ENGINEERING GEOLOGY

ACHIEVEMENTS AND PROSPECTS FOR DEVELOPMENT

Lecture proposed by visiting Professor Vyacheslav Iegupov, Kharkiv National University for Civil Engineering and Architecture, March 2020.

Target audience: Civil Engineering Students, Lecturers and practising professionals

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Geology is one of the oldest areas of human activity and one of the most ancient sciences. The study of rocks, minerals, ores of various metals has been conducted for many centuries.

Modern civilization on Earth is based on the use of rocks and minerals. From the first primitive tools made of flint, the extraction of fire with it, to the most advanced microcircuits, also made on a silicon basis. All metal products are made from ore minerals mined at different times from the earth's crust. All stone buildings and structures are built from materials made from mineral raw materials. The basis of modern artificial materials is also made up of natural minerals and substances.

Using the complex approach of geological sciences, the history of the development of planet Earth and life on it was studied.

According to modern scientific ideas, the Earth was formed 4.54 ± 0.04 billion years ago from a primary gas-dust cloud, together with other planets of the solar system.

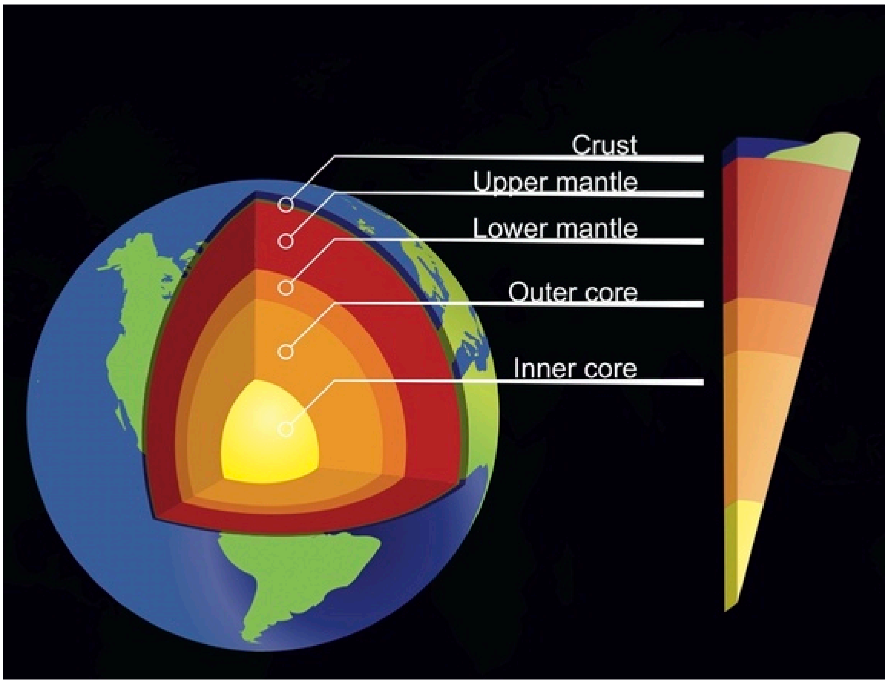
As a result of gravitational compression, heating and melting of the matter inside the Earth took place and a core was formed, surrounded by a series of concentric shells - the mantle, the earth's crust (lithosphere); hydrosphere and atmosphere formed later (fig. 1).

In the center of the Earth is a metal core, consisting mainly of iron, with an admixture of silicon and nickel. The inside of the core is a solid ball. The outer part of the core is liquid; its diameter is about 4400 km, the depth from the earth's surface is 2900 km.

The next shell is a mantle having a predominantly silicate composition. It occupies the space between the earth's crust and contains the largest part of the earth's substance - 67% of the mass and 83% of the volume of the globe.

The lithosphere is the Earth's solid shell. It includes the upper part of the mantle and the Earth's crust. Fault lines divide the lithosphere into separate blocks that are lithospheric (or tectonic) plates (Fig. 2). The eight largest lithospheric plates occupy more than 90 % of the Earth's surface: the Pacific Plate, the North American Plate, the Eurasian Plate, the African Plate, the Australian Plate, the Antarctic Plate, the South American Plate and the Indian Plate.

The overall structure of the planet EartH



Depth, km	Layer	Density, g / cm^3
0-35	Earth's crust (in some places varies from 5 to 70 km)	2,2 – 2,9
35-60	Upper mantle	3,4 – 4,4
35-2900	Mantle	3,4 – 5,6
2900-5100	Outer core	9,9 – 12,2
5100-6370	Inner core	12,8 – 13,1

Fig. 1. Structure of the Earth.

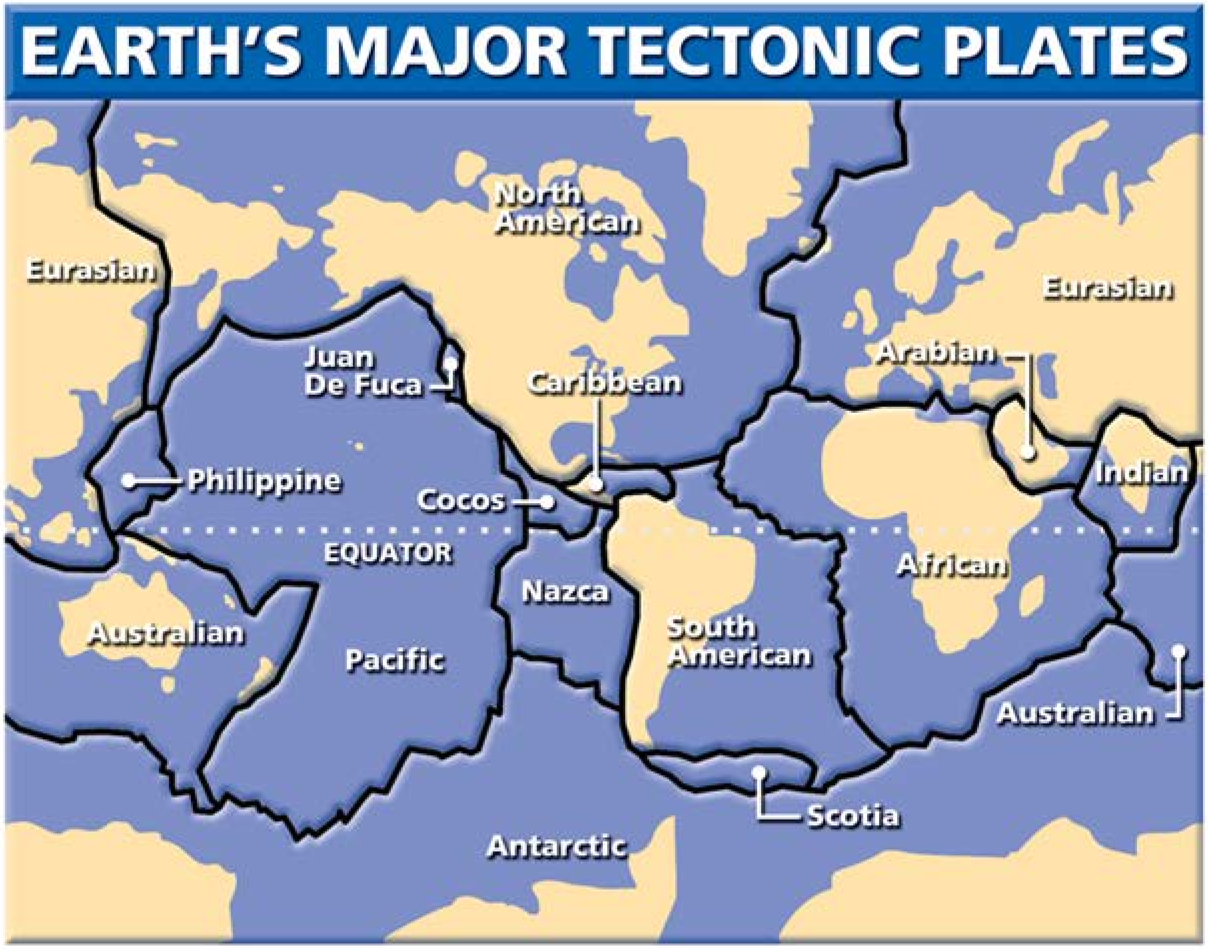


Fig. 2. Lithospheric tectonic plates

The plates move relative to each other at different rates: from 2 cm / year for the ‘slowest’ Eurasian plate to 5.2 - 6.9 cm/year and 7.5 cm/year for the ‘fastest’ Pacific and Cocos Plates. The outlines of the lithospheric plates are continuously changing; they can either split or unite. Sometimes they sink into the mantle and disappear from the Earth surface. Contemporary outlines of the continents and oceans arose due to the movement of the lithospheric plates. Hereby South America and Africa used to be a single continent, which can be clearly seen from the outlines of the coastline of Brazil and the Gulf of Guinea (fig. 3).

India, Madagascar and Africa have split relatively recently. Madagascar separated from Africa about 160 million years ago, and about 70 million years ago - from India.

The Hindustan Plate continues to move north. As a result of its collision with the Eurasian Plate, the highest mountains on Earth - the Himalayas - formed.

The study of the movement of lithospheric plates is carried out by tectonics - science as part of a large complex of geological sciences. This complex includes, for example, the following sciences:

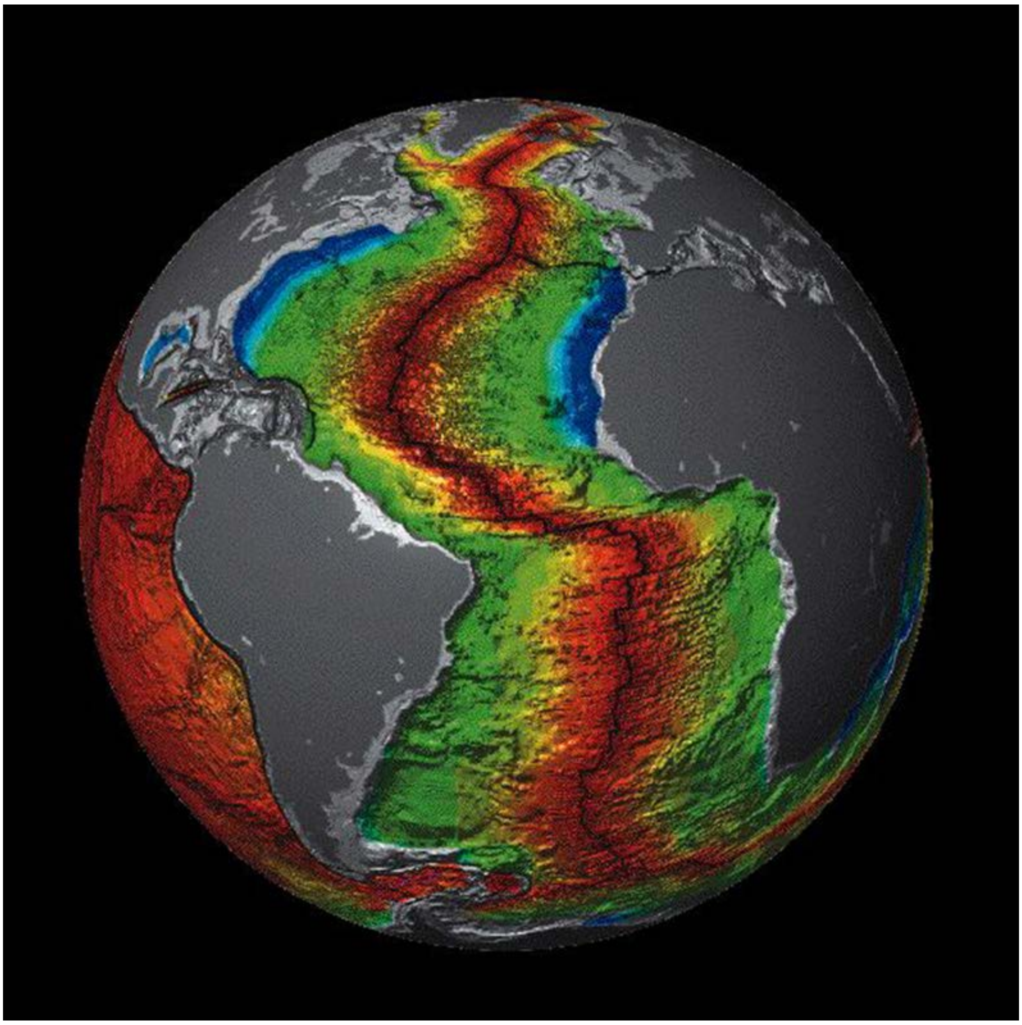


Fig. 3. Mid-Atlantic Ridge. The youngest rocks of the oceanic crust are red, the oldest ones are purple

Mineralogy is one of the main and probably the earliest branches of geology, which studies the diversity of minerals, their properties and physico-chemical characteristics. Note that in the ancient world, until the Middle Ages, geology among the Earth sciences was represented by only one mineralogy.

The composition, physical properties of rocks, their origin and occurrence forms are studied by the science of petrology (from the Greek. Πέτρος - stone). In Russian-speaking countries, the term petrography is more often used.

Stratigraphy (from Lat. Stratum - layer and ancient Greek. Γράφω - write, draw) is a branch of geology that studies the occurrence of sedimentary (as well as pyroclastic) rocks and determines their relative geological age.

Geochronology is a branch of geology that studies the chronological sequence of formation and age of rocks that make up the earth's crust.

A special place among geological sciences is occupied by **Engineering Geology**.

Academician E. M. Sergeev defines engineering geology "as a science of the geological environment, its rational use and protection in connection with the possibility of occurrence of geological processes harmful to humans".

Engineering Geology is a relatively young science, its principles, methods and practice began to form as a separate discipline only in the late 19th and early 20th centuries. The first book, *Engineering Geology,* was published by William Penning in 1880. Over the next 140 years, it developed rapidly thanks to the implementation of large-scale construction projects in many countries.

The largest studies of the first half of the twentieth century in Engineering Geology were carried out in the USA - K. Terzagi, R. Peck, J. Taylor, T. Lamb; in the UK - A. Skempton; in France - J. Talobre; in Austria - L. Muller. A particularly significant role in the formation of engineering geology as a science was played by the Soviet scientist F.P. Savarensky.

The three main sections of engineering geology are characterized by E. M. Sergeev as follows:

Engineering Geodynamics - the science of modern geological processes that are important in the national economic and construction activities;

Soil science is a science that studies any rocks and soils as multicomponent dynamic systems that change in connection with human activities in the field of engineering;

Regional Engineering Geology is a scientific direction for understanding the laws governing the formation of engineering and geological conditions in large geological regions and predicting their changes under the influence of human engineering activities.

One of the most important tasks of Engineering Geology is the interpretation of terrain features, geological structure and processes on Earth to identify potential geological and related technological hazards that can have a big impact on civil structures and human life. Knowledge in the field of engineering geology gives construction specialists an understanding of how the "earth" works, which is extremely important to minimize the dangers and risks associated with it. Most builders receive special education and training in soil mechanics, rock mechanics, geotechnics, hydrogeology, hydrology and civil engineering. These two aspects of education provide geologists and builders with a unique ability to understand and mitigate the dangers associated with the interaction of construction sites and earthworks.

The reliability of buildings and structures, the preparation of foundations and cost reduction have always been and remain a very urgent task. A rational solution largely depends on the ability to correctly assess the engineering and geological conditions of construction sites, the properties of soils in the foundations, the joint work of these soils with the structures. An important role is played by the assessment of the possibility of occurrence or intensification of hazardous Engineering-Geological processes: karst, slope processes (landslides, rockfalls, etc.), flooding of territories and seismic processes. For Civil Engineers, a clear knowledge of such processes and methods for protecting construction sites is a must.

Research practice.

Geotechnical investigations and studies are performed for the following:

• residential, commercial and industrial buildings and structures;

• state and military facilities;

• public developments, such as power plants, wind turbines, power lines;

• storm water evacuation, wastewater treatment plants, water treatment plants, pipelines (aqueducts, water pipes), tunnels;

• hydraulic structures: canals, dams and reservoirs;

• railways and roads, bridges, airports;

• the development of a mine and quarry, reclamation of territories of worked mines;

• wetland recovery programs;

• government, commercial or industrial waste disposal sites;

• coastal works: protection of sandy beaches, stability of cliffs or sea cliffs, the construction of a harbor, pier and promenade;

• offshore operations: drilling platforms and underwater pipelines, underwater cable;

and as well as for other types of objects.

Engineering and Geological studies can be carried out at the stages of long-term planning, analysis of environmental impact, general structural design, detailed design and construction of public and private buildings and structures and also at the stages of reconstruction and rehabilitation.

Geological Engineering investigation is carried out by an Engineering Geological or a Geotechnical Engineer who is trained, has the qualifications and experience related to the recognition and interpretation of natural processes, understanding how these processes affect human-made structures (and vice versa), as well as knowledge of the methods preventing hazard risks or mitigate the consequences arising from adverse natural or man-made incidents. The main task of a Geological /geotechnical Engineer is to protect life and property from damage that can be caused by various geological processes and phenomena.

At present, the main task of Engineering Geology as a science can be considered the creation of prerequisites for participation in managing the development of the geological environment and harmonization of the "man - geological environment" system.