ИНОСТРАННЫЙ ЯЗЫК

АНГЛИЙСКИЙ ДЛЯ ГЕОФИЗИКОВ

Методические указания к практическим занятиям для студентов специальности 21.05.03

FOREIGN LANGUAGE

ENGLISH FOR GEOPHYSICISTS

САНКТ-ПЕТЕРБУРГ
2019

Министерство науки и высшего образования Российской Федерации

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Санкт-Петербургский горный университет

Кафедра иностранных языков

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Методические указания составлены для использования на практических занятиях по дисциплине «Иностранный язык». Предлагаемый материал направлен на развитие и совершенствование навыков чтения и перевода текстов по специальности, расширение словарного запаса и приобретение разговорных навыков в рамках профессиональной тематики.

Предназначены для студентов специальности 21.05.03 «Технология геологической разведки», изучающих иностранный язык.

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ВВЕДЕНИЕ

Данные методические указания к практическим занятиям по английскому языку предназначены для студентов специальности 21.05.03 «Технология геологической разведки», специализация «Геофизические методы поисков и разведки месторождений полезных ископаемых». Методические указания составлены в соответствии с учебной программой по дисциплине «Иностранный язык» для формирования иноязычной профессиональной компетенции будущих специалистов.

Предложенные методические материалы предназначены для аудиторной работы студентов и состоят из четырех разделов, содержащих информацию об основных типах горных пород, особенностях внутреннего устройства планеты и геофизических методах исследования земных недр.

Методические указания содержат учебные и аутентичные тексты на английском языке с разработанным комплексом предтекстовых и послетекстовых упражнений. Изучение предложенного материала имеет целью развитие и совершенствование навыков чтения и перевода текстов по специальности. Комплекс упражнений направлен на расширение словарного запаса, преодоление трудностей перевода и приобретение разговорных умений в сфере профессиональной деятельности.

UNIT 1 GEOPHYSICAL SCIENCE AND ITS APPLICATIONS

TEXT 1.1 How is the Earth's Interior Studied?

1 Read and translate the following words. Be careful to pronounce them correctly.

geology (n)	[dʒɪˈɒlədʒi]	kimberlite (n)	[ˈkɪmbəlaɪt]
geologist (n)	[dʒɪˈɒlədʒɪst]	intrusion (n)	[ɪnˈtruːʒən]
geophysics (n)	[dʒiːə(ʊ)ˈfɪzɪks]	erosion (n)	[ɪˈrəʊʒən]
geophysicist (n)	[ʤiːəʊˈfɪzɪsɪst]	oceanic (adj)	[əʊʃɪˈænɪk]
basalt (n)	[ˈbasɔːlt]	lithosphere (n)	[ˈlɪθəsfɪər]
diamond (n)	[ˈdʌɪ(ə)mənd]	gravity (n)	[ˈgrævɪtɪ]

2 Make up verbs from the following nouns. Translate the words.

1 a sample – to sample
2 a mine -
3 a study -
4 a flow -
5 an experience -

3 Translate the following word combinations. Make up sentences using the word combinations below.

to sample rocks, some deep mines, rock samples, basalt flows, to mine diamonds, to experience extension, to study directly, are studied indirectly, the study of Earth

4 With a partner, discuss the questions below. Compare your ideas with other students.

- What do geologists know about the Earth's interior?
- How is the Earth's interior studied?

5 Read the text to check your answers.

What *do* geologists know about Earth's interior? How do they obtain information about the parts of Earth beneath the surface? Geologists, in fact, are not able to sample rocks very far below Earth's surface. Some deep mines penetrate 3 kilometers into Earth, and a deep oil well may go as far as 8 kilometers beneath the surface; the deepest scientific well has reached 12 kilometers in Russia. Rock samples can be brought up from a mine or a well for geologists to study.

A direct look at rocks from deeper levels can be achieved where mantle rocks have been brought up to the surface by basalt flows, by the intrusion and erosion of diamond-bearing kimberlite pipes, where the lower part of the oceanic lithosphere has been tectonically attached to the continental crust at a convergent plate boundary, or where old oceanic lithosphere experiences extension and produces a "tectonic window" into the upper mantle. However, Earth has a radius of about 6,370 kilometers, so it is obvious that geologists can only scratch the surface when they try to study *directly* the rocks beneath their feet.

Deep parts of Earth are studied *indirectly,* however, largely through the branch of geology called **geophysics,** which is the application of physical laws and principles to the study of Earth. Geophysics includes the study of seismic waves and Earth's magnetic field, gravity, and heat. All of these things tell us something about the nature of the deeper parts of Earth. Together, they create a convincing picture of what makes up Earth's interior.

Taken from: Charles C. Plummer, Diane H. Carlson, Lisa Hammersley. (2016) Physical geology (Fifteenth edition), McGraw-Hill Education, New York. – p. 413.

6 Explain what these numbers mean in the text: 3; 8; 12; 6,370

7 Fill in the gaps using the words in the box. There is one extra word.

A Earth's heat	**B** Gravity measurements	**C** Magnetic anomalies	**D** Seismic waves

To learn more about the deep interior of Earth, geologists must study it indirectly, largely by using the tools of geophysics — that is, seismic waves, and measurements of gravity, heat flow, and Earth's magnetic field.

1) ____________ are used to image shallow and deep geologic structures within the Earth. **2)** ____________ can indicate where certain regions of the crust and upper mantle are being held up or held down out of their natural position of equilibrium. **3)** ____________ can indicate hidden ore and geologic structures.

Adapted from: Charles C. Plummer, Diane H. Carlson, Lisa Hammersley. (2016) Physical geology (Fifteenth edition), McGraw-Hill Education, New York. – p. 413.

Geophysical Quiz

How well do you know the interior of Earth? Read the statements below and fill in the gaps. If you have any difficulties, use the terms and expressions from the box at the bottom of the page.

1. The interior of Earth is studied indirectly by ______ — a study of seismic waves, gravity, Earth magnetism, and Earth heat.
2. Seismic reflection and seismic refraction can indicate the presence of ______.
3. Earth is divided into three major zones — ______.
4. The crust beneath oceans is 7 kilometers thick and made of ______ on top of gabbro.
5. Continental crust is 30 to 50 kilometers thick and consists of a crystalline basement of ______ (and other rocks) capped by sedimentary rocks.
6. The *Mohorovičić* discontinuity separates the crust from ______.
7. The mantle is a layer of solid rock 2,900 kilometers thick and is probably composed of ______ such as peridotite.
8. The lithosphere is 70 to 125 (or more) kilometers thick and moves over the ductile ______.
9. Seismic-wave shadow zones show the core has a radius of 3,450 kilometers and is divided into ______.
10. A core composition of mostly ______ is suggested by Earth's density, the composition of meteorites, and the existence of Earth's magnetic field.
11. A positive gravity anomaly forms over ______.
12. A negative gravity anomaly indicates ______.
13. Earth's magnetic field has two ______ probably generated by convection circulation and electric currents in the outer core.
14. ______ develops over rock that is more magnetic than neighboring rock.

Adapted from: Charles C. Plummer, Diane H. Carlson, Lisa Hammersley. (2016) Physical geology (Fifteenth edition), McGraw-Hill Education, New York. – p. 431.

basalt / the mantle / asthenosphere / low-density rock / a positive magnetic anomaly / geophysics / the crust, the mantle, and the core / granite and gneiss / a liquid outer core and a solid inner core / magnetic poles / iron and nickel / an ultramafic rock / boundaries between rock layers / dense rock

TEXT 1.2 Geophysicist

1 With a partner, discuss the questions below. Make a list of possible answers. Compare your ideas with other students.

- What do geophysicists study?
- Where can geophysicists work?

2 Read the text to check your answers.

A geophysicist is a scientist who studies the physical properties of the Earth, and who may also study the physical properties of other planets along with moons and other objects found in space. In order to work in this field, it is usually necessary to have a graduate degree. Numerous universities around the world offer graduate programs in geophysics, with both masters and doctorate degrees available to students.

The field of geophysics is quite broad, and geophysicists may engage in a wide range of activities as part of their work. The study of geophysics includes the study of surface properties of the Earth, like the characteristics of the Earth's crust, the study of the atmosphere, the study of the interior of the Earth, and the study of the Earth's oceans.

One example of the application of geophysics is studying the Earth's core by analyzing seismic waves. Using supercomputers, geophysicists can map irregularities in the Earth's core on scales as small as one kilometer.

At one point, it was believed the outer core was fairly homogeneous, but geophysical calculations have shown otherwise. Scientists now suspect that the outer core may consist of alternating layers of liquid and solid material.

Geophysicists can work in the field, collecting data, making observations, and calibrating equipment. They can also work in the lab performing controlled experiments and conducting analysis of samples, teach students in the classroom, and be employed by government agencies and private organizations interested in topics within the scope of geophysics.

Some professionals use their knowledge of physical properties to assist in mining, drilling, and construction efforts. Research geophysicist jobs are usually held by experts in geodesics, geodynamics, or geomagnetism.

The largest number of geophysicists find employment in the petroleum industry. Since most of the petroleum deposits are buried deep below the surface, petroleum geophysicists find oil and gas by building a clear picture of what is below the Earth's surface.

Adapted from: Тарасова В.В., Даминова Э.Р., Сабирова Р.Н. Reading science. –учеб. пособие. – Казань: Казан. ун-т, 2016 – с 34 - 35.

3 Match the words combinations with their Russian equivalents:

1 to be engaged in a wide range of activities	**A** собирать данные и проводить наблюдения
2 to study the interior of the Earth	**B** проводить контрольные опыты
3 to perform controlled experiments	**C** изучать недра Земли
4 to conduct analysis of samples	**D** проводить анализы образцов
5 to collect data and to make observations	**E** иметь высшее образование (диплом)
6 to study physical properties of the Earth	**F** изучать физические свойства Земли
7 to have a graduate degree	**G** заниматься различными видами деятельности

4 Make a list of responsibilities you will have as a geophysicist. What kinds of work interest you the most? Explain your choice.

5 Fill in the gaps using the words in the box. There is one extra word.

hazards outdoors	evaluate features	evolution structure	studies indoors

A geophysicist is someone who **1**_______ the Earth using gravity, magnetic, electrical, and seismic methods. Some geophysicists spend most of their time **2**_______ studying various **3**_______ of the Earth, and others spend most of their time **4**_______ using computers for modeling and calculations. Some geophysicists use these methods to find oil, iron, copper, and many other minerals. Some **5**_______ earth properties for environmental **6**_______ and evaluate areas for dams or construction sites. Research geophysicists study the internal structure and **7**_______ of the Earth, earthquakes, the ocean and other physical features using these methods.

Taken from: https://earthquake.usgs.gov/learn/kids/become.php

6 Write an essay of between 120 and 150 words.

Advantages and disadvantages of being a geophysicist.

UNIT 2 OUR PLANET

TEXT 2.1 The Physical Structure of the Earth

1 Fill in the gaps using the words in the box. There is one extra word.

A. Mantle	**B.** Outer core	**C.** Inner core	**D.** Lithosphere	**E.** Crust

The Earth is almost a sphere, consisting of four main layers.
1. __________ is made from solid nickel and iron
2. __________ has the properties of a solid, but can flow very slowly
3. __________ is relatively thin and rocky
4. __________ is made from liquid nickel and iron

2 Read the text to check your answers.

The Earth is an oblate spheroid. It is composed of a number of different layers as determined by deep drilling and seismic evidence. These layers are:

- The **core** which is approximately 7000 kilometers in diameter (3500 kilometers in radius) and is located at the Earth's center.
- The **mantle** which surrounds the core and has a thickness of 2900 kilometers.
- The **crust** floats on top of the mantle.

The core is a layer rich in iron and nickel that is composed of two layers: the **inner** and **outer cores**. The inner core is theorized to be solid with a density of about 13 grams per cubic centimeter and a radius of about 1220 kilometers. The outer core is liquid and has a density of about 11 grams per cubic centimeter. It surrounds the inner core and has an average thickness of about 2250 kilometers.

The mantle is almost 2900 kilometers thick and comprises about 83% of the Earth's volume. It is composed of several different layers. The **upper mantle** extends from the base of the crust downward to a depth of about 670 kilometers. This region of the Earth's interior is thought to be composed of peridotite, an ultramafic rock made up of the minerals olivine and pyroxene. The top layer of the upper mantle, 100 to 200 kilometers below surface, is called the **asthenosphere**. Scientific studies suggest that this layer has physical properties that are different from the rest of the upper mantle. The rocks in this upper portion of the mantle are more rigid and brittle because of cooler temperatures and lower pressures. Below the upper mantle is the **lower mantle** that extends from 670 to 2900 kilometers below the Earth's surface. This layer is hot and plastic. The higher pressure in this layer causes the formation of minerals that are different from those of the upper mantle.

The **lithosphere** is a layer that includes the crust and the uppermost portion of the mantle (Fig. 1). This layer is about 100 kilometers thick and has the ability to glide over the rest of the upper mantle. Because of increasing temperature and pressure, deeper portions of the lithosphere are capable of plastic flow over geologic time. The lithosphere is also the zone of earthquakes, mountain building, volcanoes, and continental drift.

The topmost part of the lithosphere consists of crust. This material is cool, rigid, and brittle. Two types of crust can be identified: **oceanic crust** and **continental crust** (Fig. 1). Both of these types of crust are less dense than the rock found in the underlying upper mantle layer. Ocean crust is thin and measures between 5 to 10 km thick. It is also composed of basalt and has a density of 3.0 grams per cubic centimeter.

The continental crust is 20 to 70 kilometers thick and composed mainly of lighter granite. The density of continental crust is about 2.7 grams per cubic centimeter. It is thinnest in areas like the Rift Valleys of East Africa. Continental crust is thickest beneath mountain ranges and extends into the mantle. Both of these crust types are composed of numerous **tectonic plates** that float on top of the mantle. Convection currents within the mantle cause these plates to move slowly across the asthenosphere. *Taken from*: http://www.physicalgeography.net/fundamentals/10h.html

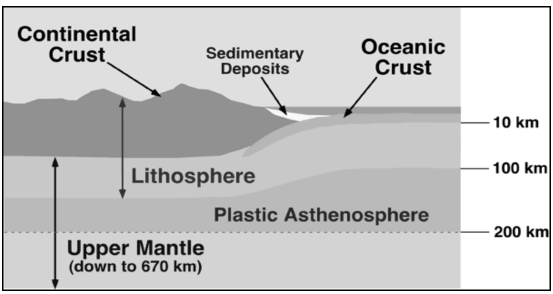


Fig. 1. Structure of the Earth's crust and top most layer of the upper mantle.

2 Scan the text 2.1 and fill in the table below.

Elements and minerals mentioned in the text	*Granite, ...*
Physical properties mentioned in the text	*Rigid, ...*
Physical quantities mentioned in the text	*Density, ...*

3 Check your knowledge of the physical structure of our planet. Take turns asking each other questions and answer them. Give your partner one mark for each correct answer. Count your score at the end.

Student 1

- Which layer surrounds the core?
- Which layer contains most of the Earth's mass?
- Which type of the crust is rich in basalt?
- Which layer is made up mostly of iron?
- What causes the slow movements of tectonic plates across the asthenosphere?

Student 2

- What is the crust composed of?
- Which layer includes the crust and the uppermost part of the mantle?
- Which layer surrounds the inner core?
- Which layer floats on the top of the mantle?
- Which layer extends from 670 to 2900 km below the Earth's surface?

Take turns making up your own questions. Continue until one of you gives up. Who is the winner today? Who got the most right answers?

4 Tell about the physical structure of the Earth, using the diagram below.

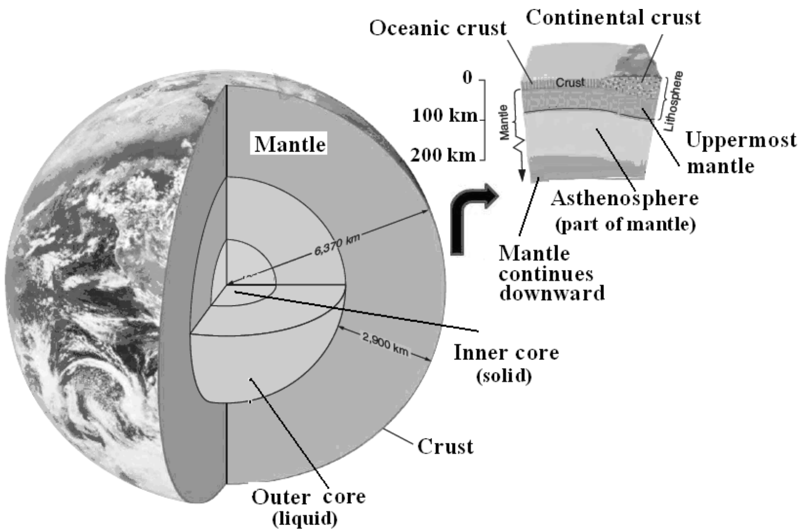


Fig. 2. Cross section through the Earth.

TEXT 2.2 Types of Rocks

1 Discuss these questions with a partner.

- What is the difference between rocks and minerals?
- How many types of rocks make up the Earth's crust?
- What are the names of the three types of rocks?
- How are they formed?

2 Read the text to check your answers.

Rocks and Minerals

The ground we walk on, build on, and grow gardens on is made of rock. All the rocks in the world are made up of chemicals called **minerals**. Minerals are solid, inorganic (not living) substances found in and on the earth. Most are chemical compounds, which means that they are made of two or more elements. For example, the mineral sapphire is made up of aluminum and oxygen. A few minerals such as gold, silver and copper are made of a single element. Minerals are considered to be the building blocks of rocks. Rocks can be a combination of as many as six types of minerals. Through a microscope, a rock shows that it is made of crystals of different minerals, all growing together like a puzzle.

Three types of rocks make up the Earth's crust. Rocks are formed in three different ways to produce igneous, metamorphic, and sedimentary rocks. Igneous rocks form when molten magma cools and solidifies. Metamorphic rocks form when a rock is chemically changed by heat or pressure to form a new rock type. Sedimentary rocks form when fragments of rocks and other debris are cemented together.

Igneous Rocks

When a candle burns, a runny wax is formed that trickles down its side and solidifies. Igneous rocks are formed in a similar way. The rocks solidify from a mass of molten rock, such as when a lava flow cools and hardens. Because of the heat needed to form igneous rocks, they are sometimes called "rocks of fire." There are two main types of igneous rock: extrusive and intrusive. Extrusive types form when molten rock comes to the surface and cools quickly, as with lava. This produces a very fine-grained rock. Intrusive rocks are those that solidified underground, cooling slowly to produce coarse-grained rocks. Examples: Granite, basalt, obsidian.

Sedimentary Rocks

Sedimentary rocks are formed when sediment (bits of rock plus materials such as shells and sand) get packed together. They can take millions of years to form. You never know what you might find in a sedimentary rock since many rocks of this type are made up of lots of other rocks, or even animal remains, all stuck together. Sedimentary rocks are built up of particles laid down as layers or beds of sediment and are later buried, compressed, and cemented into a solid mass. Most rocks that you see on the ground are sedimentary. Examples: Sandstone, shale, limestone.

Metamorphic Rocks

Metamorphic rocks are igneous or sedimentary rocks that have been transformed by heat, pressure, or both. Metamorphic rocks are usually formed deep within the Earth, during a process such as mountain building. When you bake bread, you mix flour, yeast, and water together and bake in a hot oven. In a similar way, heat and pressure from the overlying rocks, may change the nature of the rocks below. This process is called metamorphosis, which means "change." Examples: Schist, slate, marble.

Taken from: www.k5learning.com

2 Answer the questions below.

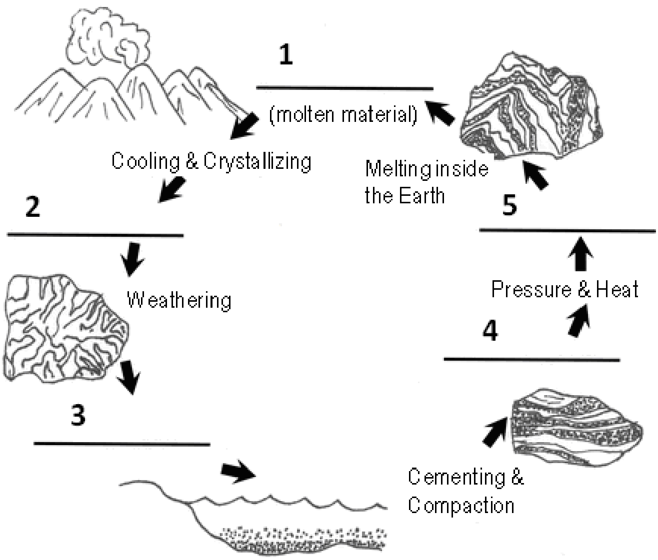
1. How are igneous rocks formed?
2. What is another name for igneous rocks?
3. What is the difference between to the two types of igneous rocks?
4. How are sedimentary rocks made?
5. How are metamorphic rocks made?
6. What does the word "metamorphosis" mean?
7. Which two layers of the Earth are made of rock?
8. Put the following layers of the earth in order from the most dense to the least dense: atmosphere, crust, inner core, mantle, outer core, water.

3 Summarize the information given in text 2.2. Write at least 150 words.

TEXT 2.3 The Rock Cycle

1 Fill in the blanks to complete the rock cycle using these words:

magma	igneous rock	sediment
metamorphic rock		sedimentary rock



2 Describe the rock cycle.

3 Read and translate the text from Russian into English.

Just like plants and animals have a life cycle, rocks can go through a rock cycle! Many rocks start from magma or lava, so they are igneous rocks. The igneous rocks could get broken up in a river or stream and settle to the bottom of a lake. Over thousands or millions of years, the broken up rocks could get compacted into a sedimentary rock. The sedimentary rock could get exposed to intense heat, and change to a metamorphic rock. Then the metamorphic rock could get covered by many other rocks and end up deep in Earth's crust. It may melt and turn into magma, and the cycle could start over again. The rock cycle is different than a life cycle of a plant or animal, though, because a rock doesn't have to go through the cycle in order, and it may not go through all the stages.

Taken from: www.k5learning.com

UNIT 3 THEORIES OF THE EARTH'S FORMATION

TEXT 3.1 Continental Drift

1 With a partner, study the map of Pangaea (fig.3) and answer the questions below.

1. What is Pangaea?
2. How were the modern continents formed according to the 20th-century theory of continental drift?
3. What is the most striking evidence for this theory?

Fig. 3. Map of Pangaea

2 Read the text to check your answers.

The theory of continental drift dates back to the early 1900s. It suggests that all the present-day continents were previously joined into one supercontinent, Pangaea. During the early Jurassic, about 200 million years ago, Pangaea broke up. The fragments of the supercontinent drifted across the face of the earth into their present positions to form the modern continents.

The most striking evidence for the theory is the close "fit" between the eastern edges of the continents of North and South America and the western edges of the continents of Europe and Africa. However, the theory was not widely accepted at first. It was not known what process would cause Pangaea to break up and the continents to move.

Adapted from: Hyne, Norman J. Nontechnical guide to petroleum geology, exploration, drilling, and production / Norman J. Hyne. -- 3rd ed. – p. 74.

3 Find the words in the text which have the same or similar meaning to the words below. Translate the text from Russian into English.

1 considers	**4** parts	**7** proof
2 modern	**5** moved across	**8** broadly

3 were glued together **6** current locations

TEXT 3.2 Seafloor Spreading

1 Read and translate the following words and word combinations. Use a dictionary if necessary.

breakup, drifting, convection currents, viscous liquids, the mid-ocean ridge, the ridge crest, compatible theories, the Gulf of Aden, the Great Rift Valley of East Africa, graben

2 Fill in the table below. Translate the words.

verbs	nouns	verbs	nouns
occur	- occurrence	spread out	-
penetrate	-	produce	-
split	-	collide	-
drag	-	form	-

3 Scan the text and find the explanation for the following terms:

seafloor spreading, subduction zone

A new theory, seafloor spreading, was presented in the early 1960s. This theory provided the processes for the breakup of Pangaea and the drifting of the continents. Seafloor spreading postulates that large, slow-moving convection currents occur in the interior of the earth where rocks act as viscous liquids. A convection current is a cell of flowing liquid caused by heating and cooling. Where the liquid is heated, it becomes less dense and rises. Where the liquid is cooled, it becomes more dense and sinks. Convection currents cause the interior of the earth to be constantly moving. A rising hot current from the interior of the earth cannot penetrate the crust of the earth. It arches the crust up to form the mid-ocean ridge. The hot, molten current then divides and flows to either side of the mid-ocean ridge. This splits the solid crust of the earth (lithosphere) at the ridge crest and drags it to either side of the ridge. The term seafloor spreading comes from the seafloor being spread out at right angles from the crest of the mid-ocean ridge. The seafloor is spreading out from several mid-ocean ridges in different oceans. Areas where seafloors from two different mid-ocean ridges collide are called subduction zones.

Seafloor spreading and continental drift are compatible theories. A mid-ocean ridge formed under Pangaea during the Jurassic time and caused it to break up. The continents, riding on the spreading seafloor, would have been carried to their present positions as the Atlantic Ocean became wider. There are modern examples of a newly formed ocean and a continent that is breaking up. A segment of the mid-ocean ridge from the Indian Ocean enters the Gulf of Aden and bifurcates into two sections. One section is located on the bottom of the Red Sea. The Red Sea is a long, narrow arm of the ocean that separates Egypt and Sudan, in Africa, from Saudi Arabia. Africa and Saudi Arabia were joined millions of years ago. A mid-ocean ridge rose beneath them about 20 million years ago, split them apart, and created the Red Sea. The Red Sea is growing wider by inches each year. It is similar to the Atlantic Ocean when Pangaea first broke up.

Another section of the mid-ocean ridge underlies the Great Rift Valley of East Africa. The valley is a series of large, long grabens with active volcanoes, earthquakes, and deep lakes. East Africa is breaking up today. A long, narrow arm of the ocean, similar to the Red Sea, will eventually occupy the rift valley in the next few thousands of years, forming two Africas.

Adapted from: Hyne, Norman J. Nontechnical guide to petroleum geology, exploration, drilling, and production / Norman J. Hyne. -- 3rd ed. – p. 75-79.

4 Do the following statements agree with the information in the text? Write *TRUE*, *FALSE* or *NOT GIVEN*.

1. The theory of seafloor spreading was developed in the second half of the 20th century.
2. The theory explained the movement of the supercontinent Pangaea.
3. Heating and cooling of rocks inside our planet causes convection currents.
4. Convection currents go through the crust of the earth.
5. Mid-ocean ridges can be found in different oceans.
6. The existence of a graben is a striking evidence for the theory of seafloor spreading.
7. Modern continents can’t brake up.
8. There will be two Africas in the future.

TEXT 3.3 **Plate Tectonics**

1 With a partner, write as many facts as you know about the theory of plate tectonics. Compare your list with those of other students.

2 Do the following quiz.

1. The theory of continental drift was suggested by …

A. Harry H. Hess **B.** Robert S. Dietz **C.** Alfred Wegener **D.** Francis Bacon

2. The theory of plate tectonics was developed in …

A. 1965 **B.** 1968 **C.** 1960 **D.** 1967

3. At present, there are … large plates and many smaller ones.

A. nine **B.** ten **C.** eight **D.** seven

4. Each plate originates at …

A. a mid-ocean ridge **B.** molten rocks **C.** the earth's surface **D.** the seafloor

5. Mount Everest is composed of … rocks.

A. plutonic **B.** sedimentary **C.** metamorphic **D.** volcanic

6. The Andes are located along the … coast of South America.

A. west **B.** south **C.** north **D.** east

3 Read the text and check your answers.

The theory of seafloor spreading developed more or less simultaneously by Harry H. Hess and Robert S. Dietz helped support the Wegener theory of continental drift. Today it is a widely accepted fact that the continents are in motion. The study of how continents spread apart and move over the surface of the earth has led to an entirely new branch of earth science known as plate tectonics.

The modern day theory of plate tectonics, suggested in 1967, combines the ideas of seafloor spreading and continental drift. Plate tectonics postulates that the solid lithosphere of the earth is divided into large, moving plates. Every location on the earth's surface, whether a continent or a seafloor, is on a moving plate that is sliding across the partially molten rocks below it. Each plate originates at a mid-ocean ridge where new seafloor is being formed. The plate is moving at right angles away from the crest of the ridge at the spreading rate of that ridge. At the opposite side of the plate from the mid-ocean ridge is a subduction zone, an ocean trench, and/or a mountain range. Large strike-slip faults occur where different plates scrape against each other. Continents ride along on the moving plates.

At present, there are eight large plates and many smaller ones. In the geologic past, the number and size of the plates have varied along with their rates and directions.

The major features of the earth's surface, both modern and ancient, can be explained by moving plates. Mountains are formed by the collision of plates. For hundreds of millions of years, thick sediments accumulated along continental margins on two different seafloor plates. The continents eventually collided, and the sediments were compressed, forming mountain ranges such as the Himalayan Mountains. Mount Everest is composed of sedimentary rocks deposited in the seas between India and Asia before they collided. The collision between one seafloor plate with a continent and another seafloor plate forms a coastal mountain range. The Andes Mountains along the west coast of South America are an example.

Adapted from: Hyne, Norman J. Nontechnical guide to petroleum geology, exploration, drilling, and production / Norman J. Hyne. -- 3rd ed. – p. 79.

4 Complete the sentences with the appropriate words. There is one extra word.

1 ____ combines the ideas of seafloor spreading and continental drift.
2 ____ is divided into large, moving plates.
3 ____ are sliding across the molten rocks below the earth's surface.
4 ____ ride along on the moving plates.
5 ____ are formed by the collision of plates.
6 ____ occur where different plates scrape against each other.
7 ____ are accumulated and deposited in the seas.

A Sediments
B Mountains
C Plates
D A seafloor
E Plate tectonics
F Lithosphere
G Continents
H Faults

5 Look through the texts 3.1, 3.2, 3.3 and fill in the table below.

Theory	Author	Year	Main Idea
1. … **2. …**			

3. …			

6 Search the Internet for more information. Make a report or a presentation "Theories of the Earth's Formation".

UNIT 4 METHODS OF GEOPHYSICAL EXPLORATION

TEXT 4.1 Magnetic Exploration

1 Read and translate the following words. Be careful to pronounce them correctly. What do you know about these rocks and minerals?

magnetite (n)	[ˈmægnɪtaɪt]	hematite (n)	[ˈhemətaɪt]
pyrrhotite (n)	[ˈpɪrətaɪt]	basalt (n)	[ˈbasɔːlt]
maghemite (n)	[ˈmæghɪmaɪt]	iron ore (n)	[ˈaɪən ɔː]

2 Match the words to make collocations. Translate them into Russian

I.

1 significant	**A** currents
2 electric	**B** anomalies
3 permanent	**C** axis
4 geographic	**D** mineral
5 magnetic	**E** effects
6 local	**F** deposits
7 abundant	**G** dykes
8 ore	**H** properties
9 basalt	**I** basement
10 outcropping	**J** magnetic bar

II.

1 extremely	**A** used
2 strictly	**B** magnetic
3 naturally	**C** variable
4 widely	**D** occurring
5 highly	**E** proportional

3 Translate the sentences below. Pay attention to the words in bold.

1) Geophysical techniques are ***applied*** to find magnetite ores.
Their magnetization is not proportional to the ***applied*** field.

2) Significant magnetic effects are ***produced*** by only a very small number of minerals.
Magnetic fields ***produced*** by massive magnetite deposits are thousands of nT.

3) Electric currents circulate in the ***liquid*** outer core.
Water is the most important ***liquid*** we know.

4) The ***force*** lines of the magnetic field indicate the presence of a magnetic ***force*** at every point in space.

5) Variations in magnitude and direction of this field ***influence*** the shapes of local anomalies.

Science studies don't indicate the ***influence*** of the magnetic fields of geological bodies on the environment.

6) Most ***observed*** magnetic anomalies contain ferro- or ferri-magnetic substances. Lunar eclipse was ***observed*** yesterday.

4 Scan the text to find the following information:

- *description of the Earth's magnetic field model*
- *examples of naturally occurring magnetic minerals*
- *magnitudes of magnetic fields produced by basalt dykes and sedimentary rocks*

Compasses and dip needles were used in the Middle Ages to find magnetite ores in Sweden, making the magnetic method the oldest of all applied geophysical techniques. It is still one of the most widely used, even though significant magnetic effects are produced by only a very small number of minerals.

The Earth's main magnetic field originates in electric currents circulating in the liquid outer core, but it can be largely modelled by a small but powerful permanent magnetic bar, located near the center of the Earth and inclined about 11° from the geographic axis; the force lines of the magnetic field indicate the presence of a magnetic force at every point in space.

A body placed in a magnetic field acquires a magnetization which, if small, is proportional to the field. The magnetic properties of highly magnetic rocks tend to be extremely variable and their magnetization is not strictly proportional to the applied field. The magnetic fields of geological bodies are superimposed on the background of the Earth's main field. Variations in magnitude and direction of this field influence both the magnitudes and shapes of local anomalies.

Most observed magnetic anomalies are due to the small number of *ferro*- or *ferri-magnetic* substances. Ferro- and ferri-magnetic materials may have permanent as well as induced magnetic moments, so that their magnetization is not necessarily in the direction of the Earth's field. Magnetite, pyrrhotite and maghemite, are the only important naturally occurring magnetic minerals and, of the three, magnetite is by far the most common. Hematite, the most abundant iron mineral, has a very small susceptibility and many iron ore deposits do not produce significant magnetic anomalies.

Magnetic field strengths are now usually measured in *nanoTesla* (nT). Massive magnetite deposits can produce magnetic fields of as much as 200 000 nT, which is several times the magnitude of the Earth's normal field. Anomalies of this size are unusual, but basalt dykes and flows and some larger basic intrusions can produce fields of thousands and occasionally tens of thousands of nT. Anomalous fields of more than 1000 nT are otherwise rare, even in areas of outcropping crystalline basement. Sedimentary rocks generally produce changes of less than 10 nT, as do the changes in soil magnetization important in archaeology.

Adapted from: Milsom, J. (2003) Field geophysics (Third Edition), John Wiley & Sons Ltd, England, 232 pp.- p. 51 – 52.

5 Study the photo of the aeromagnetic survey. What equipment is used in the stinger behind the airplane? What does it measure?

Fig. 4. Aeromagnetic survey

6 Read the text to check your answers. Translate it into Russian.

The magnetic method exploits small variations in magnetic mineralogy among rocks. A magnetometer is designed to measure variations in the magnetic field of the Earth. Magnetic data are used to verify the presence or absence of magnetically susceptible materials.

The magnetometer is very sensitive to rocks containing a very magnetic mineral called magnetite. If a large mass of magnetite-bearing rock (e.g., basement rock) occurs near the surface, it is detected by a larger magnetic force than the normal, regional value. The magnetometer is primarily used to detect variations of basement rock depth and composition. It can be used to estimate the thickness of sedimentary rocks filling a basin and to locate faults that displace basement rock.

The magnetometer is a relatively inexpensive, portable, and easy-to-use instrument. It is small enough to be transported in the back of a pickup truck. The magnetometer can be mounted in a stinger on the back of an airplane to conduct an aeromagnetic survey that is fast and efficient and does not need permission from the land owners. The magnetometer can also operate while being towed behind a boat.

TEXT 4.2 Gravity Exploration

1 Read and translate the following words. Be careful to pronounce them correctly. What do you know about these rocks and minerals?

chromite (n)	[ˈkrəumaɪt]	halite (n)	[ˈhælaɪt]
hematite (n)	[ˈhemətaɪt]	kimberlite (n)	[ˈkɪmbəlaɪt]
barite (n)	[ˈberɪt]	diatomaceous earth	[daɪəˈtɒmeɪʃəs ɜːθ]

2 Translate the following word combinations from the text.

- ground-based gravimeters
- easy-to-use instruments
- shallow high density bodies
- shallow low density bodies
- relatively light rocks
- higher-than-normal gravity values
- a grid pattern of points
- abnormally high gravity

3 Read the text and fill in the gaps in the statements below.

1) Ground-based gravimeters are used to measure …
2) Gravity is measured in …
3) Regions of higher than average density produce …
4) Deposits of low-density yield …
5) Basement rock is …
6) Salt domes or porous reefs are relatively … rocks.

Differences in rock density produce small changes in the Earth's gravity field. Gravity measurements define anomalous density within the Earth; in most cases, ground-based gravimeters are used to precisely measure variations in the gravity field at different points.

Gravity meters are relatively inexpensive, portable, and easy-to-use instruments. A gravity meter or gravimeter measures the acceleration of the earth's gravity at that location. It is very sensitive to the density of the rocks in the subsurface. It measures gravity in units of acceleration called *milligals*.

Positive gravity anomalies are associated with shallow high density bodies, whereas gravity lows are associated with shallow low density bodies. Thus, deposits of high-density chromite, hematite, and barite yield gravity highs, whereas deposits of low-density halite, weathered kimberlite, and diatomaceous earth yield gravity lows.

Over a typical area of earth's crust with 5,000 ft (1,525 m) of sedimentary rocks underlain by basement rock that is very dense, the gravity measurement is predictable. A mass of relatively light rocks such as a salt dome or porous reef can be detected by the gravity meter because of values over it that are lower than normal gravity. A mass of relatively heavy rocks near the surface such as basement rock in the core of a dome or anticline can be detected by higher-than-normal gravity values (fig. 5).

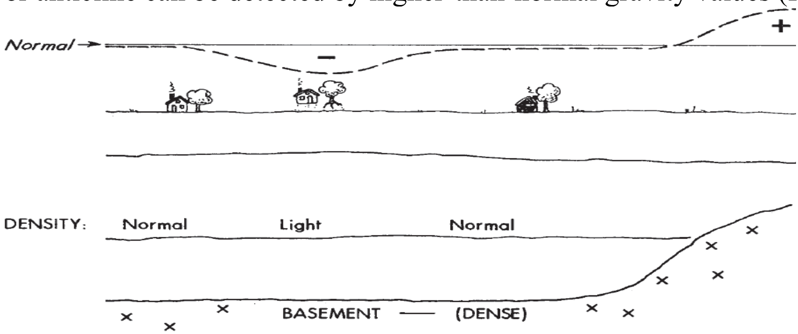
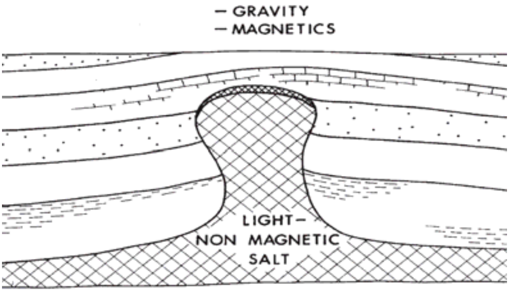


Fig. 5. Gravity meter measurements over an area

In order to explore the subsurface of an area using a gravity meter, a grid pattern of points is located on the surface. A gravity reading is made at each point. The gravity values are then plotted on a base map and contoured similar to a topographic map. With an aeromagnetic survey, the plane flies in two sets of parallel lines that intersect at right angles. Most of the area will have "normal" gravity measurements. Anomalies of abnormally high (maximum) or low (minimum) gravity are noted.

Adapted from: Hyne, Norman J. Nontechnical guide to petroleum geology, exploration, drilling, and production / Norman J. Hyne. -- 3rd ed. – p. 211 - 215.



4 Many salt domes in the coastal areas of Texas and Louisiana were discovered in the 1920s by gravity meter surveys. How was it done? Explain using the diagram below (fig. 6).

Fig. 6. Magnetic anomalies over a salt dome

TEXT 4.3 Seismic Waves

1 With a partner, study the diagram (fig.7) below and answer the following questions.

- **What types of seismic waves do you know?**
- **What causes seismic waves?**
- **What are their differences?**

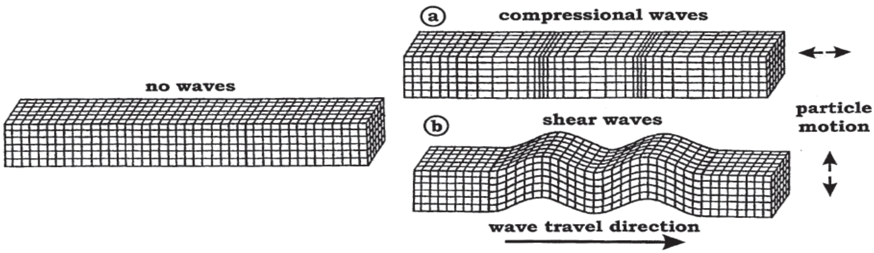


Fig. 7. Seismic waves: (a) compressional and (b) shear

2 Read the text to check your answers and find the following information:

- *type of energy a seismic wave is*
- *difference between body waves and surface waves*
- *methods of elastic wave generation*
- *application of seismic methods*
- *type of waves which can only occur in solids*
- *difference between velocities of P and S waves*

A seismic wave is acoustic energy generated by an earthquake, explosion, or similar energetic source and propagated within the Earth or along its surface. Earthquakes generate four principal types of elastic waves; two, known as body waves, travel within the Earth, whereas the other two, called surface waves, travel along its surface. Seismographs record the amplitude and frequency of seismic waves and yield information about the Earth and its subsurface structure. Artificially generated seismic waves recorded during seismic surveys are used to collect data in oil and gas prospecting and engineering. Seismic methods are the most effective, and the most expensive, of all the geophysical techniques used to investigate layered media.

When a sound wave travels in air, the molecules oscillate backwards and forwards in the direction of energy transport. This *compressional* wave thus travels as a series of compressions and rarefactions. The compressional wave in a solid medium has the highest velocity of any of the possible wave motions and is therefore also known as the *primary* wave or simply the *P wave*.

Particles vibrating at right angles to the direction of energy flow create an *S* (*shear*, 'shake' or, because of its relatively slow velocity, *secondary*) wave. Shear waves are slower than compressional waves and cannot pass through a liquid or gas. Their velocity in many consolidated rocks is roughly half the P wave velocity. It depends slightly on the plane in which the particles vibrate but these differences are not significant in small-scale surveys. P and S waves are *body waves* and expand within the main rock mass.

Adapted from: Milsom, J. (2003) Field geophysics (Third Edition), John Wiley & Sons Ltd, England, 232 pp. – p. 179.

3 Read the first paragraph of the text and find English equivalents for the following Russian expressions.

распространяемые, упругие волны, сейсмограф, собирать данные, амплитуда, искусственно, частота, поиск нефти и газа, объемные волны, поверхностные волны, записываемые (регистрируемые), сейсморазведка, тогда как, давать информацию

4 Match the opposite words. There is one extra word.

stretch, increase, move, liquid, expansion, compress, transmit, compression, drop, stop, solid

5 Do the following statements agree with the information in the text? Write *TRUE* or *FALSE*.

1) Of the body waves, S wave has the highest speed of propagation.
2) Compressional waves reach a seismic recording station faster than shear waves.
3) P waves give the transmitting medium—whether liquid, solid, or gas—a back-and-forth motion in the direction of the path of propagation.
4) P waves are also called shear or transverse waves.
5) S waves cause points of solid media to move back and forth perpendicular to the direction of propagation.

TEXT 4.4 Geophone

1 Discuss the following questions with a partner.

- **What is a geophone?**
- **How does it work?**
- **What's the difference between geophones and hydrophones?**

2 Read the text and label the diagram (fig. 8) below.

Land seismic detectors are known as *geophones* (fig. 9), marine detectors as *hydrophones*. Both convert mechanical energy into electrical signals. Geophones are usually positioned by pushing a **spike** screwed to the **casing** firmly into the ground but it may be necessary to unscrew the spike and use some form of adhesive pad when working on bare rock.

A geophone consists of a **coil** wound on a high-permeability magnetic core and suspended by **leaf springs** in the field of a permanent magnet. If the coil moves relative to the magnet, voltages are induced and current will flow in any external circuit. The current is proportional to the velocity of the coil through the magnetic field, so that ground movements are recorded. In most cases the coil is mounted so that it is free to vibrate vertically, since this gives the maximum sensitivity to P waves rising steeply from subsurface interfaces.

Adapted from: Milsom, J. (2003) Field geophysics (Third Edition), John Wiley & Sons Ltd, England, 232 pp. – p. 188.

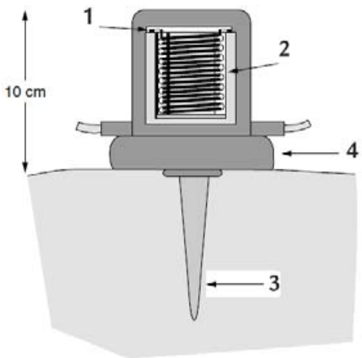


Fig. 8. The diagram of a geophone

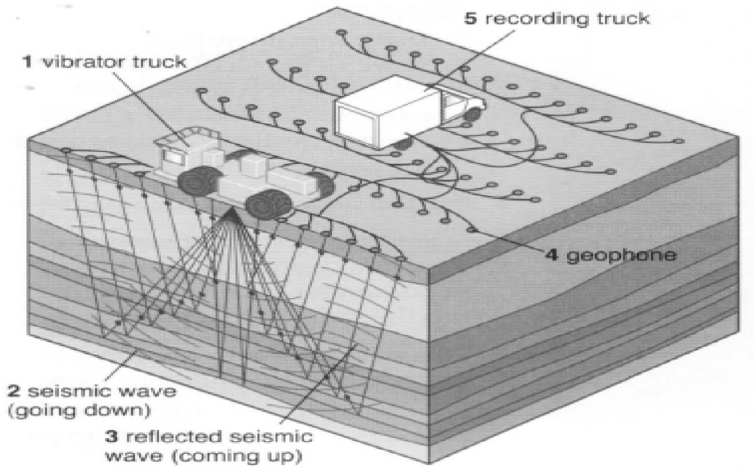
Fig. 9. Geophone.

3 Translate the text from English into Russian.

TEXT 4.5 Seismic Exploration

The first oil field found by seismic exploration alone was the Seminole field of Oklahoma in 1928. The seismic data at that time were recorded by analog in the field on a sheet of paper. The printout was noisy and not very accurate. The greatest improvements in petroleum exploration in the last several decades have involved new seismic acquisition techniques and computer processing of digital seismic data.

1 Study this diagram below. What do you think the trucks and the geophones do?



2 Read the text. Decide if the statements below are *TRUE* or *FALSE*.

1 Oil companies make maps of the surface.
2 Seismic waves can't go through rocks.
3 Vibrator trucks make seismic waves.
4 One rock layer reflects all the waves.
5 Geophones send electrical signals to the recording truck.
6 The geophones produce 3D maps.

Drilling is expensive. So oil companies plan carefully before they start drilling. First they make 3D maps of the rocks below the surface. Then they study these maps carefully. They look for possible oil traps.

How do they make these maps? How do they find out what is below the surface? The answer is 'seismic waves'. Seismic waves are sound waves, and they can travel through rock layers.

Most oil companies use vibrator trucks to make seismic waves. These heavy trucks make vibrations on the surface, and the vibrations send waves down to the rocks below.

Each rock layer reflects some of the waves. The reflected waves travel up to geophones on the surface. Geophones are like microphones: they convert the waves into electrical signals. A machine in the recording truck records the signals. Computers can convert these signals into 3D maps.

Seismic reflection works at sea too. But the crews use hydrophones, not geophones, and they use an underwater gun to make seismic waves.

Taken from: Lansford L., Vallance D. Oxford English for Careers. Oil and Gas 1. Student's Book. – Oxford University Press, 2011. –p. 29.

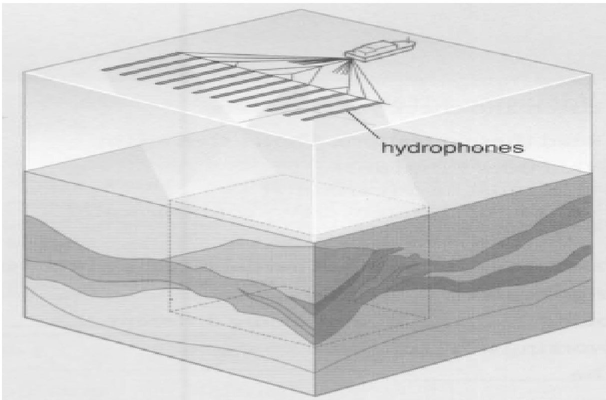
3 The word "they" is used in the text nine times. It can mean different things in different sentences. Find every "they" and say what it means.

EXAMPLE: *In paragraph 1, "they" means "oil companies".*

4 Look at the labels (1-5) in the diagram above (task 1) and explain the process.

BEGIN: *Vibrator trucks make seismic waves. The waves go …*

5 Look at the diagram of seismic reflection at sea and explain the process.



TEXT 4.6 Seismic Equipment

1 With a partner, discuss the meanings of the following words and word combinations. Use a dictionary if necessary.

a noise survey, a shot point, a shot hole, vibroseis technique, a vibrator truck, a sweep, an air gun, a geophone, a recording truck, a doghouse, a hydrophone, a streamer

2 Scan the text to check your answers.

3 Read the text to find out the meaning of these numbers in the text.

1) about 2 to 4%	**3)** about 70%	**5)** 6 to 9 m	**7)** 5 knots
2) 18 to 30 m	**4)** 7 to 20 seconds	**6)** 2,000 psi	

The seismic method uses impulses of sound energy that are put into the earth. The energy travels down through the subsurface rocks, is reflected off subsurface rock layers, and returns to the surface to be recorded. Seismic exploration uses subsurface echoes to image the shape of subsurface sedimentary rocks and locates petroleum traps. A source and a detector are used. The source emits an impulse of sound energy either at or near the surface of the ground or at the surface of the ocean. The sound energy is reflected off subsurface rock layers. The maximum reflection energy occurs when the angle of incidence between the seismic source and reflector is equal to the angle of reflection between the reflector and seismic detector (fig. 10). Only about 2 to 4% of each sound impulse is reflected off each layer, and the remaining sound impulse goes further into the rock, to be reflected off deeper and deeper layers. The reflected sound energy from each layer returns to the surface, where the detector records it.

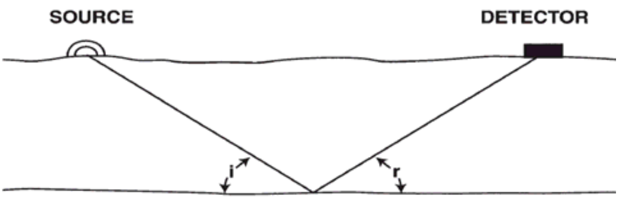


Fig. 10. A seismic reflection with the angle of incidence (i) equal to the angle of reflection (*r*)

The detector on the surface records both the *signal*, wanted direct (primary) reflections from the subsurface rock layers, and *noise*, unwanted energy. Noise can be caused by surface traffic, wind, surface and air waves, and subsurface reflections that are not direct reflections from subsurface rock layers. A high signal/noise ratio is desired. A *noise survey*, a small seismic survey, can be run first to determine the nature of noise in that area and plan the optimum seismic program to reduce noise.

The location of the seismic source is called the *shot point*. On land, the most common seismic sources are explosives and vibroseis. Dynamite was the first seismic source used and is still the most common explosive source used today. Explosives are used today where the surface is covered with loose sediments, swamps, or marshes. When using explosives, a small, truck-mounted drilling rig often accompanies the seismic crew to drill a *shot hole*, usually 60 to 100 ft (18 to 30 m) deep, to a point below the soil. The explosives are planted in solid rock on the bottom of the hole.

About 70% of the seismic exploration run on land today is done by *vibroseis*, a technique developed by Continental Oil (now ConocoPhillips). In vibroseis, a *vibrator truck* (fig. 11) with hydraulic motors mounted on the back of a truck and a plate called a *pad* or *baseplate* located on the bottom of the truck bed are used. The vibrator truck drives to the shot point and lowers the pad onto the ground until the back wheels are above the ground and most of the weight of the truck is on the pad. The hydraulic motors use the weight of the truck to shake the ground for a time (*sweep length*), often 7 to 20 seconds. A range of frequencies, called the *sweep*, is imparted into the subsurface. Vibroseis is very portable and can be run in populated areas. Other less common land seismic sources include weight drop, gas gun, land air gun, and guns such as a shotgun.

At sea, a common seismic source is an air gun. The *air gun* is a metal cylinder that is several feet long (fig. 12). It is towed in the water at a depth of 20 to 30 ft (6 to 9 m) behind the ship. On the ship are air compressors. High-pressure air at 2,000 psi (140 kg/cm^2) is pumped through a flexible, hollow tube into the air gun in the water. On electronic command, ports are opened on the air gun. An expanding, high-pressure air bubble in the water provides a seismic source that is not harmful to marine life. The air gun is also used in some applications in swamps and marshes. Other seismic sources used at sea include water gun, sleeve gun, and sparker.

Fig. 11. Vibrator truck

Fig. 12. Air gun

The impulse of seismic energy travels down through the subsurface rocks, strikes the top of the subsurface layers, and is reflected back to the surface as echoes. The returning echoes are recorded on land by vibration detectors called *geophones* or *jugs*. They detect vertical ground motion and translate it into electrical voltage.

The geophone often has a spike on the bottom so it can be planted in the ground. One to dozens of geophones are connected to form a *group* that records as a single unit called a *channel*. By using several geophones in a group, noise is reduced. The geophones in a group are arranged in a line, several parallel lines, a star, a rectangle, or another geometric pattern. Groups of geophones are deployed in a larger geometric pattern called the *spread*. A common spread called a *linear spread* consists of a long main cable stretched out in a line several miles long. Shorter cables at specific intervals connect the individual geophone groups, which are equidistant, with the main cable. A *split spread*, with the source in the middle of the linear spread, is commonly used on land.

Using these methods, a large number of geophone groups can be used to cover a large area of the subsurface with each seismic shot. The geophones are all connected to a lead cable that goes to the recording truck or doghouse. The data can also be transmitted digitally by a radio telemetry system that uses radio signals to make the connection. The *recording truck* has an enclosure on the back called a *doghouse*, which contains equipment used to digitally record and store the seismic data.

At sea, the source is towed in the water behind a boat that travels at about 5 knots (5 nautical miles per hour). The seismic energy is powerful enough for much of the sound to penetrate the ocean bottom. The returning reflections are recorded on vibration detectors, called *hydro-*

phones, contained in a long plastic tube, the *streamer*, that is towed behind the boat. Wires are run from the hydrophones through the streamer to the doghouse on the ship where the recording equipment and computers are located.

Seismic exploration is most expensive on land, especially in rugged terrain. It is less expensive and of better quality at sea.

Adapted from: Hyne, Norman J. Nontechnical guide to petroleum geology, exploration, drilling, and production / Norman J. Hyne. -- 3rd ed. – p. 215 - 223.

4 Complete the statements using the information from the text.

1) Seismic exploration makes it possible to …
2) The maximum reflection energy takes place when …
3) Noise occurs due to …
4) The most common explosive source used today is …
5) Except vibrator trucks other land seismic sources are …
6) A common seismic source used at sea and in some applications in swamps and marshes is …
7) Geophones record …
8) The geophone can be put into the ground because it often has …
9) Geophones are used in a group to …
10) Equipment for recording and storing seismic data is located in …

5 Study the following diagrams (fig. 13, fig. 14) and tell about seismic exploration on land and at sea.

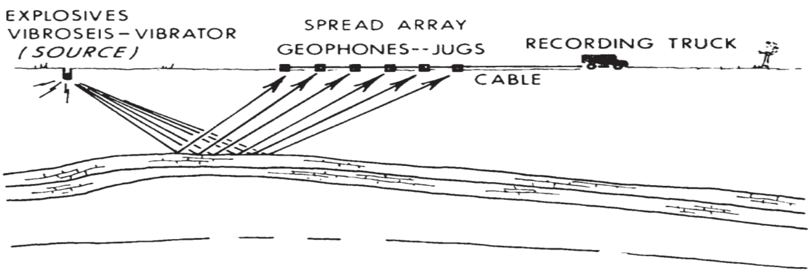


Fig. 13. The seismic method on land

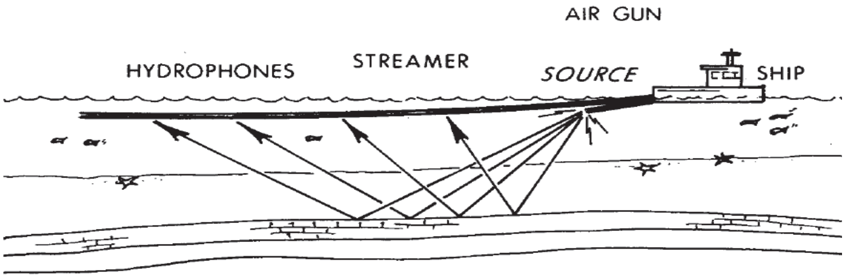


Fig. 14. The seismic method at sea

6 Read the text about geophysical methods and fill in the gaps with the words from the box. There are two words you do not need to use.

geophone	surface	magnetometer	sub-surface
gravimeter	vibrator truck	density	search
hole	planes	sound	explosives

Geophysicists use mathematics and physics to create a picture of the **1**___. They can identify types of rock by their **2**___ (mass) and magnetic qualities. They use different equipment in their **3**___. A **4**___ shows rock density, and a **5**___ measures magnetic fields. A magnetometer can be used in **6**___ while flying over an area. Another method is seismic exploration, which uses **7**___. Shock waves are produced by **8**___ that are placed in a **9**___ in the ground. These waves are reflected back and show the different kinds of rock under the surface. Instead of explosives, a **10**___ will be used.

7 Translate the text in 6 from English into Russian.

APPENDIX

Варианты экзаменационных заданий

<u>ВАРИАНТ 1</u>

Задание 1. Письменный перевод текста.

The three main types of rocks are sedimentary, metamorphic, and igneous. The differences between them have to do with how they are formed. Sedimentary rocks are formed from particles of sand, shells, pebbles, and other fragments of material. Metamorphic rocks arise from the transformation of existing rock types, in a process called metamorphism, which means "change in form". Igneous rocks are formed when magma cools and hardens. All rocks are continually changing from one type to another and back again, as forces inside the earth bring them closer to the surface (where they are weathered, eroded, and compacted) and forces on the earth sink them back down (where they are heated, pressed, and melted). So the elements that make up rocks are never created or destroyed — instead, they are constantly being recycled.

Задание 2. Заполните пропуски, используя правильную грамматическую форму.

1 Joe ran all the way. It wasn't necessary. Joe … (модальный глагол, выражающий отсутствие необходимости / not) have run all the way.
2 I … (jog) yesterday from 7 till 8 a.m. in the park.
3 She … (модальный глагол, выражающий способность/ not) pass her driving test yesterday.
4 Sorry, I can't give you a lift to the station. – Ok, I … (take) a taxi.
5 She … (write) her first novel when she was 16.
6 The crime … (investigate) very quickly and the killer got to prison.
7 If we … (live) in the country, we would swim in the lake in summer.
8 Let me … (pay) for the meal. You paid last time.
9 How… (much/ many) milk is there in the fridge?
10 I've got … (any/ much/ little/ a few) friends, so I'm not lonely.

11 I will call you as soon as I … (get) to the hotel.
12 She … (meet) a customer at the moment.
13 David always enjoyed … (play) football at school.
14 The Ritz is … (expensive) hotel in our city.
15 The results of the competition … (know) in a week’s time.
16 Your essay was … (bad) than Jim’s.
17 I … (wait) for you since 11.00 this morning.
18 They … (not talk) to the head teacher yet.
19 In 2035 robots … (do) all the housework!
20 …Tom often … (read) your e-mails?

Задание 3. Сочинение на заданную тему. Объем 100-120 слов.
What is the best way to master a foreign language? Explain your opinion.

ВАРИАНТ 2

Задание 1. Письменный перевод текста.

The speed of seismic waves is affected by the properties of the material the waves pass through. Measuring the time it takes for certain waves to get to a seismometer after an earthquake can indicate specific properties of the materials that the waves encountered. Where a wave encounters a layer with a different composition, it will change direction and/or velocity. There are two types of seismic body waves: P-waves, or pressure waves, and S-waves, or shear waves. P-waves, which go through both liquids and solids, travel 60% faster than S-waves on average, because the interior of the Earth does not react the same way to both of them. S-wave can only move through solid rock, not through any liquid medium. This property of S-waves led seismologists to conclude that the Earth's outer core is liquid.

Задание 2. Заполните пропуски, используя правильную грамматическую форму.

1 Joe ran all the way. It wasn’t necessary. Joe … (модальный глагол, выражающий отсутствие необходимости / not) have run all the way.
2 I … (jog) yesterday from 7 till 8 a.m. in the park.

3 She … (модальный глагол, выражающий способность/ not) pass her driving test yesterday.
4 Sorry, I can't give you a lift to the station. – Ok, I … (take) a taxi.
5 She … (write) her first novel when she was 16.
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19 In 2035 robots … (do) all the housework!
20 …Tom often … (read) your e-mails?

Задание 3. Сочинение на заданную тему. Объем 100-120 слов.
Do you agree with the statement *«Eating a little bit healthier helps you live longer»?*

ANSWER KEY

UNIT 1

TEXT 1.1: How is the Earth's Interior Studied?

Ex. 7: 1D, 2B, 3C

Geophysical Quiz

1. geophysics
2. boundaries between rock layers
3. the crust, the mantle, and the core
4. basalt
5. granite and gneiss
6. the mantle
7. an ultramafic rock
8. asthenosphere
9. a liquid outer core and a solid inner core
10. iron and nickel
11. dense rock.
12. low-density rock.
13. magnetic poles
14. A positive magnetic anomaly

TEXT 1.2: Geophysicist

Ex. 3: 1G 2C 3B 4D 5A 6F 7E

Ex. 5: 1 - studies **2 -** outdoors **3 -** features **4 -** indoors **5 -** evaluate **6** - hazards **7** - evolution

UNIT 2

TEXT 2.1: The Physical Structure of the Earth

Ex. 1: 1E, 2A, 3B, 4C

TEXT 2.3: The Rock Cycle

Ex. 1: 1 - magma, 2 - igneous rock, 3 - sediment, 4 - sedimentary rock, 5 - metamorphic rock

UNIT 3

TEXT 3.1: Continental Drift

Ex. 3:

1 suggests – considers
2 present-day – modern
3 were joined – were glued together
4 fragments – parts
5 drifted across – moved across
6 present positions – current locations
7 evidence – proof
8 widely – broadly

TEXT 3.2: Seafloor Spreading

Ex. 2:

verbs	nouns	verbs	nouns
occur	- occurrence	spread out	- spreading
penetrate	- penetration	produce	- production
split	- splitting	collide	- collision
drag	- dragging	form	- formation

Ex. 4: 1T, 2F, 3T, 4F, 5T, 6NOT GIVEN, 7F, 8T

TEXT 3.3: Plate Tectonics

Ex. 2: 1C, 2D, 3C, 4A, 5B, 6A
Ex. 4: 1E, 2F, 3C, 4G, 5B, 6H, 7A

UNIT 4

TEXT 4.1: Magnetic Exploration

Ex. 2(possible answers):
I. significant effects, electric currents, permanent magnetic bar, geographic axis, magnetic properties, local anomalies, abundant mineral, ore deposits, basalt dykes, outcropping basement
II. extremely variable, strictly proportional, naturally occurring, widely used, highly magnetic

TEXT 4.2: Gravity Exploration

Ex. 2 (possible answers):
1) Ground-based gravimeters are used to measure *variations in the gravity field at different points.*
2) Gravity is measured in *units of acceleration called milligals.*
3) Regions of higher than average density produce *positive gravity anomalies / positive anomalies.*
4) Deposits of low-density yield *gravity lows.*
5) Basement rock is *very dense*
6) Salt domes or porous reefs are relatively *light* rocks.
Ex. 4 (possible answer): A subsurface salt dome is seen as a surface anomaly of relatively low gravity and magnetics because the salt is light in density and has no magnetite mineral grains compared to the surrounding sedimentary rocks.

TEXT 4.3: Seismic Waves

Ex. 3:

распространяемые	- propagated	*поиск нефти и газа*	- oil and gas prospecting
упругие волны	- elastic waves	*объемные волны*	- body waves
сейсмограф	- seismograph	*поверхностные волны*	- surface waves
собирать данные	- collect data	*записываемые (регистрируемые)*	- recorded
амплитуда	- amplitude	*сейсморазведка*	- seismic surveys
искусственно	- artificially	*тогда как*	- whereas
частота	- frequency	*давать информацию*	- yield information

Ex. 4: stretch – compress; increase – drop; move – stop; liquid – solid; expansion – compression; transmit

Ex. 5: 1F, 2T, 3T, 4F, 5T

TEXT 4.4: Geophone

Ex. 2: 1- leaf spring; 2 – coil; 3 – spike; 4 - casing

TEXT 4.5: Seismic Exploration

Ex. 2: 1F, 2F, 3T, 4F, 5T, 6F

TEXT 4.6: Seismic Equipment

Ex. 4 (possible answers):

1) Seismic exploration makes it possible to *image the shape of subsurface sedimentary rocks and locates petroleum traps.*

2) The maximum reflection energy takes place when *the angle of incidence between the seismic source and reflector is equal to the angle of reflection between the reflector and seismic detector.*

3) Noise occurs due to *surface traffic, wind, surface and air waves, and subsurface reflections that are not direct reflections from subsurface rock layers.*

4) The most common explosive source used today is *dynamite.*

5) Except a vibrator truck, other land seismic sources are *weight drop, gas gun, land air gun, and guns such as a shotgun.*

6) A common seismic source used at sea and in some applications in swamps and marshes is *an air gun.*

7) Geophones record *vertical ground motion.*

8) The geophone can be put into the ground because it often has *a spike on the bottom.*

9) Geophones are used in a group to *reduce noise.*

10) Equipment for recording and storing seismic data is located in *a doghouse*

Ex. 6: 1. sub-surface; 2. density; 3. search; 4. gravimeter; 5. magnetometer; 6. planes; 7. sound; 8. explosives; 9. hole; 10. vibrator truck

APPENDIX

№	ВАРИАНТ 1	ВАРИАНТ 2
1	was watching	needn't
2	arrived.	was jogging
3	have had	couldn't/ wasn't able to
4	may/might/ could	will take
5	will live/ will be living	wrote
6	the most beautiful	was investigated
7	is being repaired	lived
8	has been crying	pay
9	can	much
10	some	a few
11	many	get
12	to start	is meeting
13	am meeting / *am going to meet*	playing
14	better	the most expensive
15	talk	will be known
16	reading	worse
17	could/ might/ would buy	have been waiting
18	speaks / *can speak*	haven't talked
19	are visiting	will do
20	was/is made	does Tom often read

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ИНОСТРАННЫЙ ЯЗЫК

АНГЛИЙСКИЙ ДЛЯ ГЕОФИЗИКОВ

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