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ИНОСТРАННЫЙ ЯЗЫК

ПОИСКИ И РАЗВЕДКА ПОЛЕЗНЫХ ИСКОПАЕМЫХ

Методические указания к практическим занятиям для студентов специальности 21.05.02

FOREIGN LANGUAGE

MINERAL PROSPECING AND EXPLORATION

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Данные методические указания составлены для использования на практических занятиях по дисциплине «Иностранный язык». Предлагаемый материал направлен на развитие навыков технического перевода, анализа оригинальной литературы по специальности, накопление и усвоение лексического материала в рамках профессиональной тематики, преодоление трудностей перевода и приобретение разговорных навыков по специальности.

Предназначены для студентов специальности 21.05.02 «Прикладная геология», изучающих иностранный язык.

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ВВЕДЕНИЕ

Данные методические указания к практическим занятиям по английскому языку предназначены для студентов специальности 21.05.02 «Прикладная геология», специализация «Геологическая съёмка, поиски и разведка месторождений твёрдых 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 двух разделов, содержащих информацию о типах горных пород и методах поисков и разведки полезных ископаемых. Каждый текст сопровождается комплексом предтекстовых и послетекстовых заданий и упражнений, направленных на контроль понимания прочитанного материала, формирование умения ориентироваться в оригинальных научно-технических текстах, отработку и закрепление лексико-грамматического материала в устной речи, контроль навыков перевода.

Изучение предложенного материала имеет целью развитие и совершенствование навыков чтения и перевода оригинальной научной литературы по геологической тематике, расширение словарного запаса, преодоление трудностей перевода и приобретение разговорных умений в сфере профессиональной деятельности.

UNIT 1 TYPES OF ROCKS

TEXT 1.1 Sedimentary Rocks

1 Define to what part of speech the following words belong to and translate them into Russian.

erode – erosion – erosive; melt – molten – melting – melted (water); origin – original – originally – originate; compose – composition - composed of – compositing – decompose - decomposition; sediment - sedimentary – sedimentation; crystal – crystalline – crystallize – crystallization; lay (down) – laid (down) – layer – layered; stratum – stratify – stratified – stratification; precipitate – precipitated – precipitating – precipitation

2 Discuss these questions with a partner.

- What is called "sediment"?
- What is the difference between detrital and chemical sediments?
- What processes affect the character of sediment?

3 Read the text to check your answers.

Most sedimentary rocks form from loose grains of sediment. Sediment is the collective name for loose, solid particles of mineral that originate from:

1. Weathering and erosion of preexisting rocks (detrital sediments).

2. Precipitation from solution, including secretion by organisms in water (chemical sediments).

Sediment includes such particles as sand on beaches, mud on a lake bottom, boulders frozen into glaciers, pebbles in streams, and dust particles settling out of the air. An accumulation of clam shells on the sea bottom offshore is sediment, as are coral fragments broken from a reef by large storm waves. These particles usually collect in layers on Earth's surface. An important part of the definition is that the particles are loose. Sediments are said to be unconsolidated, which means that the grains are separate, or unattached to one another.

Detrital sediment particles are classified and defined according to the size of individual fragments. Table 1 shows the precise definitions of particles by size.

Table 1. Sediment Particles and Detrital Sedimentary Rocks

Diameter (mm)	Sediment		Sedimentary Rock
256	Boulder		**Breccia** (angular particles)
64	Cobble	Gravel	or **conglomerate** (rounded
	Pebble		particles)
2	Sand		**Sandstone**
1/16	Silt	"Mud"	Siltstone (mostly silt)
1/256	Clay		**Shale** or mudstone (mostly clay)

Weathering, erosion, and transportation are some of the processes that affect the character of sediment. Both mechanically weathered and chemically weathered rock and sediment can be eroded, and weathering continues as erosion takes place. Sand being transported by a river also can be actively weathered, as can mud on a lake bottom. The character of sediment can also be altered by rounding and sorting during transportation, and even after eventual deposition.

Adapted from: Charles C. Plummer, Diane H. Carlson, Lisa Hammersley. (2016) Physical geology (Fifteenth edition), McGraw-Hill Education, New York. – p. 128-129.

4 Give the Russian for:

sedimentary rocks; loose grains; preexisting rocks; detrital sediments; precipitation from solution; chemical sediments; particles; sand ; mud , boulders; pebbles; clay; silt; sandstone; shale; streams, glaciers; an accumulation; on the sea bottom offshore; to be unconsolidated; weathering; erosion; transportation; to be altered by; rounding; sorting; deposition

5 Study Table 1 and fill in the gaps in the text below.

1_____ includes all rounded particles coarser than 2 millimeters in diameter. **2**_____ range from 2 to 64 millimeters (about the size of a tennis ball). **3**_____ range from 64 to 256 millimeters (about the size of a basketball), and **4**_____ are coarser than 256 millimeters.
5_____ grains are from 1/16 millimeter (about the thickness of a human hair) to 2 millimeters in diameter. Grains of this size are visible and feel gritty between the fingers. **6**_____ grains are from 1/256 to 1/16

millimeter. They are too small to see without a magnifying device, such as a geologist's hand lens. Silt does not feel gritty between the fingers, but it does feel gritty between the teeth (geologists commonly bite sediments to test their grain size). **7**_____ is the finest sediment, at less than 1/256 millimeter, too fine to feel gritty to fingers or teeth. **8**_____ is a term loosely used for a mixture of silt and clay.

Adapted from: Charles C. Plummer, Diane H. Carlson, Lisa Hammersley. (2016) Physical geology (Fifteenth edition), McGraw-Hill Education, New York. – p. 129.

6 Translate the sentences paying attention to the use of Gerund.

1. Solar **heating** of air creates wind. 2. **Rounding** occurs in sand and gravel as rivers, glaciers, or waves cause particles to hit and scrape against one another. 3. Your **understanding** of geology is an important step in your **being** able to help resolve moral dilemmas that we face to which there is no ideal solution. 4. By **learning** how the Earth works and how different kinds of substances are distributed and why, we can intelligently search for metals, sources of energy, and gems. 5. Differentiation, assimilation, and partial **melting** may each play a part in **creating** the observed variety of rocks. 6. If the length of time since the last recorded earthquake far exceeds the recurrence interval, the fault is given a high probability of **generating** an earthquake. 7. Compaction does help consolidate clayey sediments by **pressing** the microscopic clay minerals so closely together that the forces of attraction at the atomic level tend to bind them together. 8. After **measuring** a specific wave on a seismogram and **correcting** for the type of seismograph and for the distance from the quake, scientists can assign a number called the magnitude. 9. Particles from the Sahara Desert in North Africa have been collected from the air over the islands of the Caribbean after **having been carried** across the entire Atlantic Ocean. 10. Some regions have a much higher gradient, *indicating* concentrations of heat at shallow depths. Such regions have a potential for **generating** geothermal energy. 11. **Drilling** through atolls in the 1950s showed that these reefs were built on deeply buried volcanic cores, thus *confirming* Darwin's hypothesis of 120 years before.12. One way of **measuring** groundwater velocity is to introduce a tracer, such as a dye, into the water and then watch for the color to appear in a well or *spring* some distance away.

TEXT 1.2 Weathering, Erosion and Transportation

1 Translate the following words into Russian.

a) soil, agent, glacier, rainwater, cliff, hillside, landscape, boulder, stream, crack;
b) wear down, take place, grind down, break up, break down, refer to, pick up;
c) decompose, disintegrate, indestructible

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

1 ocean	**A** particles
2 running	**B** surface
3 loose	**C** waves
4 rock	**D** crystals
5 underlying	**E** factors
6 Earth's	**F** fragments
7 environment	**G** agents
8 bound	**H** water
9 awesome	**I** bedrock

3 Complete the table where possible. Translate the words into Russian.

Verb	*Participle I*	*Participle II*	*Noun*	*Adjective*	*Adverb*
			movement		
	eroding				
loosen					
			removal		
		exposed			
			freeze		
	varying				
		altered			
oxidize					

4 Scan the text to find out the explanation of the following terms: *weathering, erosion,* and *transportation***.**

Rocks exposed at Earth's surface are constantly being changed by water, air, varying temperature, and other environmental factors. Granite may seem indestructible, but given time and exposure to air and water, it

can decompose and disintegrate into soil. The processes that affect rock are weathering, erosion, and transportation.

The term weathering refers to the processes that change the physical and chemical character of rock at or near the surface. The tightly bound crystals of any rock can be loosened and altered to new minerals when exposed to air and water during weathering. Weathering breaks down rocks that are either stationary or moving.

Erosion is the picking up or physical removal of rock particles by an agent such as ocean waves, running water, or glaciers. Weathering helps break down a solid rock into loose particles that are easily eroded. Rainwater flowing down a cliff or hillside removes the loose particles produced by weathering. Humans, of course, are awesome agents of erosion. A single pass by a bulldozer can do more to change a landscape than thousands of years of natural weathering and erosion.

After a rock fragment is picked up (eroded), it is transported. Transportation is the movement of eroded particles by agents such as rivers, waves, glaciers, or wind. Weathering processes continue during transportation. A boulder being transported by a stream can be physically worn down and chemically altered as it is carried along by the water.

Water is necessary for chemical weathering to take place. Oxygen dissolved in water oxidizes iron in rocks. Carbon dioxide mixed with water makes a weak acid that causes most minerals to decompose; this acid is the primary cause of chemical weathering. Running water contributes to weathering and erosion by loosening and removing particles and by abrading rocks during transportation in streams. Ice in glaciers is a very effective agent of erosion as rocks frozen in the base of a glacier grind down the underlying bedrock. Freezing and thawing of water in cracks in rock is also very effective at mechanically breaking them up.

Adapted from: Charles C. Plummer, Diane H. Carlson, Lisa Hammersley. (2016) Physical geology (Fifteenth edition), McGraw-Hill Education, New York. – p. 106 - 107.

5 Decide whether the statements are *TRUE* (T) or *FALSE* (F).

1. Environmental factors can affect rocks beneath Earth's surface.
2. Most rocks can be altered to new minerals by weathering.
3. Humans speed up natural erosion.
4. Physical and chemical character of rock can be changed during transportation.

5. The most effective agent of chemical weathering at Earth's surface is carbon dioxide.

6 Write true statements about the processes that affect rocks at or near Earth's surface which you have known from the text. Compare them with your partner.

7 Analyse all the *"ing-forms"* **in the text in 4. Define whether the** *"ing-form"* **is a participle, gerund or verbal noun. Translate the sentences into Russian.**

8 Analyse the *"ing-forms"* **in the following sentences. State whether the** *"ing-form"* **is a participle, gerund or verbal noun. Translate the sentences into Russian.**

1. Magma is created by partial **melting** of the asthenosphere. 2. When **openings** are large and well connected, the flow of water is more rapid. 3. The Earth is just one of eight planets **orbiting** our Sun.,4. Several techniques are being explored for scientifically **forecasting** a **coming** earthquake. 5. The water keeps on **rising** for five to ten minutes, **causing** great **flooding** before the wave withdraws. 6. Each wave stops briefly before **retreating, carrying** sediments and debris back to the sea. 7. Pressure from **overlying** material packs the sediment grains together and reduces the overall volume by **squeezing** water out of the pores. 8. **Sorting** is the process by which sediment grains are selected and separated according to grain size by the agents of transportation, especially by **running** water 9. **Orbiting** the Sun and scattered throughout the solar system are numerous bodies much smaller than the planets—asteroids and comets. 10. When the temperature of the lower crust rises sufficiently, partial **melting** takes place, **creating** felsic magma. 11. The basis for the scientific method is the belief that the universe is orderly and that by objectively **analyzing** phenomena, we can discover their **workings.** 12. The process of magmatic **underplating** involves mafic magma **pooling** at the base of the continental crust, **supplying** the extra heat necessary to partially melt the **overlying**, silica-rich crustal rocks 13. The temperature of the melted ice **rising**, the movement of its molecules is speeded up. 14. We heard of different experiments **having been carried out** by our students. 15. They insisted on the experiment **being made** to study single stars in detail.

TEXT 1.3 How Weathering Changes Rocks

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

carbon dioxide, oxygen, water vapor, granite, quartz, feldspar, ferromagnesian minerals, a clay mineral, mica, rock crevices, limestone, marble

2 Form adverbs in *–ly* from the adjectives and translate them into Russian.

mechanical, chemical, physical, principal, original, relative, typical, gradual, initial, tight, slow, individual, main

3 Give nouns corresponding to the following verbs:

change, compose, expose, weather, occur, cause, form, grow, crumble, dissolve, originate, alter

4 Form new words using prefixes from the box below and translate them into Russian.

under-	en-	inter-	un-	de-	dis-

compose, changed, relate, large, go, integrate

5 Divide into two teams. The teams in turn tell facts about weathering. Each correct statement gets 1 point. The team with the most points is the winner.

6 Do the following quiz.

1. Physical disintegration of rock into smaller pieces is called

a. chemical weathering. c. deposition.
b. transportation. d. mechanical weathering.

2. The decomposition of rock from exposure to water and atmospheric gases is called

a. chemical weathering. c. deposition.
b. transportation. d. mechanical weathering.

3. Which is *not* a type of mechanical weathering?

a. frost wedging. c. pressure release.
b. frost heaving. d. oxidation.

4. The single most effective agent of chemical weathering at Earth's surface is

a. carbonic acid H_2CO_3 .
b. water H_2O.
c. carbon dioxide CO_2 .
d. hydrochloric acid HCl.

5. The most common end product of the chemical weathering of feldspar is

a. clay minerals.
b. pyroxene.
c. amphibole.
d. calcite.

7 Read the text to check your answers.

Rocks undergo both mechanical weathering and chemical weathering. Mechanical weathering (physical disintegration) includes several processes that break rock into smaller pieces. The change in the rock is physical; there is little or no chemical change. For example, water freezing and expanding in cracks can cause rocks **to disintegrate** physically. Chemical weathering is the decomposition of rock from exposure to water and atmospheric gases (principally carbon dioxide, oxygen, and water vapor). As rock is decomposed by these agents, new chemical compounds form.

Mechanical weathering breaks up rock but does not change the composition. A large mass of granite may **be broken** into smaller pieces by frost action, but its original crystals of quartz, feldspar, and ferromagnesian minerals are unchanged. On the other hand, if the granite is being chemically weathered, some of the original minerals are chemically changed into different minerals. Feldspar, for example, will change into a clay mineral (with a crystal structure similar to mica). In nature, mechanical and chemical weathering usually occur together, and the effects are interrelated.

Weathering is a relatively long, slow process. Typically, cracks in rock are enlarged gradually by frost action or plant growth (as roots pry into rock crevices), and as a result, more surfaces are exposed to attack by chemical agents. Chemical weathering initially works along contacts between mineral grains. Tightly bound crystals are loosened as weathering products form at their contacts. Mechanical and chemical weathering then proceed together, until a once tough rock slowly crumbles into individual grains.

Solid minerals are not the only products of chemical weathering. Some minerals—calcite, for example—dissolve when chemically weathered. We can expect limestone and marble, rocks consisting mainly of calcite, **to weather** chemically in quite a different way than granite.

Taken from: Charles C. Plummer, Diane H. Carlson, Lisa Hammersley. (2016) Physical geology (Fifteenth edition), McGraw-Hill Education, New York. – p. 107.

8 Answer the questions below.

1. How does rock weather?
2. Explain the differences between and the processes involved in mechanical and chemical weathering.

9 Translate the text in 7 from English into Russian paying attention to the forms of the infinitive written in bold type.

10 Translate the sentences into Russian, state the form and the function of the Infinitive.

1. **To prove** this law experimentally is very difficult. 2. The chief function of living organisms is **to provide** organic material to the soil. 3. The best approach to understanding physical properties of minerals is **to obtain** a sample of each of the most common rock-forming minerals. 4. One of the most important jobs of geologists studying sedimentary rocks is **to try to determine** the ancient environment of deposition. 5. The idea behind an ambitious program called Project Mohole (begun during the early 1960s) was **to use** specially equipped ships **to drill** through the oceanic crust and **obtain** samples from the mantle. 6. One of the first goals of groundwater geologists, particularly in groundwater contamination investigations, is **to find** the slope of the local water table in order **to determine** the direction (and velocity) of groundwater movement. 7. He is **to make** the experiment. 8. **To understand** the evidence for plate tectonics, you need **to understand** the nature of major seafloor features such as mid-oceanic ridges, oceanic trenches, and fracture zones, as well as the surprisingly young age of the seafloor rocks. 9. **To identify** an unknown mineral, you should first **determine** its physical properties. 10. **To determine** the probability of an earthquake occurring, scientists examine rock properties near faults, slip rate studies, and paleoseismology data **to define** the recurrence interval of quakes along individual faults. 11. For

many years, this idea has been difficult **to test** for lack of a seismometer sensitive enough **to record** slight crustal movements. 12. A geologist who wants **to study** a certain process cannot **repeat** in a few hours a chemical reaction that takes a million years **to occur** in nature. 13. Experiments have shown that the amount of work **to be used** for producing a given amount of heat is the same under all conditions.

TEXT 1.4 Igneous Rocks

1 Discuss these questions with a partner.

- What rock would probably form if magma solidified at considerable depth? / at the surface?
- How does the solidification of magma in different environmental conditions affect the texture of igneous rocks?

2 Read the text to check your answers.

Igneous rocks constitute one of the three principal classes of rocks, the others being metamorphic and sedimentary. They are formed from the solidification of magma, which is a hot (600 to 1,300 °C) molten or partially molten rock material.

Magma **is thought to** be generated within the plastic asthenosphere (the layer of partially molten rock underlying Earth's crust) at a depth below about 60 kilometres. Because magma is less dense than the surrounding solid rocks, it rises toward the surface. It may settle within the crust or erupt at the surface from a volcano as a lava flow. Rocks formed from the cooling and solidification of magma deep within the crust are distinct from those erupted at the surface mainly owing to the differences in physical and chemical conditions prevalent in the two environments. Within Earth's deep crust the temperatures and pressures are much higher than at its surface; consequently, the hot magma cools slowly and crystallizes completely, leaving no trace of the liquid magma. The slow cooling promotes the growth of minerals large enough **to be identified** visually without the aid of a microscope (called phaneritic, from the Greek *phaneros*, meaning "visible"). On the other hand, magma erupted at the surface is chilled so quickly that the individual minerals have little or no chance **to grow**. As a result, the rock is either composed of miner-

als that can be seen only with the aid of a microscope (called aphanitic, from the Greek *aphanēs*, meaning "invisible") or contains no minerals at all (in the latter case, the rock is composed of glass, which is a highly viscous liquid). This results in two groups: (1) plutonic intrusive igneous rocks that solidified deep within the crust and (2) volcanic, or extrusive, igneous rocks formed at Earth's surface.
Taken from: https://www.britannica.com/science/igneous-rock

3 Complete the statements below according to the text in 2.

1) The three main types of rocks are …
2) Asthenosphere is …
3) Lava is …
4) "Phaneritic" means …
5) "Aphanitic" means …
6) Plutonic rocks are …
7) Volcanic rocks are …

4 Give the Russian for:

to constitute; partially molten; less dense; surrounding solid rocks; toward the surface; to settle within the crust; a lava flow; to be distinct from; owing to the differences in; prevalent; consequently; to crystallize completely; to leave no trace; to promote the growth of minerals; to be chilled; in the latter case; a highly viscous liquid; to result in

5 Analyse the forms of the infinitive written in bold type in the text in 2. Translate the sentences into Russian, **state the form and the function of the Infinitive.**

6 Translate into Russian paying attention to the infinitive constructions.

a) The Objective-with-the-Infinitive Construction (Complex Object)

1. Of all the planets, Venus is most like the Earth in diameter and mass. We might therefore expect **it to be** like the Earth in other ways. 2. You might suppose **mud on the sea floor to diffe**r **from** mud on a lake bottom. 3. The sudden decrease in velocity of the water causes **the river to deposit** most of its sediment near the main channel. 4. Phyllite is a rock

that is transitional between slate and schist and, as such, we assume **it to have formed** at a depth between where slate and schist form.

b) The Nominative-with-the-Infinitive Construction (Complex Subject)

1. **The universe** is believed **to have formed** 13.75 billion years ago starting with the Big Bang. 2. **The core** is considered **to be mostly composed** of the metals iron and nickel. 3. **The positions of the magnetic poles** are known **to change** on decadal time scales. 4. **Oil and natural gas** seem **to originate** from organic matter in marine sediment. 5. **The geology of an area** may seem, at first glance, **to be** hopelessly complex. 6. **These sedimentary rocks** are of late Mesozoic and Cenozoic age, and appear **to have been deposited** in much the same way as the modern shelf sediments. 7. Generally, **the magnetic poles** appear **to be moving** slowly around the geographic poles. 8. **The new materials**, stable under conditions at the Earth's surface, are said **to be** in equilibrium —that is, adjusted to the physical and chemical conditions of their environment so that they do not change or alter with time. 9. **Quartz** can always scratch calcite or feldspar and is thus said **to be harder** than both of these minerals. 10. **Sediments** are said **to be unconsolidated**, which means that the grains are separate, or unattached to one another. 11. When a rock has a planar texture, **it** is said **to be** foliated.

c) The For-to-Infinitive construction

1. Rock samples can be brought up from a mine or a well **for geologists to study**. 2. There has not been enough time **for weathering and erosion to alter** significantly the effects of glaciation. 3. Drought accelerates desertification but is not necessary **for it to occur**. 4. Even if volcanoes had created an atmosphere in its youth, the Moon's small mass creates too weak a gravitational force **for it to retain** the erupted gas. 5. However, it will become too expensive **for us to continue** exploiting oil in large quantities. 6. The vastness of geologic time is difficult **for us to comprehend**. 7. With a wide enough distribution of real-time seismometers, it is technically possible **for an urban area to get** an early warning of an impending earthquake if the earthquake's epicenter is far enough away from the city.

TEXT 1.5 Metamorphic Rocks

1 Translate the following words. Find the examples of metamorphic rocks.

limestone, marble, calcite, clay, shale, mica

2 Explain the meaning of the following words in English.

solid state; parent rock; coarse-grained; fine -grained; moderate

3 Give English equivalents of the following:

1) to be deeply buried
2) to be metamorphosed to
3) to be interlocked
4) to be composed of
5) to be at equilibrium
6) to be subjected to

4 Discuss these issues with a partner.

- What does the word "metamorphism" mean?
- Using the rock cycle, compare metamorphic rocks to sedimentary and igneous rocks in terms of the conditions under which they form.

5 Read the text to check your answers.

What happens to rocks that are deeply buried but are not hot enough to melt? They become metamorphosed.

Metamorphism (a word from Latin and Greek that means literally "changing of form") refers to changes to rocks that take place in Earth's interior. The changes may be new textures, new mineral assemblages, or both. Transformations occur in the solid state (meaning the rock does not melt). The new rock is a metamorphic rock.

In nearly all cases, a metamorphic rock has a texture clearly different from that of the original parent rock. When limestone is metamorphosed to marble, for example, the fine grains of calcite coalesce and recrystallize into larger calcite crystals. The calcite crystals are interlocked in a mosaic pattern that gives marble a texture distinctly different from that of the parent limestone. If the limestone is composed entirely of calcite, then metamorphism into marble involves no new minerals, only a change in texture.

More commonly, the various elements of a parent rock react chemically and crystallize into new minerals, thus making the metamor-

phic rock distinct both mineralogically and texturally from the parent rock. This is because the parent rock is unstable in its new environment. The old minerals recrystallize into new ones that are at equilibrium in the new environment. For example, clay minerals form at Earth's surface. Therefore, they are stable at the low temperature and pressure conditions both at and just below Earth's surface. When subjected to the temperatures and pressures deep within Earth's crust, the clay minerals of a shale can recrystallize into coarse-grained mica.

As most metamorphism takes place at moderate to great depths in Earth's crust, metamorphic rocks provide us with a window to processes that take place deep underground, beyond our direct observation. Metamorphic rocks are a feature of the oldest exposed rocks of the continents and of major mountain belts. They are especially important in providing evidence of what happens during subduction and plate convergence.

Adapted from: Charles C. Plummer, Diane H. Carlson, Lisa Hammersley. (2016) Physical geology (Fifteenth edition), McGraw-Hill Education, New York. – p. 158 – 159.

6 Translate into Russian paying attention to the words *former, latter, formerly***.**

1. Uranium, for example, commonly occurs as two isotopes, uranium-238 (^{238}U) and uranium-235 (^{235}U). The **former** has a total of 238 protons and neutrons in its nucleus, whereas the **latter** has a total of 235. 2. As the glacial theory gained general acceptance during the **latter** part of the nineteenth century, it became clear that much of northern Europe and the northern United States as well as most of Canada had been covered by great ice sheets during the so-called Ice Age. 3. Typically there is a difference in the position of the magnetic and geographic poles **(the latter** of which are defined by the spin axis of the Earth). 4. The **former** lake beds are now rich farmland. 5. In 1996, researchers announced that they found what could be signs of **former** life on Mars in one of the meteorites collected twelve years earlier in Antarctica. 6. Tectonic forces can squeeze **formerly** low-lying continental crustal rock along a convergent boundary and raise the upper part well above sea level. 7. Valley glaciers, which usually occupy valleys **formerly** carved by streams, tend to straighten the curves formed by running water.

7 Translate into Russian paying attention to the word *one*.

a) 1. Mars continues to be **one** of the most promising places to look for evidence of extraterrestrial life in our solar system. 2. **One** of the most devastating landslides in history destroyed the town of Yungay in Peru in 1970. Yungay was **one** of the most picturesque towns in the Santa River Valley, which runs along the base of the highest peaks of the Peruvian Andes. 3. Not a single **one** of the numerous dinosaur species survived into the Cenozoic Era

b) 1. Many deltas, particularly small **ones** in freshwater lakes, are built up from three types of deposits. 2. Water seeps into cracks in the bedrock, freezes there, and enlarges fractures or makes new **ones**. 3. A number of shallow-focus earthquakes occur in two other significant locations on Earth. **One** is along the summit or crest of the mid-oceanic ridge, a huge underwater mountain range that runs through all the world's oceans.

c) 1. In order to identify an igneous rock, **one must** consider both its texture and the minerals it contains. 2. To understand earthquakes, for instance, **one should** know about faults. 3. By reading directly from the graph, **one can** determine, for example, that an earthquake has occurred 5,300 kilometers away.

8 Translate into Russian paying attention to *there is, there are*.

1. In fact, even among the industrialized nations **there are** striking differences. 2. Furthermore**, there are** some concerns that catastrophic melting of ice sheets could lead to rapid sea-level rise of a few meters, which would inundate most coastal regions and displace millions. 3. **There is** also broad agreement among scientists that negative consequences are already being felt the world over that will only become stronger in the future if global temperatures continue to rise. 4. **There is** a succession of stages in coal development, from relatively low-energy forms with a small amount of concentrated carbon inside, to higher-energy forms with high relative carbon contents. 5. During that time, **there have been** two periods during which world climate was warmer than at present. 6. Within the limits of the Pleistocene epoch **there had been** four distinct glacial ages, when glaciers spread over nearly a third of the world's land area.

Terms to Remember

distinct from
indestructible
moderate
phaneritic / aphanitic
stable / unstable
tightly bound crystals
viscous (viscous liquid)
weak (weak acid)

boulder
carbon dioxide
clay mineral
cobble
conglomerate
detrital sediments
ferromagnesian mineral
grains of sediment
gravel
limestone
mica
mud / mudstone
pebble
sand / sandstone
shale
silt / siltstone

cliff
crack
hillside
landscape
lava flow
plate convergence
texture / texturally

agent (agents of erosion)
angular particles
chemically weathered rock
mechanically weathered rock
parent rock
plutonic rock
preexisting rock
surrounding rock
underlying bedrock
volcanic rock

accumulate / accumulation of
decompose / decomposition
disintegrate into soil / physical disintegration
expose / exposure to
freeze / freezing / frost action
precipitate / precipitation
remove / physical removal of rock particles
round / rounding / rounded particles
solve (dissolve) / solution
subduct / subduction
thaw / thawing
to affect rock
to be interlocked in
to be physically worn down
to be subjected to
to be unattached to one another
to be loosened / to be separate
to become metamorphosed / metamorphism
to coalesce
to constitute
to expand / to be enlarged
to oxidize
to provide evidence of

UNIT 2 MINERAL PROSPECTING AND EXPLORATION

TEXT 2.1 Prospecting and Exploration

1 Fill in the table below. Make up sentences with the words from the table.

noun	the infinitive in the active voice	the infinitive in the passive voice
prospecting		
exploration		
	search (for)	
mine		
	extend	
		to be depleted
		to be located

2 Translate from English into Russian.

prospecting and exploration activities, a mineral deposit, precious metals, mineral specimens, economic feasibility, geological belt, dwindling material, current mines, raw materials, standard of living

3 Read the text and answer the questions below:

- What is the difference between prospecting and exploration?
- What is the aim of exploration work?
- What is called “the prospect”?

Prospecting and exploration activities are used to identify the location and size of mineral deposits in order to determine the economics of mining these resources. Going from a previously unexplored piece of land ("greenfield exploration") to a well-defined mineral deposit can take years of work and huge sums of money. In 2017 companies spent roughly $8 billion global exploration efforts to find new precious and base metal, diamond and uranium deposits.

Various techniques are used in the search for a mineral deposit, an activity called prospecting. Prospecting is the first stage of the geological analysis (second – exploration) of a territory. It is the physical search for minerals, fossils, precious metals or mineral specimens. Once a discovery has been made, the second (exploration) stage begins. The proper-

ty containing a deposit, called the prospect, is explored to determine some of the more important characteristics of the deposit. Among these are its size, shape, orientation in space, and location with respect to the surface, as well as the mineral quality and quality distribution and the quantities of these different qualities. Once enough high-quality geological data has been gathered from exploration activities, a project can be analyzed for economic feasibility.

After a mine begins production, exploration activities may continue to further define the deposit and potentially extend the life of the mine (by adding more mineral resources and reserves).

Exploration work may identify opportunities outside of the current mining area, but that are located within the same regional area or along the same geological belt as the original deposit.

As reserves are depleted each year, exploration work must always continue across the world in order to replace dwindling material at current mines – and so exploration efforts are vital to ensure our continued supply of raw materials like copper, iron ore, coal and other minerals that are critical to our modern standard of living.

Adapted from: https://newpacificmetals.com/mining-101/types-of-mineral-exploration; https://www.britannica.com/technology/mining/Prospecting-and-exploration

4 Decide whether the statement is *TRUE* (T) or *FALSE* (F). Give reasons for your opinion.

Exploration never stops.

5 Put the main stages of the mining process into the correct order. Tell your partner about the mining process.

	A) Determining economic feasibility
	B) Exploration
	C) Mining the mineral resources
	D) Searching for a new mineral deposit
	E) Prospecting
	F) Reserve depletion

TEXT 2.2 Prospecting Techniques

1 Give definitions to the following words and word combinations.

Example: anomalies are the differences between what is observed at a particular location and what would normally be expected.

- ✓ valuable minerals
- ✓ a prospector
- ✓ direct observations
- ✓ outcrops
- ✓ economic value
- ✓ traces of surface mineralization
- ✓ a mineral prospecting program

2 Read the text and translate it into Russian.

Prospecting is an important tool and is defined as a brunch of geological science which on its application is search for minerals/ ores that can lead to the location of mineral deposit on surface or underneath the earth's crust.

In searching for valuable minerals, the traditional prospector relied primarily on the direct observation of mineralization in outcrops, sediments, and soil. Although direct observation is still widely practiced, the prospector of today also employs a combination of geologic, geophysical, and geochemical tools to provide indirect indications for reducing the search radius. His aim is to detect subsurface ore-bodies of economic value by identifying anomalous traces of surface mineralization, through the use of geochemical and/or geophysical prospecting methods. Methods used will vary depending on the mineral deposit type and stage of exploration that is being pursued – as well as the location and budget of the mineral prospecting program.

There are three main groups of techniques that may be utilized during mineral prospecting programs. They include geological, geochemical and geophysical surveys.

Adapted from: https://www.britannica.com/technology/mining/Prospecting-and-exploration;
https://ibm.gov.in/writereaddata/files/07252017105204Monograph%20on%20Iron%20Ore_3.pdf

TEXT 2.3 Geological Surveys

1 Read the text and answer the questions below.

- What activities do geological surveys include?
- What are their aims?
- What results are achieved at each stage?

Geological surveys provide key clues of a potential discovery at surface.

Desk study. The search for new deposits has become a complex undertaking, and the prospector should be as well informed as possible that is why an initial period of data review, collation and analysis is usually carried out. All available historic and public data are collated and studied for potential information on target areas. Previous geologic reports and geologic maps of areas of interest are also analyzed. Topographic maps or air photographs of areas to be prospected are obtained and used to plot sample locations and other appropriate data.

Field mapping. Additional geological field mapping is used to augment the information presented on geological maps. Geologists try to find all the bedrock exposures, or outcrops, in an area to construct a geologic map. They identify rock types, relationships, textures, features (such as cross-bedding), and structures (such as folds and faults) as well as rock mineral contents, and fossils. Detailed directional measurements along structures are then documented and assayed to increase the exploration knowledge of the property.

Geological mapping. A geological map of an area of prospective mineral sites can be compiled from existing geological information maps and/ or new field work.

Adapted from: https://www.economy-ni.gov.uk/publications/mineral-prospecting-common-exploration-methods

2 Find the English equivalents for the following phrases in the text.

теоретическое (кабинетное) исследование, сложная задача, полевая съемка, выход коренной породы на поверхность (обнажение породы), поперечное напластование (косая слоистость), складки и разломы, содержание минералов в породе, земельный участок, геологическое картирование, участки возможного залегания полезных ископаемых, полевые работы (разведка)

3 Find the synonyms for the following words in the text in 1.

1	exploration (n)	
2	surveyor (n)	
3	original, start (adj.)	
4	compare (v)	
5	goal (n)	
6	map (v)	
7	specimen (n)	
8	enhance (v)	
9	analyze (v)	

4 Speak about your own experience of carrying out geological surveys. Use the questions below to help you.

- ✓ What did you do?
- ✓ When did you do it?
- ✓ What was the aim of your work?
- ✓ What results did you obtain?
- ✓ How did you feel about it?

5 Translate the text from English into Russian.

Geologic maps graphically communicate vast amounts of geologic information. A geologic map represents the projection on a flat piece of paper of the intersection between geological 3D features with the surface topography. A detailed geologic map shows where similar rocks or sediments may be found; how old they are; what they are composed of; how they formed; how they have been affected by faulting, folding, or other geologic processes; and what existing or potential mineral resources and geologic hazards are nearby. Geologic information shown on maps is necessary for countless reasons, from finding natural resources (water, minerals, oil and gas) to evaluating potential hazards (earthquakes, landslides, floods, volcanic eruptions) to describing a fundamental part of the environment that controls distribution of plants and animals.
http://www.geosci.usyd.edu.au/users/prey/FieldTrips/BrokenHillOlary/Mapping.html

6 Describe a geologic map. You should say:

- what it looks like
- what information it provides
- what it is used for

TEXT 2.4 Geochemical and Geophysical Surveys

1 Match the pictures with the words in the box.

A **B** **C** **D** **E**

1) spade	**2)** magnetometer	**3)** mesh screen	**4)** geophone	**5)** auger

2 Translate the following multi-component terms.

soil sampling, stream sediment sampling, the overlying material, paper sample bags, an exploration property, an inductively coupled plasma (ICP) device, natural remanent magnetization, electrical conductivity, dielectric permittivity, magnetic permeability, seismic wave velocity, radioactive decay, the underground rock formations, the Earth's magnetic field

3 With a partner make a list of geochemical and geophysical activities. Read the text to get more information.

Geochemical surveys involve sampling rocks, soils, and stream sediments, which are then analysed for mineral elements. The results of studies on these samples are then mapped to show the areas where concentration of minerals may lie in the assigned prospecting or exploration area.

Soil sampling. It is carried out by individuals or teams of people. Samples of a few hundred grams up to 5 – 10kg are collected using a hand held auger for the small samples and a spade for the larger ones. Auger method has low impact on the environment and the ground can be left with no visible signs of disturbance. Larger samples are collected

from a dug pit. Surveys are usually carried out over a rectangular grid. The area covered could be very large for regional work or down to less than a few km^2 for detailed surveys.

Stream sediment sampling. Samples are collected from streams as near the middle of the stream as possible. Approximately 50 grams of material is normally taken but larger samples may also be required depending on the method used. Where heavy metal mineralisation is being targeted, samples are collected as close to the bedrock as possible. This may require digging down through the overlying material. The sediment is wet sieved through mesh screens to the required size and put in paper sample bags for drying.

*Analysis at assay labs***.** Samples collected from an exploration property are sent to labs for assaying. At the lab, the samples (rocks, soil, etc) are prepared for analysis by going through drying, crushing and/or milling to create fine material that is then run through various tests to determine the chemical makeup of the sample and the concentration of each component in it.

An example of a common test is to dissolve the sample in an acid mixture and analyze it using an inductively coupled plasma (ICP) device that can measure the relative mass of each element using a technique called mass spectrometry (MS). These tests can detect up to 40 different elements.

In ***geophysical prospecting*** gravity, magnetic, electrical, seismic, and radiometric methods are used to distinguish such rock properties as density, natural remanent magnetization, electrical conductivity, dielectric permittivity, magnetic permeability, seismic wave velocity, and radioactive decay.

Seismic surveys record energy waves reflected from different rock layers in the earth. The energy which is reflected from the underground rock formations is recorded as ground movements at the surface by geophones. *Magnetic surveys* are commonly done by air using magnetometers, which measure small changes in the earth's magnetic field caused by magnetic minerals in rocks. *Electromagnetic surveys* measure the electrical conductivity of different rocks. Certain mineral types are more conductive then others and allow electrical current to pass through them more easily. *Radiometric surveys* measure the natural radiation of

different mineral types in the earth's surface. *Gravity surveys* can be done by air or on land. The Earth's gravity field is affected by the density of different kind of rocks. Surveys to map all these differences can be used by mineral explorers to help locate certain rock formations.

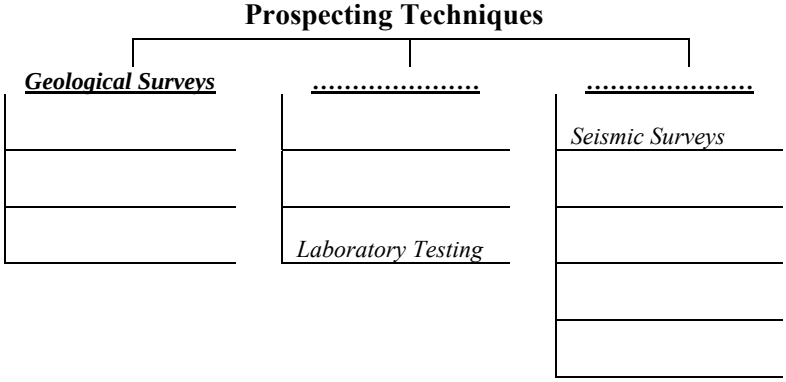
Geophysical techniques are especially useful on properties that have a large amount of overburden, making it difficult or impossible to access mineralized rock for geochemical analysis. Certain geophysical methods can detect anomalies 500 metres below surface.

Adapted from: https://www.economy-ni.gov.uk/publications/mineral-prospecting-common-exploration-methods; http://www.mnra.gov.bz/wp-content/uploads/2015/04/Prospecting-and-Exploration-Fact-Sheet.pdf

4 Decide whether the statements are *TRUE* (T) or *FALSE* (F).

1) Auger method seriously affects the environment as samples are collected from a dig pit.
2) Mesh screens are always used to collect soil specimens.
3) Field-collected samples should be prepared for laboratory testing.
4) Geophysical surveys let us know more about rock properties.
5) Geophysical techniques can be used to explore for minerals without physically going under the surface of the earth.

5 Complete the following diagram. Tell about mineral prospecting.



TEXT 2.5 Exploration Field Activities

1 Fill in the table below.

zinc, petroleum, coal, clay, copper, limestone, opals, oil shale, natural gas, uranium, sulphur, diamonds, salts, iron, sapphires, fertilizer rocks

industrial raw materials	ores	gemstones	solid fuels	gaseous fuels	liquid fuels

2 Read the text and check your answers.

Mineral exploration aims to discover deposits of minerals and rocks that can be used to meet the resource needs of society. It encompasses the search for industrial raw materials (e.g., clay, limestone, sulphur, salts, and fertilizer minerals and rocks), ores from which metals are extracted (e.g., iron, copper, and zinc ores), and gemstones (diamonds, sapphires, and opals), and includes the search for solid fuels (coal, oil shale, and uranium) but not liquid or gaseous fuels (petroleum and natural gas). Mineral exploration can be as basic as prospecting, using elementary techniques such as panning for gold, or it can be very sophisticated, involving the use of complex technology for data gathering and interpretation.

Several exploration techniques are used, depending on the type of deposit and its proximity to the surface. When the top of a deposit intersects the surface, or outcrops, shallow trenches may be excavated with a bulldozer or backhoe. Trenching provides accurate near-surface data and the possibility of collecting samples of large volume for testing. The technique is obviously limited to the cutting depth of the equipment involved. Sometimes special drifts are driven in order to explore a deposit, but this is a very expensive and time-consuming practice. In general, the purpose of driving such drifts is to provide drilling sites from which a large volume can be explored and a three-dimensional model of the potential ore body developed. Old shafts and drifts often provide a valuable and convenient way of sampling existing reserves and exploring extensions.

The most widely used exploration technique is the drilling of probe holes. In this practice a drill with a diamond-tipped bit cuts a nar-

row kerf of rock, extracting intact a cylindrical core of rock in the centre. These core holes may be hundreds or even thousands of metres in length; the most common diameter is about 50 mm. The cores are placed in special core boxes in the order in which they were removed from the hole. Geologists then carefully describe, or log, the core in order to determine the location and kinds of rock and mineral present; the different structural features such as joints, faults, and bedding planes; and the strength of the rock material. Cores are often split lengthwise, with one half being sent to a laboratory so that the grade, or content, of mineralization can be determined.

Taken from: https://www.britannica.com/technology/mining/Prospecting-and-exploration
https://www.sciencedirect.com/topics/earth-and-planetary-sciences/mineral-exploration

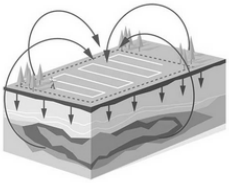
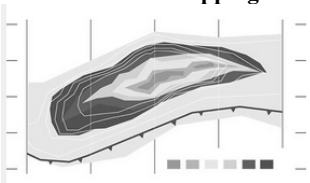
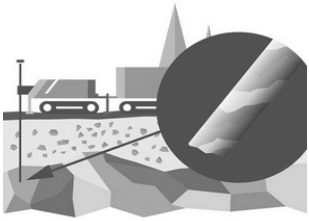
3 Finish the sentences.

1) A backhoe is used to…
2) Shallow trenches are excavated when…
3) Trenching is limited…
4) Old shafts may be useful for…
5) The most commonly used exploration technique is…
6) A diamond-tipped bit is used to…
7) The depth of core holes may be…
8) The cores are carefully examined in order to…

4 Match the English expressions with their Russian equivalents.

1	mineral exploration	**a**	долото с алмазным наконечником
2	to meet the resource needs of society	**b**	трещины, разломы и плоскости напластования
3	industrial raw materials	**c**	твердые и жидкие виды топлива
4	solid and liquid fuels	**d**	золото панорамирование
5	panning for gold	**e**	керн горной породы
6	to outcrop	**f**	трудоемкая практика
7	trenching	**g**	узкий пропил в породе
8	time-consuming practice	**h**	разведка полезных ископаемых
9	a diamond-tipped bit	**i**	промышленное сырье
10	a narrow kerf of rock	**j**	обнажаться
11	a core of rock	**k**	рытье траншей
12	joints, faults, and bedding planes	**l**	удовлетворить потребности общества в полезных ископаемых

5 Match the exploration activity with its explanation

1 Geophysical survey 		**A)** This method analyses till and drill cuttings to trace mineralisations.
2 Boulder hunting 		**B)** This method enables the mapping of the bedrock at depths as great as 2,000 metres.
3 Bedrock mapping 		**C)** This method investigates the bedrock's physical properties, and can be performed from the air, manually on the ground or using probes lowered into bore holes.
4 Geochemical sampling 		**E)** This method documents the geological properties of outcrops, including metallic minerals, and gathers the information in databases for interpretation and analysis.
5 Diamond drilling 		**F)** This method includes physically searching on site for geologically interesting boulders that have been separated from the bedrock in connection with inland ice sheet movements and are now a part of a till layer.

Terms to Remember

prospecting
mineral exploration
trenching
soil sampling
stream sediment sampling
desk study
field mapping
geological mapping
geophysical techniques
prospecting activities
search for minerals
exploration work
field work
direct observation
indirect indications
a mineral prospecting program.
a prospector
a mineral explorer
a prospect
a property
a potential discovery
an unexplored piece of land
rock properties
a mineral specimen
chemical makeup of the sample
rock mineral content
mineralization
radioactive decay
natural remanent magnetization
electrical conductivity
dielectric permittivity
magnetic permeability
seismic wave velocity
characteristics of the deposit
the location and size of mineral deposits
anomalous traces of surface mineralization
orientation in space
economic feasibility
economic value
dwindling material
the earth's magnetic field
the earth's gravity field
underneath the earth's crust
underground rock formations
joints
folds
faults
bedding planes
cross-bedding
a geological belt
ore body / subsurface ore-bodies
bedrock
bedrock exposure
outcrop
overlying material
overburden
fossils
precious metals
valuable minerals
gemstones
petroleum
natural gas
solid fuels
liquid fuels
gaseous fuels
raw materials

Terms to Remember

to access mineralized rock
to assay measurements
to begin production
to collect samples
to construct a geologic map
to cut a narrow kerf of rock
to describe a core of rock
to detect anomalies
to determine the location of rocks
to discover deposits of minerals and rocks
to do / carry out geological surveys
to document
to drill probe holes
to drive drifts
to evaluate potential geologic hazards
to excavate shallow trenches
to explore for oil
to find natural resources
to gather geological data
to identify rock properties
to intersect the surface
to locate certain rock formations
to make a discovery
to map differences
to mine mineral resources
to use a drill with a diamond-tipped bit
to outcrop
to provide accurate data
to sample rocks

to be extracted
to be depleted
to be prospected

potential geologic hazards
earthquake
landslide
flood
volcanic eruption

ANSWER KEY

UNIT 1

TEXT 1.1: Sedimentary Rocks

Ex. 5: 1 Gravel 2 Pebbles 3 Cobbles 4 boulders 5 Sand 6 Silt 7 Clay 8 Mud

TEXT 1.2: Weathering, Erosion, and Transportation

Ex. 2: 1 ocean waves; 2 running water; 3 loose particles; 4 rock fragments; 5 underlying bedrock; 6 earth's surface; 7 environment factors; 8 bound crystals; 9 awesome agents

Ex. 3 (possible answers):

Verb	*Participle I*	*Participle II*	*Noun*	*Adjective*	*Adverb*
move	moving	moved	**movement**	-	movingly
erode	**eroding**	eroded	erosion	erodent	-
loosen	loosening	loosened	looseness	loose	loosely
remove	removing	removed	**removal**	removable	-
expose	exposing	**exposed**	exposure	-	-
freeze	freezing	frozen	**freeze**/ freezer	-	-
vary	**varying**	varied	variety	various / variable	variously
alter	altering	**altered**	alternation	-	alternately
oxidize	oxidizing	oxidized	oxide	-	-

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

TEXT 4.3: How Weathering Changes Rocks

Ex. 2: mechanically, chemically, physically, principally, originally, relatively, typically, gradually, initially, tightly, slowly, individually, mainly

Ex. 3: change - change, compose - composition, expose - exposure, weather - weather / weathering, occur - occurrence, cause - cause, form – form / formation, grow - growth, crumble - crumb, dissolve - dissolvent, originate - origin, alter – alteration

Ex. 4: decompose, unchanged, interrelate, enlarge, undergo, disintegrate

Ex. 6: 1d 2a 3d 4b 5a

TEXT 1.5: Metamorphic Rocks

Ex. 1: marble, mica

Ex. 3: 1) to be at great depth, 2) to be changed into, 3) to be bound (held) together, 4) to be made up of, 5) to be stable, 6) to undergo / to be exposed to

UNIT 2

TEXT 2.1: Prospecting and Exploration

Ex. 1

noun	verb	the passive
prospecting	prospect	to be prospected
exploration	explore	to be explored
search	search (for)	to be searched
mine	mine	to be mined
extension	extend	to be extended
depletion	deplete	to be depleted
location	locate	to be located

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

TEXT 2.3: Geological Surveys

Ex. 2: desk study, a complex undertaking, field mapping, bedrock exposure / outcrop, cross-bedding, folds and faults, rock mineral content, property, geological mapping, prospective mineral sites, field work

Ex. 3

1	exploration (n)	*search (n)*	6	map (v)	*plot (v)*
2	surveyor (n)	*prospector (n)*	7	specimen (n)	*sample (n)*
3	original, start (adj.)	*initial (adj.)*	8	enhance (v)	*augment (v)*
4	compare (v)	*collate (v)*	9	analyze (v)	*assay (v)*
5	goal (n)	*target (n)*	6	map (v)	*plot (v)*

TEXT 2.4: Geochemical and Geophysical Surveys

Ex. 1: 1B 2C 3E 4A 4D
Ex. 4: 1F 2F 3T 4T 5T

TEXT 2.5: Exploration Field Activities

Ex. 4: 1h 2l 3i 4c 5d 6j 7k 8f 9a 10g 11e 12b
Ex. 5: 1C 2F 3E 4A 5B

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