. Besides, possibilities of restricted hydrogeological and hydrogeochemical zoning of the interesting area, which could be carried out according to space distribution of geological formations interesting from the geochemical viewpoint, that is - according to changes in content of some trace element in water in space, hardness and water mineralization, are formed.

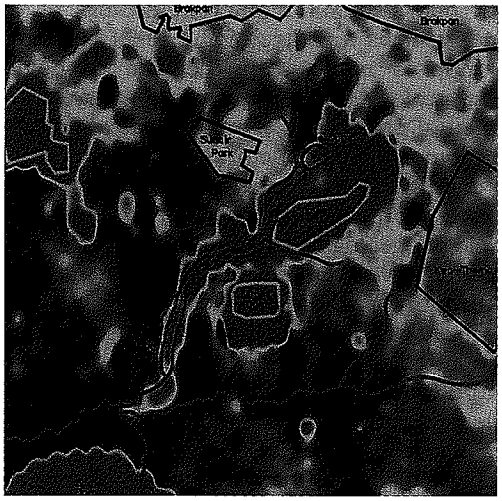

Fig. 8.2. Detailed total - field airborne radiometric color map of an area showing the presence of slimes dams and the movement of mine waste.

In any case, just now, main activity in the field of medico - geological cartography is approaching. It is necessary, in spite of all, to lean on medico - geographic maps and methodology of their compilation, particularly on the following described types of maps: 1a - *medico - geographic maps of natural environment*; 2a - *maps of medico - geographical evaluation of natural environment*; 3 - *nosogeographic maps* (3a - *maps limited principally by natural factors*), but also different special medico - geographical maps, analytical and medico - forecast maps.

Geochemical atlas of Slovak Republic, published in 1997, in scale 1:1000, 000, is an example illustrating importance of highly informative atlas for medical geology.

The atlas consists of maps and legends, referring to groundwater, rocks, soil, distinguished elements from the forest ecosystems and natural radioactivity in rocks and water. Part of the legend related to groundwater is based on results of 16,359 investigated water samples (one sample every 3 km^2), and the maps of: mineralization, Mg - content, fluoride and arsenic, as well as level of groundwater contamination and hydrochemical diagrams for all important geological formations

of the state territory are made separately. Part related to rocks (3,839 samples) contains geological - tectonic map and review of chemical content of 64 types of geological formations individually. Soil was investigated along 5,000 lines (9,892 samples) in order to investigate 36 important chemical elements; maps of As, Cd, Cr, Cu and Zn distribution within A soil horizon are attached. Part referred to ecostress maps (3,063 samples) was made on the basis of the following elements content within forest leaves: Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, F, Fe, Hg, K, Li, Mg, Mn, N, Na, Ni, Pb, Rb, S, Se, Sr, V and Zn, and maps present fluoride, sulfur and mercury concentration. Total natural radioactivity in rocks and water was evaluated by 4,900 samples, gamma - spectrometry was used for determining content of K, U, Th, U_{total} in rocks, but also natural radioactivity in rocks, radon presented by maps of risk, and $U_{natural}$, Ra_{226} and Rn_{222} in water; for rocks, maps of potassium, thorium and uranium were made, as of gamma - radiation; for Rn - map of risk and map of Rn concentration in water.

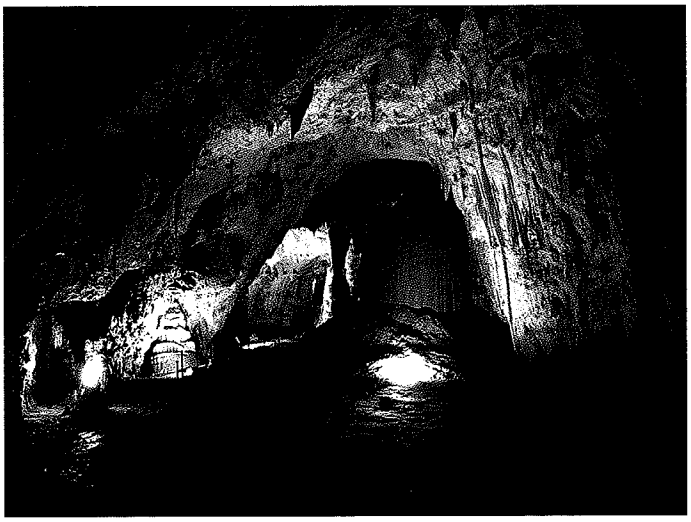

Fig. 8.3. Rajko cave, Eastern Serbia (Photo: D. Milovanovic).

16. Medico - geographical and medico - geological zoning. Long time ago, experts in **medical geography** realized necessity of distinguishing regions homogenous in natural socio - economical conditions, particularly when health of population over spacey territories has to be studied. Besides, according to practice, distinguishing of such kind of regions - zoning has to be a result of detailed exploration of the territory, and diligent consideration of medico - geographical features. Further, that some deficiencies appear if perform only physico - geographical differentiation of the territory, except in the case of presenting only preliminary information on unknown territory with natural environment lightly degraded by agricultural and other activities.

Nowadays, more and more voluminous collections of maps of medico - geographic zoning are published. Investigated regions are divided into existing dynamical territorial systems - sun ecosystems or medico - geographical comples, from elementary to the most complex - of planetary order. As the main sun ecosystem, *medico - geographic rayon* is distinguished - space unit of the environment with the equal health level of one - type groups of inhabitants and unique local pathology, caused by interior homogeneity of natural and living conditions of population within areas of each particular rayon. By the zoning of one territory, solving the main task of medical geography - making contribution to recovery of the environment, more precisely - regulation of all factors of the environment showing (or which could show) harmful effects on human physical development, health and living ability, is possible.

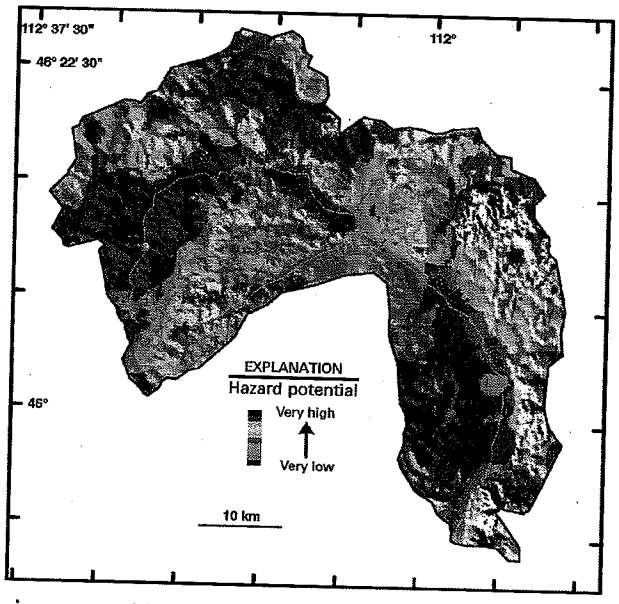

Fig. 8.4. Geoenvironmental hazard potential for acidic, metal - rich drainage in the Boulder River basin, Montana (USGS, 2000).

Numerous approaches to medico - geographical differentiation of the territory are developed, in dependence, first of all, on the research goals and researcher's abilities. So, one - factor, multi - factors and total rayons are recognized, or one - , two - , three - , four - and five - members (full) comples are distinguished. The most complex way of zoning is defining multifactor (complex) systems.

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of zoning is defining

Medical geology needs different approach to zoning of the territory, with minimal consideration of socio - economic factors, and on the basis of one or several geological factors and medical consequences. Zoning has to be carried out not only on the basis of existing geological maps and other documentation (Fig.8.6.), but also of detailed field exploration and laboratory investigations.

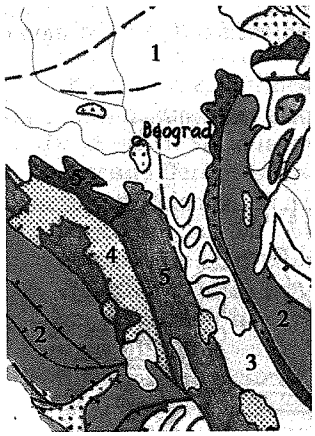

Fig. 8.5. Overview hydrogeological map of Serbia with vicinity. 1 - Neogene and Quaternary sediments of Pannonian basin (*aquifer*); 2 - Mesozoic karstified limestones (*aquifer*); 3 - Tertiary sediments (*complex*); 4, 5 - fractured medium (*low permeable formations*).

Methodology of work and content of the legend are dependent on numerous elements and characteristics within geological structure of the terrain, defined goal (problem), purpose, range of information, etc., and a lot of is based on experience and creativity of the authors in the field of cartography. Generally, as regular and indispensable result of medico - geological exploration, medico - geological zoning may be contained in classification of interesting territory or geological unit into rayons which are separated according to characteristics or intensity of influencing geological conditions, in other words - some geological factors on health of population, genesis and distribution of diseases.

For medico - geologist, one or more factors (in different cases - different) appear in the role of leading ones, as they have the most important effect on human health. Just these factors can significantly determine boundaries of distinguished medico - geological units and their range. However, zoning can become much more complicated because of anthropogenic factors (contaminants), and in such cases, distinguishing subrayons has to be made. In these circumstances, but also in general, it is very important to use as more information obtained in field and laboratory, which can be successfully processed by mathematical methods and computing techniques, as possible.

Possibility of making very different medico - geological zoning, in dependence on the subject, should be underlined. The zoning could be based on:

- *geological structure of the Earth's crust* (rocks, geological formations, tectonic structures, seismic and volcanic activity);
- *characteristics of soil and groundwater;*
- *geomorphologic characteristics of the terrain;*
- *geochemical features of rocks, soil, water, and, indirectly - vegetation and animal world;*
- *natural radioactivity of rocks, soil and water;*
- *Exogenous geodynamical processes* (landslides, rockslides, mud - stony

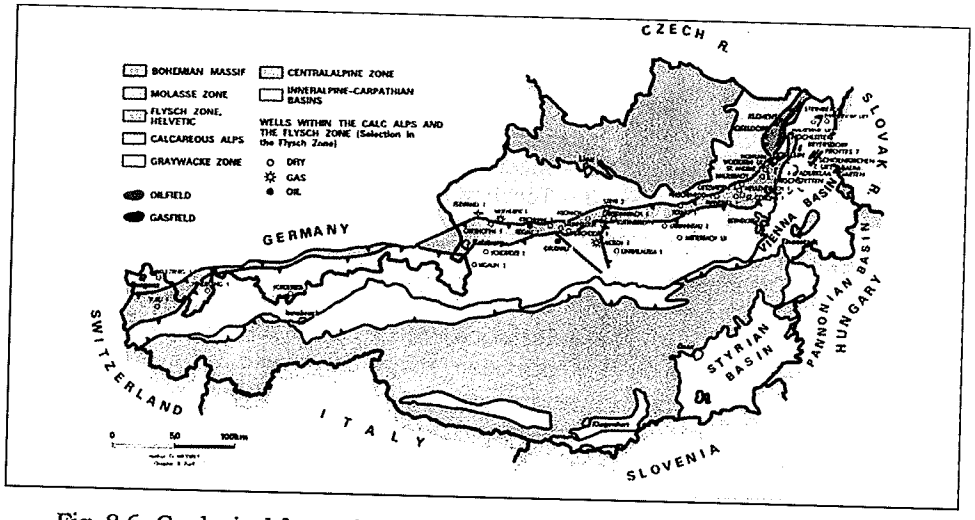

Fig. 8.6. Geological formations in the territory of Austria (G.Wessely, 2000).

Using elements of geological environment, from one side, and leading pathology as one of the basic markers of the factual health level of population, from the other side, a conclusion referring to comfortability of the territory can be made.

In the further text, examples of the two possible types of zoning are discussed.

1. Each *geological formation*, with soil formed by weathering, is characterized by certain mineralogical content and geochemical features, provoking various regional geological and geochemical regularities interesting for medical geology. Their distribution is presented in the Basic geological map and other geological maps. Presented circumstances, beside

data of geochemical exploration, make producing of *general or purpose geochemical zoning of the area* possible. *Biogeochemical zoning* according to presence (deficiency or surplus concentration) by biologically active macro - and microelements is also very useful. For example, schematic map of biogeochemical zoning of the territory of former USSR is characterized by distinguished regions and subregions of biosphere with deficiency, surplus or uneven content of elements), appearing in the form of carriers of development of natural biogeochemical endemic diseases of human beings, animals and plants. Rayons poor in Co, Cu, Ca, Se, Compounds, Zn, F, etc., as well as rayons with uneven Co/P relation, are outlined. Geochemical and biogeochemical zoning of the terrain, in general, could be of outstanding importance in exploration of careers of various diseases, particularly biogeochemical endemic diseases (different microelementoses - selenosis, fluorosis, iodine, iron or zinc deficiency, etc.). As diagnosis of biogeochemical pathology is often very complicated, high - quality medical base, that is - results of detailed medical exploration, should be available for the sake of zoning.

2. *Hydrogeological zoning,* as a method of scientific and practical generalization of data related to groundwater, has been widely distributed and applied during the last three decades. More often, goal is to distinguish rayons characterized by appropriate regularities of groundwater forming and distribution, or regularities important for solving any practical task related to use of the waters, in the areas of spacey territories of the Earth or some continents. For geomedical investigations, it is certainly important that zoning, based on the type and degree of aquifer permeability, has to point out rayons provided by drinking water. Data on drinking water quality (usability) is obtained by *hydrogeochemical zoning* (distribution of some water types according to chemical content, mineralization, hardness, deficiency or surplus of some biogenoactive components in water). All mentioned elements are very important for understanding medical occurrences and consequences. During the 2nd World War, for example, Association of American Geographers started to investigate fluorine content within American water supply systems. Results of the exploration were published in 1996, serving as an impulse for developing the first project of diseases atlas.

17. Medico - geographic and medico - geological cadastre and informatics. Necessity for the work on medico - geographic cadastre was particularly distinguished three decades ago, at the 4th symposium of medico - geographers, which was dedicated to this topic exclusively. It was concluded that cadastre has to contain completely reliable information related to influence of natural, economic - geographic and medico - sanitary conditions of the territory of interest on public health; it is compiled on the basis of complex medico - geographic study of the terrain and data of previous exploration of some parts of the territory.

Nowadays, noting, processing and forming of a cadastre (data bases, information systems) of all data referring to certain natural resources, but also data in domain of medical research and health care, are outlined as very important throughout the world. In Norway, for example, multidisciplinary group for medical geography was formed in 1982, consisting of geographers, physicians, geologists, geochemists and epidemiologists, which made geographic information system of mortality in the country. This data base contained all cases in the country starting from 1966. Authomatized data search and unique processing programms in the system make quick obtaining of different information necessary for medico - geographic analyses possible.

Introducing of unique health information systems in many countries, makes international research cooperation as well as world studies in various domains of medicine in general easier. It is noticeable that the information gets biohuman meaning and significance. It can be concluded that, with more developed information technique is, particularly information processing, biological cognition of human being is stronger (Z. Jovicic, 1997).

When speaking about contemporary data bases, territorial register of malignant diseases certainly is the most known and relatively widespread type of medical records. The main task of the cadastre is offering reliable information on malignant tumors risk. The presented form of cadastre has been suddenly developed since fifties of the last Century. Role of the cadastre in science and health care was extremely expressed in Finland, Sweden, Norway, Denmark and Eastern Germany, countries known as ones with the most regular registration of population, hence - possibilities to perform research by automatized compilation of information on each inhabitant.

Information on natural conditions, beside information on socio - economical and living conditions and material containing data on public health level and diseases dangerous for man and animals, is inevitable in making medico - geographic base of the study area. Reliability of such information can be significantly improved by medical geology with data on geological, and more, natural environment. **Geological information system (cadastre) of the state territory**, as a rule, contains all important data on abiotic components of natural environment, as are: geological and geomorphologic characteristics, surface soil (pedological soil), mineral raw materials, hydrogeological and hydrological conditions, engineering - geological features of the terrain, geochemical characteristics of rocks and soil; hydrogeochemical features of groundwater, etc. Generally, during the last several decades, noting, processing and forming data funds related to

the mentioned components of the natural environment are known throughout the world as of high importance[103].

Information on geological environment is of complex significance, not only in the field of rational use of the territory, but also in domain of efficient protection of the environment and human health. In Serbia, for example, acquiring of information started even in 1853 (when Josif Pancic introduced a new subject *Mineralogy with geology* at the Royal Serbian lycee), but suddenly intensifying during the last five decades. Basis of information system related to geological environment contains basic geological maps of the state territory, issued in the scale 1: 50,000 or 1:100,000, but also of high importance can be voluminous documentation on detailed exploration of mineral resources, groundwater, soil, engineering - geological features of soil, etc.

18. Statistic methods. Even at the end of seventeenth Century, English researchers concluded that tables of vital statistics, acquired by J. Graunt, are of a decisive significance for epidemiology. Graunt was not only the first scientist who measured difference between mortality in urban and rural environment, and determined a method of population evaluation according to samples collection, but also the first constructive critic of medico - statistical data. Later, importance of morbidity statistics was distinguished in England and USA.

Nowadays, statistic methods are widely used in medicine and medical geography, particularly in monitoring public health, including statistics of diseases frequency, mortality, physical development, but also health cure. Statistical materials can be very useful within the process of medico - geographic evaluation and diagnostics, zoning, modeling, cartography, etc.

Medical statistics studies and defines *quantitative relationships*: (1) level and dynamics of public health in general (of the country, or distinguished administrative - territorial units, etc.) and appropriate qualitatively homogenous groups (according to gender, age, profession, length of service, etc.) in concrete conditions of the place and time, on the basis of complex qualitative analysis of existing and activities of mass processes of medical and health protection; (2) state and activities of institutions and health officials; (3) evaluation of efficiency of performed measures related to public health preservation in general or among the groups (Keller, Shchepin, Chaklin, 1993). Important place and content of medical statistics belongs to methods of acquisition, processing and medico - statistical analyses of different clinical, laboratory and

[103] Within American information system, in the part related to groundwater, even in 1977, approximately 650,000 springs and wells were registered. Soon, many countries were included in hydrogeological cadastre, among of which: France, Hungary, countries of northern and western Africa.

experimental medical data, used during research and applied activities within public health care (treatment).

According to Keller, Shchepin and Chaklin, medico - statistical exploration includes five severely limited and interconnected stages: (1) *planning of exploration;* (2) *statistical acquisition of data;* (3) *statistical grouping and analysis of documentation;* (4) *statistical processing of material;* and (5) *scientific - statistical analysis of documentation, with appropriate literature and graphical design.*

By rich statistical literature, choice and use of approaches to solving concrete tasks is possible. Statistics is more and more based on numerous opportunities of computing technique and specially developed packages of suitable programs, overcoming the field of complex methods of the tasks statistical solving.

Mathematical - statistical analysis has important role in methodology of statistical research. The following typical tasks are solved in this way: (1) compiling empirical distribution and finding appropriate mathematical relationships (models), with checking validity of their agreement; (2) tasks, evaluations and checking hypotheses; (3) testing a link or mutual links; (4) methods of poli - measuring classification and factor analysis; (5) investigation methods of occurrences and processes dynamics; (6) prognosis of occurrences and processes; (7) statistical planning of experiments; (8) iteration methods of statistical model; (9) representative exploration and evaluation of obtained parameters, etc.

Among chapters of mathematical statistics, *theory of correlation* makes actual discovering of links between factors and human health possible. Within statistics, well developed mathematical - statistical apparatus for testing various correlation links (classification methods, correlation and regression analysis, dispersion analysis, etc.) is present. *Correlation coefficient* is most often used method in evaluating statistical relationships.

Graphical analysis is widely applied for processing of acquired empirical documentation, as well as for their analysis. The widest use is of graphical presentation of frequency distribution (histograms or column diagrams, distribution polygon, cumulative curve, linear graphs referring to distribution of two or more occurrences, circular and sector diagrams - available for presentation of complex distributions of the study occurrences).

In medical geography, cartograms and cartodiagrams are widely used, suitable for presenting various statistical data of medico - geographical character (level of diseases frequency and mortality for appropriate types of diseases and their groups; coverage of a territory by physicians and other medical staff, etc.) for some area on geographic map. P.P.Reshetnikov with associates (1965), for example, developed for Celinia area (Russia) relationship between occurrence of dysentery and air temperature during August by making cartograms for administrative rayons and determining *correlation coefficient r* between intensity of the studied disease and temperature in August (r_{yxl}=0.63).

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Methods of medical statistics will certainly have significantly role in solving tasks in the field of **medical geology**, providing it by material referring to public health, necessary for obtaining medico - geological evaluation of different territories (geological units, geological formations). Special possibilities are present in the field of founding statistical links between diseases markers and mortality and factors of geological medium, while we can use the numerous tests performed by medico - geographers. It is recommended, in spite of all that, to start with points (geological formations), where health problems are most frequent and with maximal use of data on geochemical and other features of rocks, soil and groundwater[104].

19. Methods of mathematical modeling. Initial stage in application methods of mathematical modeling in order to study links between environment and public health started during sixties of the last century, which was period of collecting significant experience in the field of use methods of mathematical statistics. During the first stage, uniqueness of application of mathematical statistics in medical geography was particularly in the fact that principal information related to the environment and level of public health had a space expression, which was performed by use of special geographic and medical maps.

Later, improving of simple ways of study even links, applied during the initial stage of the mathematical modeling methods development, was made simultaneously in several directions. First of all, ways of application of principal information for mathematical analysis were improved. The way out of an unpleasant situation (because of various natural and other occurrences, unhomogeneity of information, different time, different groups of inhabitants according to dimensions and status), was found in transformation of starting information through change of different concrete territorial units, by homogeneous, but conditional or formal units. The presented approach was called *formally - territorial* by B.B.Kucheruk (1965). In this way, it was attained that information on medico - biological occurrences obtained more objective character, and it's linking with information on the environment by mathematical methods become more correct. Directions of development of mathematical modeling methods according to Keller, Shchepin and Chaklin (1993), are presented in the further text, with examples of modeling shown in Fig. 8.7.

First of all, it has been concluded that determining stochastic relation between medico - biological occurrence and distinguished factors of the environment makes outlining the study area into the sectors (parcels) with equal probability of relationship of the analyzed pair of occurrences possi-

[104] For example, several authors are dealing with analysis of correlation link between gastric cancer and magnesium content in soil (W.W. Alpatov, 1960; W.A. Chervyakov, 1964.; P.P. Reschetnikov et al., 1965.).

ble. Compiling such map, with distinguished even links of the studied medico - biological occurrence with environmental factors, enables persistent analysis of the role of distinguished factors in formation of areal and structure of the event.

Character of transition from the even links analysis, including numerous different occurrences and factors, can be clearly illustrated by example of introducing ***information analysis method*** into medico - geographical exploration. The method is characterized by a large number of advantages, enabling wide use of mathematical modeling in forecasting.

During the beginning of the seventh decade of the last century, methods of ***factoral and regression analysis*** were widely applied for solving tasks of determining links and relations between human health and the environment. Advantage of the factor analysis method in comparison to information analysis method was in the fact that it enables more adequate introducing of complex systems exploration, which depends on plenty of variables. The method was intensively used in exploration of hidden links with the environment of originally non - infectious medico - biological occurrences of not so clear etiology. Links of various environmental factors with cardiovascular pathology, but also with malignant neoplasms, are particularly studied, and appropriate risk factors investigated.

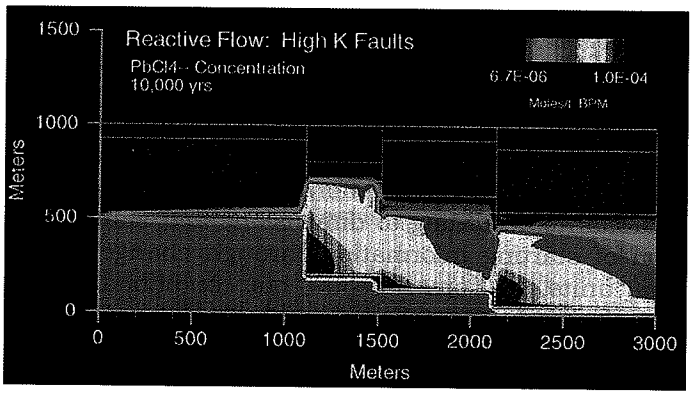

Fig. 8.7. Isotherms for the deposit - scale reactive flow simulation of Lisheen, Ireland. Flow is from South to North, driven by topography.

Regression analysis is principally used for solving the first part of medico - geographic task - to study form of the link among variety of unexpected occurrences, which in any case show effects on level of human health. The second part - informative analysis, which aim is to evaluate how the studied form of the link appears in geographic area, as a rule, has not been solved. There are numerous papers with the basic attention directed to solving only the first part of the task. In cases when informative medico - geographic analysis of obtained data doesn't lead to its logical end, good prospects are that exploration is considerably of

epidemiological, hygienic, in one word - more medico - biological, than medico - geographic character.

Basic idea of regression analysis use within medico - geographic exploration consists of presenting characteristics describing conditions of medico - biological occurrences in form of function of total action of numerous environmental factors, and regression coefficient as importance coefficient or their effects. For example, during study of some somatic symptoms of population in the northern part of Chile, it was defined that, among factors showing effect on large number of these symptoms, the first place belongs to the hypocsic factor, expressed through height of the settlement above sea level.

Mathematical modeling is used in medical geography as a method of realization of different forms of expression of medico - geographic differentiation. The following three basic types of zoning of the territory by mathematical methods are distinguished:

I type presents a form of expression of space differentiation of medico - biological occurrences, characterizing level of public health;

II type presents a form of medico - geographic evaluation of physico - geographical, economic geographical and other types of territorial differentiation;

III type presents a form of systematic analysis of factually present ecological links of population and the environment.

Sometimes, zoning according to disease preconditions (or according to potential conditions of disease distribution), corresponds to the *type II,* and zoning according to factors assigning disease presence (or according to potential risk in some territories in relation to distinguished diseases and their effect on human health) - to the *type III.*

For zoning the territory of the *I* and *II type*, factor analysis is most widely used, and of the *type III* - information analysis.

20. Medico - geographic and medico - geological diagnostics. Relatively new approach. Under the term, complexity of the approach and methods directed to defining medico - geographic type of the territory and determining basic present or potential medico - geographic occurrences. Development of medico - geographic events characteristic for some type of the territory is preconditioned by objectively present complex of sanogenic and pathogenic factors. Determining the leading factors in the areas of some territory is also subject of medico - geographical diagnostics. Computing technique can significantly contribute to operative acquiring necessary data related to indicators. Potential possibilities of distinguishing territorial preconditions of diseases applying methods of remote sensing and means of biosphere investigation are also enormous.

The methodical approach contains use of the following two ways:

analytical (information - documentary), based on study, systematization and generalization of available information sources and (2) *expedition*

(field exploration). According to Keller and others (1993), practical performing of the diagnostics in the areas of interesting region, the following stages are included:

- *defining diagnostic goals and tasks;*
- *study of present information sources;*
- *determining deadlines, itineraries, rayons, objects and exploration methods in the areas of the territory, as well as plan of exploration;*
- *field exploration and data processing;*
- *making a medico - geographical diagnosis* (basic forms of medico - geographic terms and degree of their presence; medico - geographic types of the territory; leading risk factors).

However, under real conditions, necessity for fast and simplified determining of only main medico - geographic features of the concrete area appears more often.

Expedition method of studying medical geography of certain territory is not so applied, because of other goals of scientific - exploratory expeditions[105]. One of a few of expeditions of this type, expedition in Celinuja area (Russia), was performed in two stages - in 1963 and 1964. The expedition was based on very useful contribution of medico - geographers, biogeochemists and biochemists after the first stage - compiling medico - geographic map, collecting water, soil and vegetation samples for further chemical investigations in laboratory located in Moscow (A.P. Avtsin, V.D. Arutjunov, 1965); significant attention was paid to investigation of fluoride content in drinking water and food products, as well as liquids in organism tissues of population. During the second stage, fluorosis diagnostics was stated precisely (dental fluorosis was registered at 54.3% of inhabitants), and rayons under endemic fluorosis risk (marked by high fluoride content in drinking water, up to 4.5 mg/l), were outlined at the special map. Within this part of job, dedicated to endemic fluorosis as a big problem, pathologists, stomatologists and radiologists were involved.

By the described example, where endemic fluorosis caused by geological factors was treated, it can be concluded significance of medical geology. Namely, participation of hydrogeologists and geochemists in the expedition would be certainly justified, and in making a diagnosis, particularly within the part referring to natural factors, medico - geological base and zoning would be very useful.

Medico - geological diagnostics gets a leading role in case of territories with expressed microelementoses, raised natural radioactivity and radon risk, inconvenient physico - chemical characteristics of drinking

[105] A.E. Beliaev with associates (1965), developed methodology of expedition, exploration on example of Hissar administrative rayon in Tajikjstan.

water or soil, geochemical, geomorphologic, engineering geological and other geological factors influencing negatively or positively on human health and life (Fig. 8.8.). Distinguished geological medium morphologically formed and rich in mineral and thermal waters, for example, can be suitable for carriers' reproduction of numerous dangerous diseases of human beings and animals.

21. Medico - geographic and medico - geological forecast. Presents one of the most important stages of the research work of medico - geographers and medico - geologists[106]. It is closely connected to economical and land - use planning. This stage can be analyzed as potential characteristic of the general level of public health (during *universal forecast*) or distinguished markers of that level (during *branch* or *component forecasts*) in some region for certain period in the future, with pointing to factors of the environment affecting it. Pointing out to positive and negative factors of the environment on health is indispensable, because study of the factors enables to cross from research forecast to program or organization prognosis.

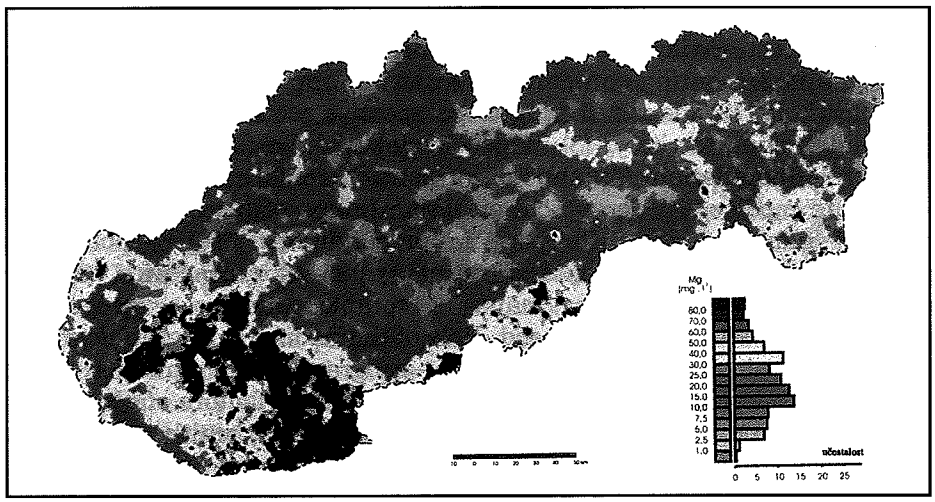

Fig. 8.8. Geochemical atlas of Slovak Republic. Distribution of magnesium in groundwater (K. Vrana, S. Rapant, 1999).

Integral (complex) medico - geographic prognoses are predominantly made for large economical rayons.

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[106] Short review of medico-geographical forecasts is presented by Keller and associates (1993). In dependence on the defined goal, the authors classified all medico-geographic prognoses into *integral* (complex), branch and component.

Branch medico - geographical forecast presents forecast in changing health level, related to occurrences studied by certain parts of medical geography. As an example, wide range of exploration made in order to forecast malignant tumors risk, can serve. According to A.V. Chaklin (1984), the exploration are contained of: studying regional characteristics of distinguished forms of malignant tumors; discovering groups of high risk; analysis of combined effect of endogenous and exogenous factors, followed by development of differentiated mark system; making diseases and mortality forecast of distinguished population groups, taking into consideration occurrence of new or rejecting environmental factors which were active earlier. Test of *branch medico - geographical forecast* is not finished with detailed development of prognosis in domain of oncology. Interesting investigations are, for example, performed in domain of biogeochemical endemics forecasting.

Component medico - geographic forecast present scientific predicting of consequences of influence of various components of geographic medium or their combinations on public health. In dependence on number of simultaneously treated components, the prognoses are classified into: one - , two - or polyfactor.

As a direct auxiliary method for giving the solution, *restricted maps*, as: (1) maps presenting contemporary natural opportunities of the prognosed territory; (2) maps referring to perspective economical development of the interesting territory; (3) maps - reviews of the future demographic structure of population; (4) maps of infrastructure; (5) maps related to up - to - date medico - geographical situation (maps of diseases frequency, maps of natural and anthropogenic preconditions of biogeochemical endemics; maps of components of the natural environment with negative influence on public health; maps of complex medico - geographic evaluation of the territory) are used. Role of the ending cartographic model for the forecasting has a map of medico - geographic differentiation of the territory, with legend. Legend of the map contains all factors of geographic medium, from negative or positive influence on human health, as well as a list of diseases with preconditions existent in each rayon.

Knowing components of the environment influencing on human health, *prognosing evaluation of public health level* can be made. In addition, evaluations given by experts, particularly of competent geographers and geologists, who studied certain environmental components from the standpoint of their influence on public health, are of outstanding significance. *Extrapolation method*, principally treated as searching method of standard situation, is also of great importance. After performing previous exploration, possibility of compiling hypothetical *nosological profile* appears. Making such profiles, work on making medico - geographical

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prognosis is mainly finished, because nosoprofile presents public health level sufficiently.

The next step after finishing work on making research forecast is *program and organizational prognosis.* On the basis of studied factors of the environment, lowering health level, as well as of character of pathology which can appear within population, *perspective program* can be made on the basis of the following questions: (1) prophylaxis which has to be taken during subduing the rayon; (2) which are the factors of the external environment dangerous for population. Concrete measures defined by organizational forecast are - *the first,* prophylaxis; *the second* - reclaiming of the territory.

Medical geology can be of high importance in forecasting level of public health for the interesting territory. That is particularly valid in domain of *branch and component prognoses,* as well as of *restricted maps,* presenting factors of the natural (geological) environment. For making prognoses, medico - geographic or medico - geological, good knowledge on geological structure, geomorphologic features, hydrogeological and engineering - geological characteristics of the terrain, but also geochemical features of rocks, soil, groundwater and vegetation of the territory, is one of very important preconditions. The factors will be also of outstanding contribution in discovering possibility of forming processes and occurrences related to anthropogenic activity and influence on the nature and society. So, for example, zoning of the territory according to the aquifer vulnerability to contamination can be very helpful in evaluating drinking water quality and proposing measures of the aquifer sanitary protection (S.Komatina, 1997).

22. Monitoring of the (natural) environment. As we could conclude from the previous text, more and more important precondition of environmental management is prompt prognosis, which is prophylactic activity and predicting possible changes in the natural environment, with necessary measures as a result of the changes. Necessary data are obtained by **monitoring of the (natural) environment,** as a system of observing, control and management of the environment. Monitoring can be performed in different scales (also in global), and has to be directed to the planned goal, interconnected and efficient.

One of the important tasks of monitoring is based on the necessity of distinguishing changes in biosphere conditions which are under influence of anthropogenic activity *(anthropogenic monitoring).* For contemporary environmental monitoring, it is necessary to use experience, present material (documentation) and main monitoring offices dealing with various natural processes and occurrences.

Introducing of control and prognosis functions into modern environmental monitoring makes its content much more complicated. In this way,

requirements for representativity of the objects and observatory places and their density are made, because quantity and quality of principal data principally determines level of control efficiency and reliability of any prognosis.

According to I.P. Gerasimov and V.M. Kotl'akov (1983), **bioecological monitoring** is the first (principal) degree or block of contemporary environmental monitoring. The main link of bioecological monitoring is observing environmental conditions from the standpoint of its influence, first of all, on level of human health. Nowadays, for mass use, within the system of bioecological monitoring, toxic indes of soil and water medium contamination - so called indes or scales of norms of permitted concentrations of anthropogenic substances within the environment, are the best developed. In the near future, significant innovations in biological monitoring are expected, among all - in exploration of organic solvents exposure time, because progress of measuring technology made detecting even minimal quantities of some organic solvents in biological material possible. Outstanding progress is also expected in domain of monitoring toxic matters metabolites as well as methods for evaluation of body depots.

The second stage of environmental monitoring has to be **geoecological,** or wider - **geosystemic monitoring**. Task of the monitoring is in observing changes in geosystem level, in that sense - natural, in other words, geoecosystems, but also their transformation into naturally - technical agrosystems, mining basins, urban environment and environment of industrial rayons.

Organizing methodology of bio - and geoecological monitoring is completely different. Bioecological monitoring is based on geophysical, biochemical and biological parameters in the network of *control "points - checkpoints"*, in other words - basically, it is of local character. Geosystemic monitoring is much more based on geophysical, geological, biogeochemical and biological methods, but, beside the network of control points, *key surfaces system* is used, that is - basically, it is of regional character. The network of *key surfaces* has not to be extremely voluminous, but must have representative character.

The third degree is known as **biosphere monitoring.** This type of monitoring has to provide observing, control and prognosis of potential changes, this time not in regional, but in global scale, in other words - in comparison to biosphere in general and its changes caused by activities of society. It contains characteristics of Solar radiation, gas content and atmosphere degradation, as well as direct influence of heat of anthropogenic nature on general energetics of atmosphere, monitoring and measuring global biological productivity of land (continents) and water of the World ocean. Within biosphere monitoring, global effect of anthropogenic influence on climate and particularly gas content of the atmosphere,

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as also anthropogenic changes of water balance and disturbing global circular motion of moisture, with forecast of future period, is of high importance. The global monitoring is based on the system of geoecological zonal and regional polygons.

Geological monitoring, as one of the important chains of geoecological monitoring, includes numerous factors of the geological environment more completely. Data obtained during the monitoring are used for solving different tasks for scientific and practical purposes, as: exploitation of mineral raw materials; providing drinking water, mineral and thermal water; exploration of geological soil for constructing, etc. State, regime and quality of groundwater but also exogenous and endogenous geological processes and occurrences; natural geophysical, geochemical and radiogeochemical anomalies; geochemical (radiogeochemical) anomalies within pedological soil and leading aquifers, formed by anthropogenic activity in agricultural areas, mining basins and urban environment, are observed by regional network. The mentioned activities are observed by the system of remote and aerocosmogeological monitoring of geological environment.

Nowadays, preservation of groundwater resources, on which water supply of population all over the world is based, and which are, from the other side, significantly contaminated, is particularly studied. Beside developed hydrogeological information systems, numerous countries are famous by well organized groundwater monitoring. So, for example, Geological Institute of Finland started in 1969 with groundwater monitoring of the southern half of the state territory, with 50 monitoring rayons included starting from 1985. (B.Backman et al., 1999).