metamorphic rocks is called **metamorphism.** The changes that produce metamorphic rocks occur within the lithosphere, usually many kilometers deep. The changed rocks resulting from metamorphism are often less porous and more dense than the original rocks. They also have larger mineral crystals, and often have a layering of mineral crystals called **foliation.**

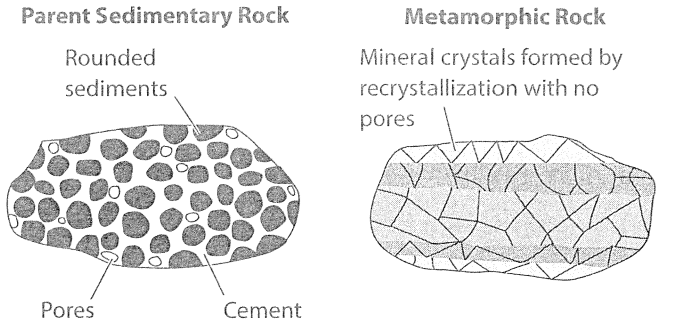


Figure 11-12. Metamorphic rock formed from sedimentary rock by recrystallization: Under the influence of heat and pressure, minerals in this clastic sedimentary rock combine by recrystallization to form mineral crystals of a coarse-texture (banded) crystalline rock. Recrystallization increases the rock's density by reducing the pore spaces.

Formation of Metamorphic Rocks When metamorphism occurs the previously existing rocks, called parent rocks, are usually recrystallized. (See Figure 11-12.) Recrystallization is the process of increasing the size of the mineral crystals or rock clasts and/or changing the mineral composition without melting. Under high heat and pressure conditions deep within the lithosphere, atoms can move small distances and become rearranged with changes in mineral composition without true melting, resulting in recrystallization. The various types of metamorphism are described in the sections that follow.

Contact Metamorphism When older rocks come in contact with the magma of an intrusion or lava of an extrusion, the heat and mineral fluids of the liquid rock alter the older rock in a process called **contact metamorphism.** Figure 11-13 shows the details of contact metamorphism. In a contact metamorphic zone there is a progression from igneous rocks, to metamorphic rocks, to the parent rocks, often without clear separations. At contact metamorphic zones, metamorphic rocks, such as hornfel, some marbles, and some quartzites are formed. Because there is mostly heat and not much directional pressure, the rocks formed by contact metamorphism usually don't have foliation.

Regional Metamorphism Sections of the lithosphere called plates may be hundreds of kilometers in width and tens of kilometers in depth. During the convergence (collision) of these plates, rocks are subjected to the high temperatures and pressures associated with a great thickness of overlying rocks and sediments and the pressures resulting from the collisions. These colliding plates often result in mountain building. The closer an area is to the boundary of colliding plates, the greater the increase in temperature and pressure. This increase in temperature and pressure transforms older rocks to a series of metamorphic rocks in a process called **regional metamorphism.** The rocks formed by regional metamorphism are often highly folded (bent) and faulted. The Taconic Mountains and the Hudson Highlands show features of regional metamorphism. Figure 11-14 illustrates the rock types and features formed by regional metamorphism.

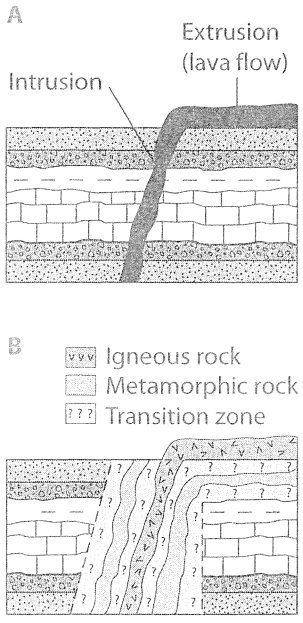


Figure 11-13. Transition of rock types in contact metamorphic zones: (A) Molten rock flows up through a crack in sedimentary rock to the surface, forming an intrusion below the surface and an extrusion (lava flow) on the surface. (B) At the contact zone, between the original local rock and the intrusion or extrusion, there is a blending of rock type from sedimentary, through metamorphic to igneous.

Textures of Metamorphic Rocks Metamorphic rocks have two major types of textures—foliated and nonfoliated. Foliated rocks have layers of mineral crystals that have formed by recrystallization under directional pressures associated with regional metamorphism. These rocks are composed of two or more minerals and are made of interconnected mineral crystals. The three types of foliations are shown in Figure 11-15.

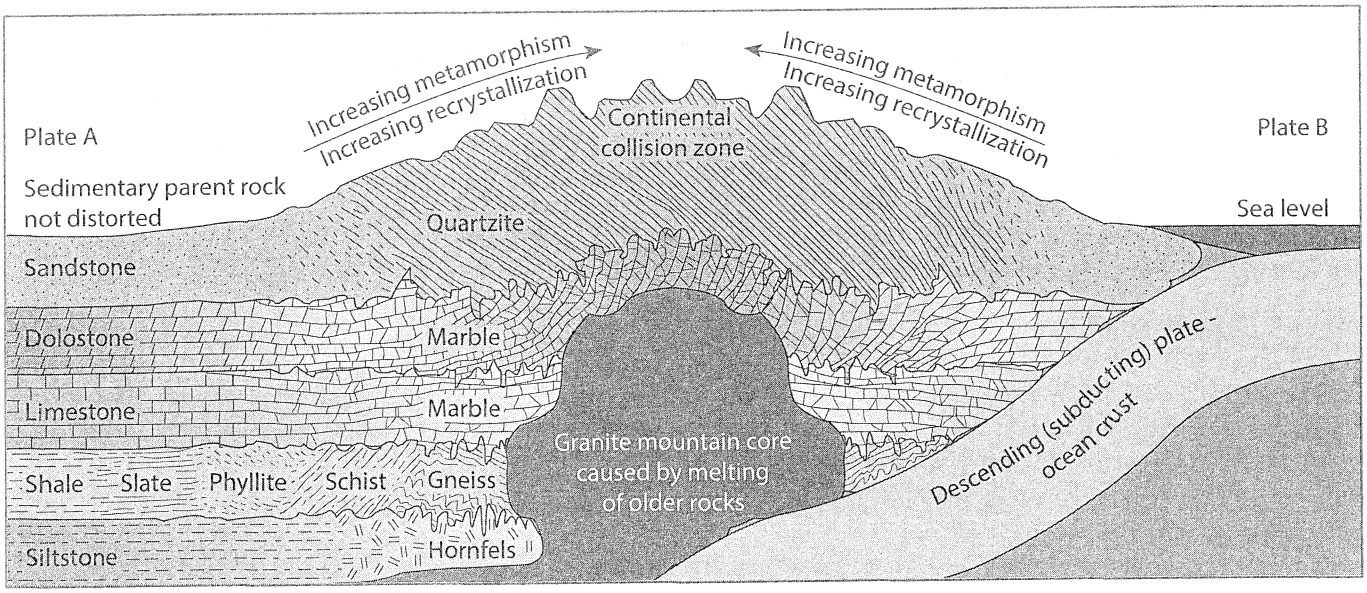


Figure 11-14. Conditions and rocks of regional metamorphism: This extremely ideal view shows two continents that have collided producing a young mountain range. The rocks become increasingly more deformed towards the center of the continents' zone of collision. As heat and pressure increase towards the collision zones, older sedimentary rocks progressively recrystallize into metamorphic rocks. With shale as the parent rock, a series of metamorphic rocks are formed as heat and pressure increases—shale → slate → phyllite → schist → gneiss. In the center of the mountain range, the heat and pressure have become so great that the rocks melted to form a granite intrusion of igneous rock.

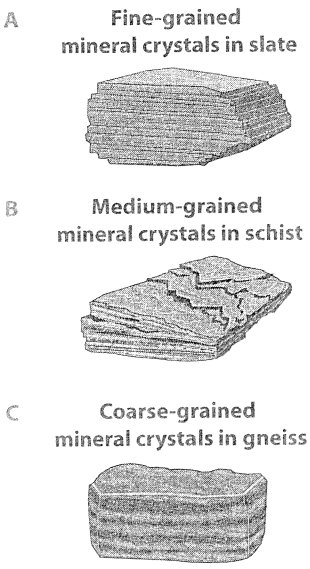


Figure 11-15. Foliation in metamorphic rocks: There are three types of foliations. Metamorphic foliations are very thin in the variety shown in diagram A. The slightly thicker foliations have mineral crystals that are reasonably visible with various minerals blending together in one foliation as in diagram B. Extreme recrystallization in diagram C has resulted in a separation (segregation) of minerals into broad bands of different color-sometimes called banding.

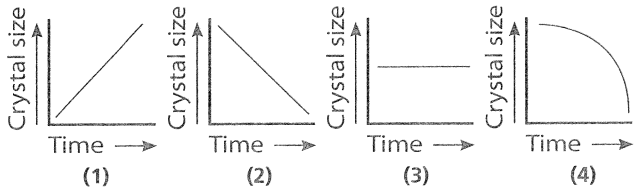
Nonfoliated metamorphic rocks are not layered because the minerals are not flat, or sheet-like, and/or the rocks were not subjected to a directional pressure. These rocks are composed of interconnected mineral crystals. Two single-mineral, crystalline rocks are quartzite, whose parent rock was pure quartz sandstone, and marble, whose parent rock is either limestone or dolostone.

Identification of Metamorphic Rocks Similar to sedimentary and igneous rocks, metamorphic rocks are classified and identified based on composition and texture. If the rock has foliations that are thin, if it breaks into smooth layers, and if the mineral crystals are not easily visible, the rock is slate, or phyllite (if the surface is shiny). If the rock is foliated, the mineral crystals are just clearly visible, and the rock has a high-mica mineral content, then the rock is schist. If the rock has coarse foliations—banded—and the mineral crystals are easy to see and distinguish, then the rock is gneiss. Refer to the Scheme for Metamorphic Rock Identification in the *Earth Science Reference Tables*.

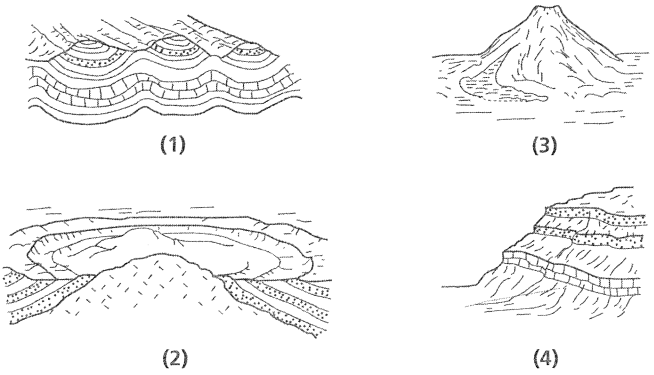
In the nonfoliated metamorphic rocks the composition of the rock is usually the key to identification and classification.

- A rock that looks something like sedimentary conglomerate, but whose crystallized pebbles are stretched out and broken through, is probably a meta-conglomerate.
- A grainy single-mineral rock that easily scratches glass—because the quartz mineral content is much harder than glass—is quartzite.
- Grainy single-mineral metamorphic rocks that don't scratch glass are likely marble.
- Marble will fizz in dilute hydrochloric acid either directly or after powdering depending on if the parent rock is limestone or dolostone.

23. Which graph best shows the relationship between the size of the crystals in an igneous rock and the length of time it has taken the rock to solidify?



24. Which diagram below shows an area in which fine-grained igneous rocks are most likely to be found?



25. The green sand found on the shores of the Hawaiian Island volcanoes most probably consists of the mineral

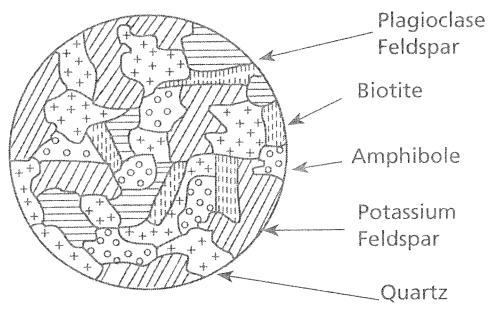
(1) quartz
(2) olivine
(3) biotite mica
(4) potassium feldspar

26. Generally as the percentage of felsic minerals in a rock increases, the rock's color will become

(1) darker and its density will decrease
(2) lighter and its density will increase
(3) darker and its density will increase
(4) lighter and its density will decrease

27. The diagram below represents a cross section of a coarse-grained igneous rock (drawn to true scale). This rock is most likely

(1) rhyolite
(2) scoria
(3) basalt
(4) granite



28. After collecting samples of igneous rocks, a student wishes to classify them as either intrusive or extrusive. Which characteristic of the samples might be the most useful to use?

29. A fine-grained rock has the following mineral composition: 50 percent potassium feldspar (orthoclase), 26 percent quartz, 13 percent plagioclase feldspar, 8 percent biotite mica, and 3 percent of the amphibole hornblende. The rock would most likely be

(1) granite
(2) rhyolite
(3) gabbro
(4) basalt

30. Metamorphic rocks form as the direct result of

(1) precipitation from evaporating water
(2) melting and solidification of magma
(3) erosion and deposition of soil particles
(4) heat and pressure causing changes in existing rock

31. What is the main difference between metamorphic rocks and most other rocks?

(1) Most metamorphic rocks contain only one mineral.
(2) Many metamorphic rocks have an organic composition.
(3) Many metamorphic rocks exhibit foliation and distortion of structure.
(4) Most metamorphic rocks contain a high amount of oxygen and silicon.

32. The regional metamorphism of a sandstone rock will cause the rock

(1) to be melted
(2) to recrystallize into smaller rock fragments
(3) to become denser
(4) to occupy a greater volume

33. Slate is formed by the

(1) deposition of feldspars and micas
(2) foliation of schist
(3) metamorphism of shale
(4) folding and faulting of gneiss

34. Which rock is composed of materials that show the greatest variety of rock origins?

(1) a limestone composed of coral fragments cemented together by calcium carbonate
(2) a conglomerate composed of pebbles of granite, siltstone, and gneiss
(3) a very fine-grained basalt with sharp edges
(4) a sandstone composed of rounded grains of quartz and feldspars

35. What ancient environment is the most likely inferred by the large rock salt deposits in the Syracuse, New York area?

36. Which statement about a large bedrock exposure of granite and gneiss is most likely correct?

(1) a number of volcanoes is nearby
(2) the granite and gneiss are the result of lava flows
(3) the rocks were never under water
(4) a great deal of erosion has taken place at this location

37. Which statement about inorganic rocks is true?

(1) all inorganic rocks are formed from other rocks
(2) all inorganic rocks except igneous rocks are formed from other rocks
(3) all inorganic rocks except metamorphic rocks are formed from other rocks
(4) all inorganic rocks except igneous and metamorphic rocks are formed from other rocks

Mineral Resources

Except for energy from the sun and the few things people might use from meteorites and similar objects, all things that people need come from Earth. These things, such as water to drink, air to breathe, plants to eat and use for lumber, and animals to provide clothing and milk products, are types of natural resources.

Earth materials—including minerals, rocks, and fossils fuels—are grouped together as **mineral resources.** In a lifetime, each person in the United States, on the average, is responsible for the consumption of some $3\frac{1}{2}$ million pounds of minerals, rocks, and mineral fuels that are extracted from the crust of Earth.

New York State has over 2,200 active mines that produce approximately 1.1 billion dollars of non-fuel resources. Of this, about 98% is from cement (made from limestone, gypsum, and shale), construction sand and gravel, crushed stone, salt, and the mineral wollastonite.

Memory Jogger

You may know that an ore is a rock or mineral deposit that can supply enough of a needed material to make it worthwhile to mine or drill for it from Earth's crust. Most minerals are mined to obtain one or more of the chemical elements the mineral contains.

Mineral Resources Are Nonrenewable

Some types of natural resources are renewable—which means they are replaced, or can be replaced, by Earth or sun processes at rates similar to the rates at which humans use them. Renewable natural resources include drinking water, trees, soil, oxygen, fish, and electromagnetic energy from the sun. Mineral resources are nonrenewable natural resources. This means that once the minerals are extracted—by mining or drilling—they are gone and will not be replaced at rates comparable to human life spans. Thus, there is a limited supply of the mineral resources, such as oil, gold, copper ore, sulfur, pure white marble, and other similar resources.

Rock Properties and Humans

Humans often use rocks because of the characteristics of the whole rock. Some examples include the following:

- Slate is impermeable and cleaves along foliations to produce thin flat pieces that can be used for roofing and chalkboards.
- Basalt and diabase resist crushing, so they are used as a base under roads and railroad tracks.
- Coal can burn releasing much heat energy.
- The natural pore space and low density of pumice make it useful for building insulation.
- Granite and quartzite are very resistant to weathering because of their nonporous composition, thus they are used as building stone.

Rock Properties and Land Usage

The type of rock that underlies the landscape of an area has many effects on how people use the land. Some examples follow:

- Limestones and dolostones often weather to produce nonacidic soils which are useful for certain crops; but often, underground water can dissolve these rocks producing caves that collapse forming dangerous depressions called sinkholes.
- Regions having much shale are often low in topography with a rolling landscape of gentle slopes. These topographic features are the result of the fact that shales usually weather and erode easily. This low rolling topography makes it easy to build homes and other human constructions such as roads. The high populations and many transportation facilities of the Hudson-Mohawk Lowlands of eastern New York State are often built on shale.
- Certain rock types withstand tremendous weight without crumbling or flowing under pressure. These types of rocks, such as gneiss and granite, occurring near Earth's surface allow for the safe construction of high-rise buildings, such as in New York City.

Mineral Properties and Humans

The physical properties of a mineral often determine how people use the mineral. Some examples of minerals and their useful properties are listed below:

- Quartz, when put under even minor amounts of pressure, will vibrate in a very regular fashion, which makes it ideal to use in the inexpensive yet very accurate quartz watches.
- Many minerals with a high hardness are used in jewelry and as abrasives in sandpapers and drilling operations. Diamond, corundum (ruby when red and sapphire when blue), the garnets, and quartz (amethyst when purple and citrine when golden yellow) are used in great volumes in the jewelry and abrasive industries. Mines in the Adirondack Mountains of New York State are one of the largest producers of garnet in the world.
- Graphite is soft and has a black streak that makes it very useful as a main ingredient of pencil "lead." The lead is largely graphite, not the element lead.
- Talc is very soft and has one direction of cleavage, which makes it feel smooth or greasy. For these reasons it is used in cosmetics and many baby and foot powders. Portions of the Adirondack Mountains have talc mines.
- Hematite's red color has proven to be useful to humans for many thousands of years. It is the red color of cave paintings, many cosmetics, and most red paints.
- The use(s) of many minerals is listed in the chart "Properties of Common Minerals" in the *Earth Science Reference Tables.* (R)

Global Distribution of Mineral Deposits

Many of the more important elements required by our society are found in ores located outside of the United States. As the population of the United States and the rest of the world continues to grow, demand for the limited

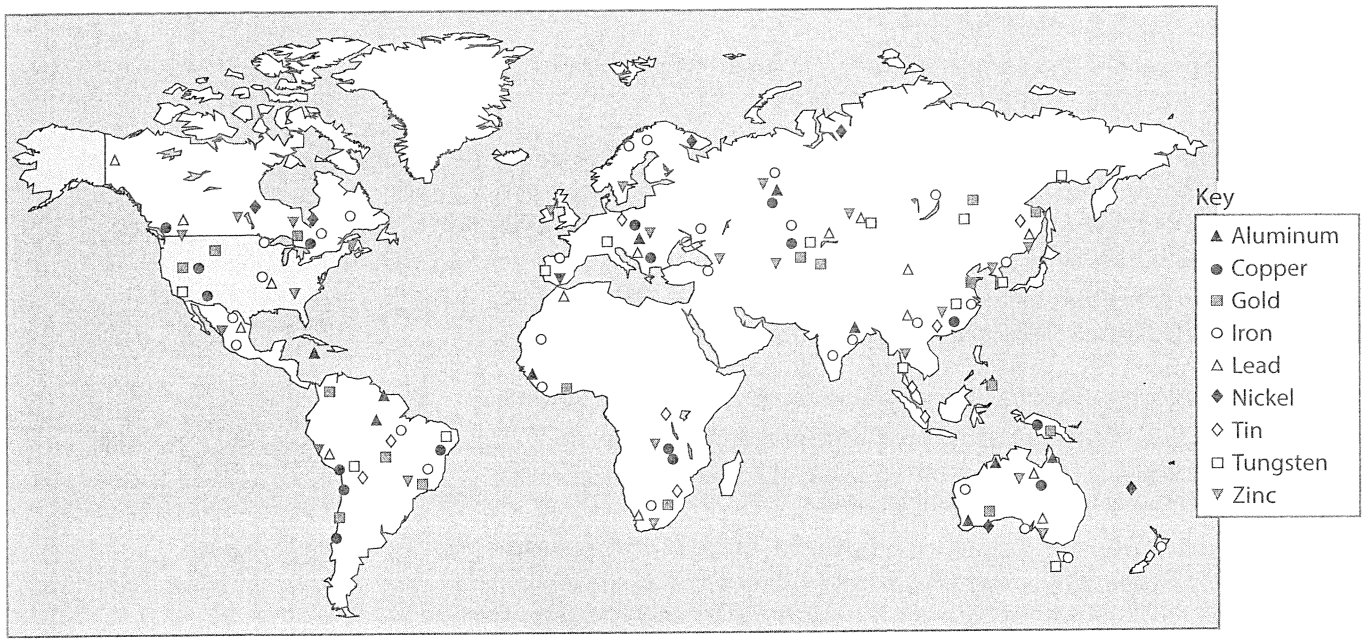


Figure 11-17. Locations of mineral ores of some important chemical elements used in the United States: The map shows that the United States must import much of the rock and mineral sources of aluminum, nickel, tin, tungsten, and zinc.

rock and mineral resources becomes more and more competitive. At present the United States has to import almost 100 percent of the ores for aluminum, tungsten, cobalt, manganese, and graphite—plus over 50 percent of the ores for tin, zinc, nickel, and chromium. These materials are crucial for the production of much of our advanced industrial and military equipment. (See Figure 11-17.)

Fossil Fuels

Fossil fuels—which include oil (or petroleum), natural gas, coal, and oil shale—are the result of compaction and organic chemical changes in large deposits of organic sediments. These sediments are the remains of dead plants and animals.

Figure 11-18A indicates that at present three nonrenewable fossil fuels provide 90 percent of our energy needs. At present the United States can

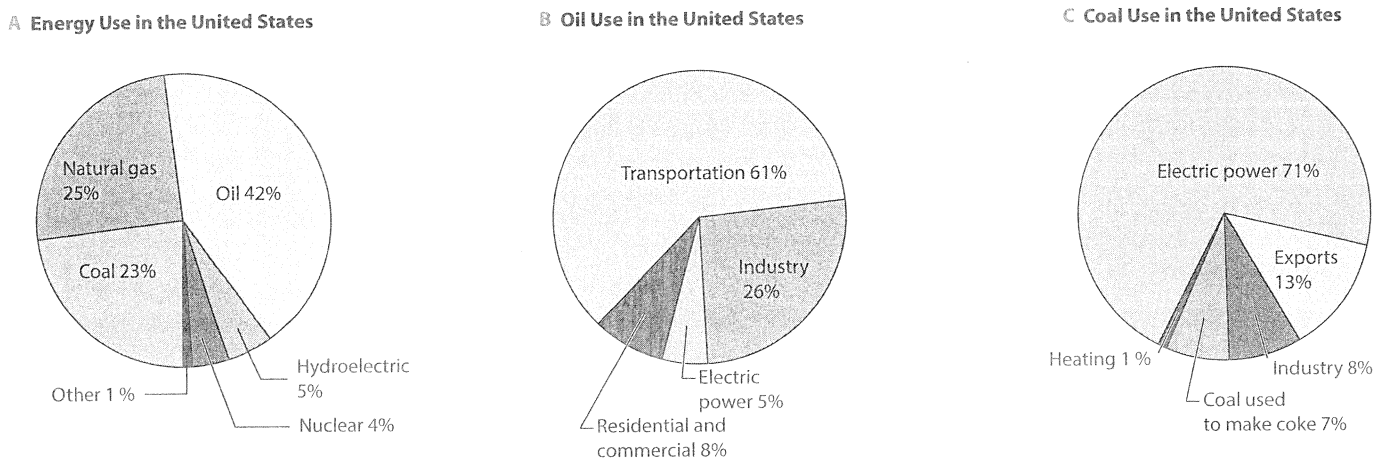


Figure 11-18. Circle graphs of sources of energy and uses of two fossil fuels in the United States.

ide a large proportion of our coal and natural gas demands, though
:eserves are dwindling fast. Almost 60 percent of the oil used in the
ed States is imported. New York State produces small amounts of oil
natural gas, but has no commercial coal deposits. In recent years
· 54 million cubic feet of natural gas and 300,000 barrels of oil
e produced from 13,000 wells in New York State.

Review Questions

. Which geological resource in New York State resulted from glaciation?

(1) oil shale and anthracite coal
(2) sand and gravel deposits
(3) gold and silver ores
(4) calcite and gypsum crystals

). Rocks and minerals are natural resources that are mined in New York State. State *one* negative impact that should be considered before mining these natural resources.

ase your answers to questions 40 through 43 on he following chart. The chart shows information ıbout selected mineral and energy resources.

Group	Mineral Resource	Uses
Elements	Gold	coins, jewelry, investment, electrical conductors, dental fillings
	Copper	electrical wiring, plumbing, coins
	Graphite	lubricants, pencil "lead"
Mineral Compounds	Hematite (ore of iron)	construction, motor vehicles, machinery parts
	Halite	food additive, melting of ice, water softeners, chemicals
	Feldspar	abrasives (sandpaper), jewelry
Fuels	Coal	heating, electric generation plants, plastics and other synthetic chemicals
	Petroleum	automobile fuel, lubricants, plastics and other synthetic chemicals, medicines, heating

40. Name two resources that would last longer if people used public transportation.

41. What is the primary source of all the resources listed in the chart?

(1) recycled and discarded waste materials
(2) deposits within Earth's crust
(3) substances extracted from ocean water
(4) meteorites that came from outer space

42. Which of the minerals listed in the chart does NOT have a metallic luster?

(1) gold
(2) copper
(3) graphite
(4) halite

43. Which of the materials from the chart is NOT a mineral or NOT made of minerals?

(1) copper
(2) hematite
(3) halite
(4) coal

44. Which home-building material is made mostly from the mineral gypsum?

(1) plastic pipes
(2) window glass
(3) drywall panels
(4) iron nails

45. Which statement about the minerals plagioclase feldspar, gypsum, biotite mica, and talc can best be inferred?

(1) These minerals have the same chemical and physical properties.
(2) These minerals have different chemical properties, but they have similar physical properties.
(3) These minerals have different physical and chemical properties, but they have identical uses.
(4) The physical and chemical properties of these minerals determine how humans use them.

46. Which of the minerals listed below contain only one element?

(1) graphite
(2) hematite
(3) halite
(4) garnet

47. Wood and coal are both organic natural resources. Explain why coal is considered a fossil fuel, while wood is not.

Directions

Review the Test-Taking Strategies section of this book. Then answer the following questions. Read each question carefully and answer with a correct choice or response.

Part A

1 Which of the following pairs of rocks usually contains only one mineral?
(1) rock gypsum and marble
(2) sandstone and conglomerate
(3) quartzite and schist
(4) dunite and gabbro

2 Which of the following properties is most useful in mineral identification?
(1) hardness
(2) color
(3) size
(4) texture

3 Which property of minerals is illustrated by the peeling of biotite mica into thin flat sheets?
(1) fracture
(2) cleavage
(3) a low hardness
(4) a weak streak

4 The main difference between sedimentary, metamorphic, and igneous rocks is the
(1) means by which they are located
(2) conditions under which they are formed
(3) minerals of which they are composed
(4) location in which they are found

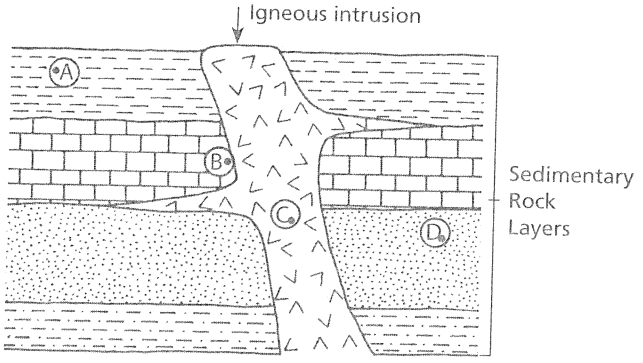
5 Which rock was formed by the compaction and cementation of particles 0.07 centimeters in diameter?
(1) conglomerate
(2) sandstone
(3) shale
(4) siltstone

6 Dolostone and rock gypsum are formed by the processes of
(1) melting and solidification
(2) evaporation and precipitation
(3) erosion and deposition of clastic fragments
(4) weathering and metamorphism

7 Which would most likely cause molten rock material to become glassy igneous rock?
(1) cooling over a long period of time
(2) cooling under high pressure
(3) cooling on Earth's surface
(4) cooling at great depth within the crust

8 An igneous rock, which has crystallized deep below Earth's surface, has the following approximate composition: 70 percent pyroxene (augite), 15 percent plagioclase feldspar, and 15 percent olivine. What is the name of this igneous rock?
(1) granite
(2) rhyolite
(3) gabbro
(4) basalt

Use the following diagram to answer questions 9 and 10. The diagram shows an igneous rock intrusion in sedimentary rock layers.

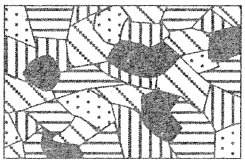


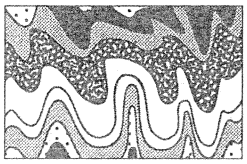
9 At which point would there most likely be contact metamorphic rock?
(1) A
(2) B
(3) C
(4) D

10 Which rock type would most likely be located at the contact between rocks C and D?
(1) metaconglomerate
(2) gneiss
(3) marble
(4) quartzite

11 In which parts of New York State would you most likely find large amounts of bedrock formed by regional metamorphism?
(1) Atlantic Coastal Plain and Newark Lowlands
(2) Hudson Highlands and Adirondack Mountains
(3) Tug Hill Plateau and Allegheny Plateau
(4) Erie-Ontario Lowlands and the Catskills

12 Which actual-size diagram best represents a sample of the metamorphic rock gneiss?


(1)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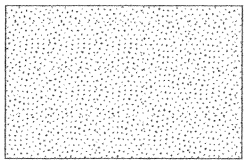
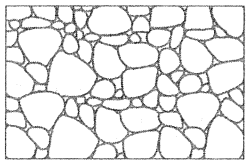

(2)


(4)

13 Which type(s) of rock can be the source of deposited sediments?
(1) igneous and metamorphic rocks, only
(2) metamorphic and sedimentary rocks, only
(3) sedimentary rocks, only
(4) igneous, metamorphic, and sedimentary rocks

14 A certain igneous rock is composed of large mineral grains. This suggests that the rock formed
(1) on the surface, under high pressure, and at a rapid rate of cooling
(2) on the surface at high temperature, and at a slow rate of cooling
(3) deep underground under high pressure, at high temperature, and at a rapid rate of cooling
(4) deep underground under high pressure, at high temperature, and at a slow rate of cooling

15 Which characteristic would indicate that a rock was formed from sediments deposited in shallow water near shore rather than in deep water?
(1) hardness
(2) dark color
(3) a large grain size
(4) a large amount of cement

Part B

Base your answers to questions 16 and 17 on the diagram below and the *Earth Science Reference Tables*. The diagram shows the elements found in four minerals.

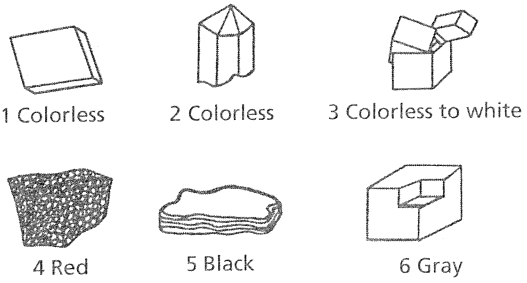
	O	Si	Al	Fe	Ca	Na	C
Quartz	■	■					
Feldspar	■	■	■		■	■	
Olivine	■	■		■	■		
Diamond							■

■ = element present

16 Which of the minerals in the diagram has the greatest variety of elements in it? [1]

17 Which of the elements listed in the diagram is second in abundance, by mass, in Earth's crust? [1]

Follow these directions for questions 18 through 23. The following numbered diagrams represent mineral specimens. Using these diagrams, write the name of the mineral which is best described by each of the statements. (If a mineral has cleavage, the diagram illustrates it.)



1 Colorless 2 Colorless 3 Colorless to white

4 Red 5 Black 6 Gray

18 Diagram 1 is a mineral that easily bubbles when exposed to dilute acids. [1]

19 Diagram 2 is a very hard mineral that has a curved fracture. [1]

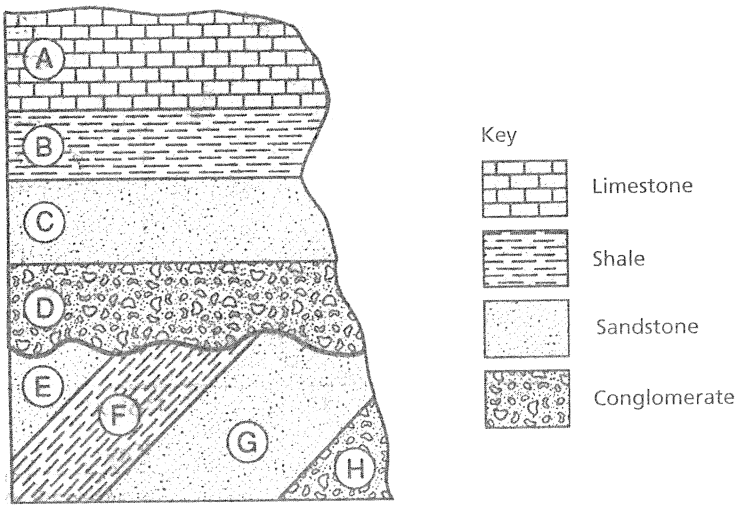
20 Diagram 3 shows intergrown crystals of this salty tasting mineral. [1]

21 Diagram 4 is an ore of iron with a red streak. [1]

22 Diagram 5 is a soft mineral with cleavage that forms thin flexible sheets. [1]

23 Diagram 6 is an ore of lead that is soft and has a metallic luster. [1]

Base your answers to questions 24 through 28 on the following diagram. The diagram represents a profile view of exposed rock layers. The layers are labeled A through H.



24 State the range of particle sizes of the sediments that formed rock layer C. [1]

25 State two ways in which the composition of rock layer A differs from the composition of rock layer B. [2]

26 State a method by which rock layer A could have formed. [1]

27 Based on information in the diagram, state a reason why you would choose to use rock from layer A instead of rock from layers C or D for a tombstone or statue. [1]

28 State the name of the sediment that was compacted to form rock unit B. [1]

---

29 Describe two conditions that can result in the metamorphosis of a rock. [2]

30 If an igneous rock layer is composed of vesicular andesite, identify three types of minerals that could be found in sand weathered from the rock layer. [1]

40 The mineral wollastonite forms during the intense metamorphism of a sandy limestone. The expression below shows part of the process that results in the formation of wollastonite.

Metamorphism

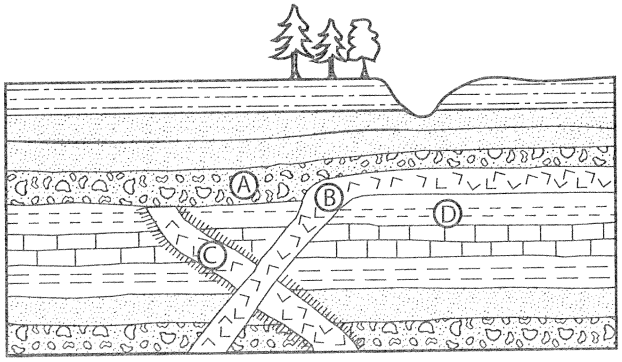
$$CaCO_3 + SiO_2 \rightarrow CaSiO_2 + CO_2$$

Mineral 1 Mineral 2 Wollastonite Carbon dioxide

a Name the *two* minerals involved in the formation of wollastonite. [1]

b What *two* conditions normally cause intense metamorphism? [1]

Base your answers to questions 41 through 43 on the cross-section below which represents a portion of the Earth's crust. Letters A, B, C, and D are rock units.



Key

Igneous rock

Contact metamorphism (transition zone)

41 Igneous rock *B* was formed after rock layer *D* was deposited but before rock layer *A* was deposited. Using the contact metamorphism symbol shown in the key, draw that symbol in the proper locations on the cross section above to indicate those rocks that underwent contact metamorphism when igneous rock *B* was molten. [1]

42 In relation to rock units *A* and *B* in the cross section, when was igneous rock *C* formed? [1]

43 Describe one observable characteristic of rock *A* that indicates that rock *A* is sedimentary. [1]

Base your answers to questions 44 through 46 on the passage below.

Carbon

Carbon may be the most important element on our planet because it is the chemical building block of all living things. The element carbon is formed in dying stars and scattered when the stars explode. Our solar system formed from such star remnants. Pure carbon comes in several forms, which include the minerals graphite and diamond (hardness = 10), and the fossil fuels bituminous coal and anthracite coal. Almost all diamonds are mined from igneous rocks that originate at an approximate depth of 150 kilometers under immense pressure. Most graphite is formed through the metamorphism of organic material in rocks closer to Earth's surface.

44 Identify two uses for the mineral graphite. [1]

45 Explain why graphite and diamond have different properties. [1]

46 Complete the table below to show the properties of the minerals diamond and graphite. [1]

Property	Diamond	Graphite
color	variable	
luster	nonmetallic	
hardness		

Part C

The following paragraph provides information about a meteorite impact in New York State. Use data from the paragraph and your knowledge of earth science to answer questions 31 through 34.

Recently a New York State Geological Survey geologist has produced much evidence indicating a large meteorite impact crater in the Catskills of New York State. This supposed crater that formed approximately 375,000,000 years ago is now buried by hundreds of feet of horizontal sedimentary rock. By drilling beneath the surface sedimentary rock, samples of various rock types have been brought up from in and around the crater.

31 Suppose that the meteorite impact produced enough heat to melt much of the meteorite and parts of Earth's surface at the impact site. Describe the type of rock and its texture that would form from the melted meteorite and Earth rocks. [2]

32 Further out from the center of the crater, the meteorite impact caused high temperatures and very high pressure, but the temperatures were not high enough to melt the rocks. What type of rock would form in this environment? [1]

33 At the time of the impact, solid angular rock fragments, mostly larger than sand grains, were hurled far out from the crater. Describe how these fragments could form a sedimentary rock and suggest the most likely name of this sedimentary rock. [2]

34 State the geologic eon, era, and period when this supposed impact crater was formed. [2]

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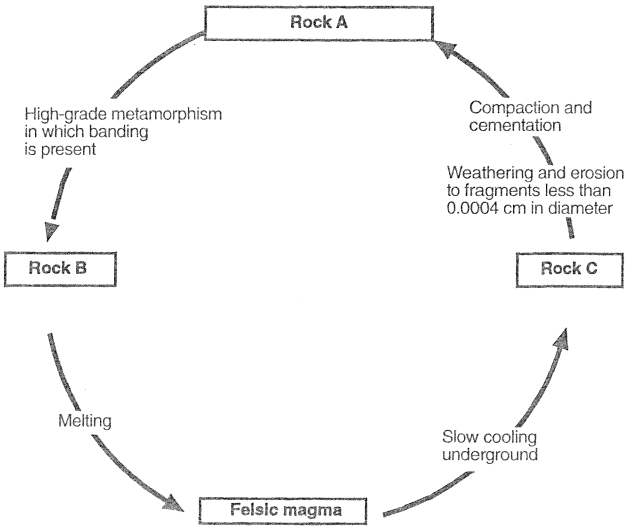
35 You observe that a sample of mineral has many smooth sides or surfaces. The sample has not been cut, sanded, or otherwise smoothed by people. Describe two ways in which the parallel smooth sides of the mineral specimen were most likely formed. Then describe an experiment that could help you determine which of the two ways formed the smooth sides on this mineral specimen. [3]

36 Two students were given nearly identical samples of the same mineral and were asked to identify the mineral. Student A said the mineral was graphite because it had a silver color and had a low hardness. Student B said the mineral was hematite because of its silver color and low hardness. Describe two mineral tests that could be used to determine the correct identification of the mineral. [2]

Base your answers to questions 37 and 38 on the rock cycle diagram below.



37 State the specific names of rocks *A*, *B*, and *C* in the diagram. Do *not* write the terms "sedimentary," "igneous," and "metamorphic." [3]

38 State *one* condition or process that would cause the high-grade metamorphism of rock *A*. [1]

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39 A family wants to use rock materials as flooring in the entrance of their new house. They have narrowed their choice to granite or marble. Which of these rocks is more resistant to the physical wear of foot traffic and explain why this rock is more resistant. [2]