

## Unit 7 Metamorphic rocks

### 1.1 Vocabulary

#### 1. Pay attention to the pronunciation of the following terms:

gneiss [naɪs] гнейсовый	slate [sleɪt] сланец	granite ['grænɪt] гранитный
mica ['mɪkə] слюдяной	quartz [kwɔ:ts] кварцевый	orthoclase ['ɔ:θəkleɪs] ортоклаз
phyllite ['fɪlaɪt] филлитовый	schistose ['ʃɪstəʊs] сланцеватый	
marble [mɑ:bl] мрамор	chlorite ['klɔ:rɑɪt] хлорит	

#### 2. Pay attention to the terms and expressions:

3. schistose ['ʃɪstəʊs]	сланцеватый
4. constituent [kən'stɪtʃənt]	составная часть; компонент
5. band [bænd]	слой; прослоек
6. to cleave [kli:v]	расщепляться
7. Plate [pleɪt]	пластина
8. excess [ɪk'ses]	излишек
9. low-grade [ləʊ greɪd]	низкая ступень (метаморфизма)
10. medium-grade ['mi:djəm-greɪd]	средняя ступень (метаморфизма)
11. high-grade [haɪ greɪd]	высокая ступень (метаморфизма)
12. flaky ['fleɪki]	чешуйчатый; расслоенный
13. split into	раскалываться на
14. sheet [ʃi:t]	пластина, лист
15. foliated ['fəʊleɪtɪd]	листоватый; сланцеватый
16. dislocation [dɪslə'keɪʃn]	нарушение, дислокация

17. distribute [dɪs'trɪbjʊt]	распределять; раздавать
18. disturb [dɪs'tɜ:b]	нарушать; смещать

### 3. Read the following word formations and remember their pronunciation:

cleave [kli:v] раскалывать, расщеплять	cleavage ['kli:vɪdʒ] расщепление, спайность		
foliate ['fəʊliət] облиствлять, расслаивать	foliated ['fəʊlietɪd] слоистая, расслоенный	foliation расслоение	
relate [rɪ'leɪt] соотносить	related родственная	relationship отношения	relative родственник
differ ['dɪfə] различать	different разная	difference разница	

#### 1.2 Read the text “Metamorphic rocks”

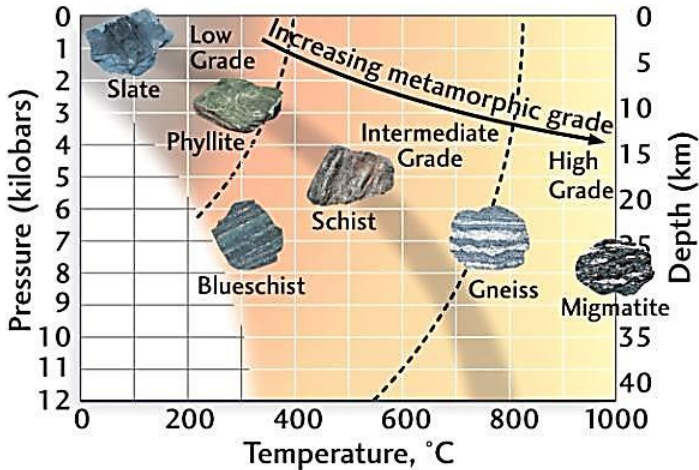
Metamorphic rocks compose the third large family of rocks. Metamorphic means «changed form». It shows that the original rock has been changed from its primary form to a new one. Being subjected to pressure, heat and chemically active fluids beneath the Earth's surface, various rocks in the Earth's crust undergo changes in texture, in mineral composition and structure are transformed into metamorphic rocks. This process is called metamorphism. As is known, metamorphic rocks developed from earlier igneous, sedimentary or metamorphic rocks by the action of heat and pressure.

Gneiss, mica schist, phyllite, marble, slate, quartzite belong to the same group of rocks. Having the same mineral composition as granite, gneiss consists chiefly of quartz, orthoclase and mica. However unlike granite, they have a schistose structure. It means that their constituents are distributed in bands or layers and run parallel to each other in one direction. If disturbed the rock cleaves easily into separate plates.

The role of water in metamorphism is determined by at least four variable geologically related parameters: rock pressure, temperature, water pressure and the amount of water present.

During a normal progressive metamorphism rock pressure and temperature are interdependent and the amount of water and the pressure of water are related to the sediments and to the degree of metamorphism in such a way that the excess of water characterizes the low-grade metamorphic rocks. The medium-grade metamorphic rocks are characterized by the absence of water.

## INDEX MINERALS, GRADE, AND FACIES DESCRIBE METAMORPHISM



**Fig. 40. Grade and facies describe metamorphism**

Many of the metamorphic rocks consist of flaky materials such as mica and chlorite. These minerals cause the rock to split into thin sheets and rocks become foliated. Slate, schist and gneiss belong to the group of foliated metamorphic rocks. Marble and quartzite are non-foliated metamorphic rocks.

The structure of metamorphic rocks is of importance because it shows the nature of pre-existing rocks and the mechanism of metamorphic deformation. Every trace of original structure is of great importance to geologists. It gives an opportunity of analyzing the causes of its metamorphism. Metamorphic rocks represent the oldest portion of the Earth's crust. They are mostly found in the regions of mountain belts where great dislocations on the Earth took place.

(М.Я. Баракова, Р. И. Журавлева, Английский язык для горных инженеров, М. 2001)

**Table 6. Classification of Common Metamorphic Rocks**

TEXTURE	DIAGNOSTIC FEATURES	ROCK NAME
FOLIATED	Granulitic texture, medium to coarse, even grained. Foliation present in light-colored quartzo-feldspathic rocks, but virtually lacking in pyroxene-plagioclase-bearing rocks.	GRANULITE
	Gneissic texture. Coarse grained. Foliation present as macroscopic grains arranged in alternating light and dark bands. Abundant quartz and feldspar in light-colored	GNEISS

	bands. Dark bands may contain hornblende, augite, garnet, or biotite.	
	Schistose texture. Medium to fine grained. Common minerals are chlorite, biotite, muscovite, garnet, and dark elongate silicate minerals. Feldspars commonly absent. Recognizable minerals used as part of rock name. Porphyroblasts common.	SCHIST
	Phyllitic texture. Fine grained to dense. Micaceous minerals are dominant. Has a sparkling appearance.	PHYLLITE
	Slaty texture (slaty cleavage apparent). Dense, microscopic grains. Color variable; black, and dark gray common. Also occurs in green, dark red, and dark purple colors.	SLATE
NONFOLIATED	Crystalline. Hard (scratches glass). Breaks across grains as easily as around them. Color variable; white, pink, buff, brown, red, purple.	QUARTZITE
	Dense, dark-colored; various shades of gray, gray-green, to nearly black.	HORNFELS
	Crystalline. Composed of calcite or dolomite. Color variable; white, pink, gray, among others. Fossils in some varieties.	MARBLE
	Black, shiny luster. Conchoidal fracture.	ANTHRACITE COAL

## 2. Exercises

### 2.1 Define the following terms with their similar meaning in Russian

**metamorphic** rocks; some changes in **texture**; in mineral **composition**; the description of **metamorphism**; schistose **structure**; the **role** of water; four variable **geologically** related **parameters**; flaky **materials**; the **mechanism** of **metamorphic deformation**; **crystalline** schists; the great **dislocation** of the Earth's crust; during normal **progressive metamorphism**.

### 2.2 Match the English equivalents to the Russian terms.

1. as a result of the chemical and physical changes	a. составляющие пород
2. constituents of rocks	b. расщепляться на отдельные слои

3. to be subjected to constant development	с. в результате химических и физических изменений
4. to undergo changes	d. избыток воды
5. excess of water	е. находиться в постоянном развитии
6. to cleave into separate layers	f. следы первоначального строения
7. traces of original structure	g. изменяться

**2.3 Match the Russian equivalents to the English terms.**

1. сланцеватая текстура	a. unlike granite
2. в отличие от гранита	b. schistose structure
3. недостаток воды	c. pre-existing rocks
4. существовавшие ранее породы	d. to define (determine) rock texture
5. расслоенные породы	e. deficiency of water
6. мрамор и сланец	f. flaky rocks
7. гнейс	g. marble and slate
8. определить структуру	h. gneiss

**2.4 Fill in the gaps using the word formations.**

a)

cleave	cleaves	cleavage
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1. Metamorphic rocks which have a schistose structure can \_\_\_\_\_.
2. As a result of splitting \_\_\_\_\_ is formed.
3. Generally speaking, the constituents of gneiss are distributed in bands or layers and the rock \_\_\_\_\_ easily.

b)

relationship	related	relate
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1. The \_\_\_\_\_ between rock pressure and temperature is interdependent.

2. The role of water in metamorphism can be characterized at least by four variable geologically \_\_\_\_\_ parameters.
3. These parameters \_\_\_\_\_ to each other.

c)

foliates	foliation	foliated
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1. A rock \_\_\_\_\_ when it splits into thin sheets.
2. Marble and quartzite are non-\_\_\_\_\_ metamorphic rocks.
3. \_\_\_\_\_ is a characteristic feature of only metamorphic rocks.

d)

differ	different	difference
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1. Gneiss, marble and slate \_\_\_\_\_ from granite due to their schistose structure.
2. There are many \_\_\_\_\_ types of metamorphic rocks due to two main factors.
3. The \_\_\_\_\_ between low-grade and medium-grade metamorphic rocks is the amount of water present.

### 2.5 Match the similar word in column A to the one in column B

1. band	a. allow
2. cleave	b. size
3. constituent	c. fissure
4. foliated	d. take place
5. be like	e. speed
6. permit	f. layer
7. crack	g. split
8. occur	h. component
9. rate	i. flaky
10. dimension	j. be similar to

## 2.6 Match the opposite word in column A to the one in column B

1. deep	a. small
2. cool	b. shallow
3. slowly	c. low-grade
4. vast	d. non-foliated
5. extrusive	e. rapidly
6. like	f. unlike
7. high-grade	g. intrusive
8. common	h. deficiency
9. excess	i. heat
10. foliated	j. uncommon

## 2.7 State whether the following statements are true or false.

1. Generally speaking, metamorphic rocks developed from ores.
2. Marble, slate and phyllite belong to the group of metamorphic rocks.
3. As is known, unlike granite metamorphic rocks have a schistose structure.
4. It is quite obvious that the role of water in metamorphism is important.
5. Flaky minerals cause the rock to split into thin sheets.
6. It should be mentioned that marble and quartzite are foliated metamorphic rocks.
7. As a rule, low-grade metamorphic rocks are characterized by the absence of water.
8. The structure of metamorphic rocks shows the nature of older pre-existing rocks and the mechanism of metamorphic deformation.
9. All metamorphic rocks are non-foliated.

## 3. Reading comprehension

### 3.1 Detailed reading:

#### Occurrence and classification of metamorphic rocks

Recrystallized or deformed preexisting rock units constitute approximately 15 % of the continental crust. Metamorphic rocks are products of pressure-temperature conditions intermediate between those of igneous and sedimentary environments. Thus, on the one hand, metamorphic processes merge with diagenesis, a sedimentary phenomenon; on the other hand, metamorphism leads to partial fusion of deeply buried continental and oceanic crust and in the generation of granite and andesitic magmas.

Two principal metamorphic processes may be distinguished: mechanical deformation and chemical recrystallization. The former process includes grinding, crushing and ductile deformation of an initial rock, phenomena that reflect readjustment of the material. Recrystallization takes place because preexisting mineral assemblages are destabilized by changes in the temperature, pressure or chemical milieu. Nearly all-metamorphic rocks show a combined influence of both mechanical deformation and chemical reaction; they differ principally in the degree of development of these effects. Metamorphic rocks exhibit contrasts reflecting variations in bulk composition as well, due to differences in original rock chemistry or to alteration.

Mechanical deformation is called cataclasis and metamorphic rocks in which reduction to small particle size is conspicuous are known as cataclastic rocks. In contrast to cataclastic rocks, which are produced by dominantly mechanical deformation, contact metamorphic rocks are formed by a significant increase in temperature in the absence of differential stress. Contact metamorphic rocks are localized as concentric zones surrounding igneous bodies emplaced at upper levels of the crust.

The most common varieties of metamorphic rocks develop on a regional scale in response to both deformation and mineral reaction. Such widespread rocks are known as regional metamorphic rocks and are typified by orientated mineral fabrics. Foliation and lineation are widespread features reflecting differential motions of the rock sections undergoing recrystallization.

(Barret E. , Hunt A. And Milner B.” Earth and Atmosphere”, 1993, Longman)

### **3.1.1. State whether the following sentences are t (true) or f (false), according to the information from the text**

1. Metamorphic rocks compose about 25% of the continental crust.
2. Metamorphic rocks are a combination of sedimentary and igneous rocks altered under pressure and heat conditions.
3. There are two main metamorphic processes.
4. Mechanical deformation includes grinding and crushing of the country rock.
5. Pre-existing mineral assemblages are chemically recrystallized by changes in the temperature, pressure or chemical milieu.
6. All metamorphic rocks show a combination of both mechanical deformation and chemical reaction.
7. Metamorphic rocks show contrasts because of the differences in original rock chemistry or change.
8. Mechanical deformation forms the so-called cataclastic rocks.
9. Contact metamorphic rocks are formed by a great increase in heat without differential stress.
10. Contact metamorphic rocks are found in zones surrounding sedimentary rocks on the surface of the crust.
11. Regional metamorphic rocks are a result of both deformation and mineral reaction.
12. Foliation and lineation are characteristic features of various rock motions in the process of recrystallization.

**Match the definition with the following terms.**

1. regional metamorphic rocks	a. metamorphic rocks in which particles are reduced to a small size
2. cataclasis	b. developed on a regional scale in response to both deformation and mineral reaction
3. recrystallization	c. readjustment of the material
4. cataclastic rock	d. formed by a significant increase in temperature in the absence of differential stress
5. contact metamorphic rocks	f. preexisting mineral assemblages are destabilized by changes in the temperature, pressure or chemical milieu

**4. Revision**

**4.1 Choose the correct variant**

**1. A rock is metamorphosed when**

- A. heat and pressure melt the rock
- B. heat and pressure change the rock composition
- C. heat and pressure alter the mineral texture

**2. Rocks exposed to lots of heat are**

- A. stable
- B. ductile
- C. rigid

**3. Pressure in metamorphism involves**

- A. buried rocks influenced by stress
- B. buried rocks pressurized by their own weight
- C. buried rocks subjected to weight of overlying rocks

**4. Recrystallization is the result of**

- A. temperature and pressure
- B. pressure and stress
- C. only stress

**5. Another factor influencing metamorphism is**

- A. carbon dioxide
- B. water
- C. fluids

**6. The two main types of metamorphism are**

- A. contact and regional
- B. contact and foliation
- C. burial and lineation

**7. Aureole is**

- A. metamorphosed intruding magma
- B. metamorphosed continental crust
- C. metamorphosed country rock

**8. You can \_\_\_\_\_ and \_\_\_\_\_ foliation.**

- A. smell and feel
- B. feel and see
- C. see and taste

**9. Slate has**

- A. slaty cleavage
- B. gneissosity
- C. schistosity

**10. Another term for schistosity is**

- A. slaty schist
- B. schistose lineation
- C. schistose foliation

**11. Gneiss is formed when granite withstands**

- A. pressure and stress
- B. high temperature and pressure
- C. heat and stress

**12. Hornfels are formed from**

- A. contact metamorphism
- B. regional metamorphism
- C. burial metamorphism

**4.2 Match the definitions with the following terms**

1. metamorphism	a. metamorphic rocks that don't have foliation, lineation and directional texture
2. contact metamorphism	b. scaly foliation composed of large-grained minerals that you can see without magnifying them
3. aureole	c. locking minerals that don't align themselves in any

	particular direction or fashion.
4. regional metamorphism	d. when granite withstands the high heat and pressure of metamorphism
5. foliation	e. hot magma comes into contact with the country rock and the heat from the intruding magma causes the country rock to metamorphose
6. slaty cleavage	f. minerals in an igneous rock, or the particles in a sedimentary rock in certain circumstances (under extreme conditions of pressure or temperature) change and recrystallize
7. schistosity	g. the part of the country rock that metamorphoses as a result of contact with the magma
8. gneissosity	h. the heat and pressure is great enough to cause rocks to change their mineral composition and crystalline textures
9. hornfels	i. a texture caused by the alignment of minerals into parallel bands
10. metamorphic rocks	j. the coarsest foliation characterized by alternating bands of light and dark minerals.
11. gneiss	k. high pressures and temperatures affect huge areas of the Earth's crust, metamorphosing huge regions of rocks
12. hornfelsic (granular) metamorphic rocks	l. it can easily be split along cleavage planes and the planes often have bumpy parallel ridges