

Answers to Section E: Earth Materials (Metamorphic Rocks and Processes)

1. Relate the types and characteristics of metamorphic rocks to parent rock, temperature, pressure, and chemical conditions

The metamorphic changes in a rock depend on the mineral composition of the parent rock, and on the temperature and pressure to which the rock is subjected. As the temperature increases minerals become unstable and break down to form new minerals. As the pressure increases the texture of the rock becomes more compact and dense, and mineral grains can become aligned parallel to each other, which is perpendicular to the directed stress. As pressure increases minerals grow in size. The chemical conditions of a rock can be altered by the presence of hot water that migrates through pores. The hot water can take away or add new elements.

2. Describe the features of the following metamorphic rocks: slate, phyllite, schist, gneiss, metaconglomerate (stretched pebble), quartzite, marble.

| | |
|--|---|
| Slate | <i>Parent rock is shale. Mineral grains are too small to be seen unaided. Foliated rock; mica lines up.</i> |
| Phyllite | <i>Progressively more metamorphism than slate. Mineral grains are very small. Foliated rock; mica lines up.</i> |
| Schist | <i>Further metamorphism than phyllite. Visible mineral grains. Foliated rock; mica lines up more.</i> |
| Gneiss | <i>Strongest metamorphism. Large visible grains. Foliated rock. Compositional banding.</i> |
| Metaconglomerate (stretched pebble) | <i>Formed when sedimentary rock conglomerate undergoes directed stress and metamorphism.</i> |
| quartzite | <i>Metamorphism of quartz-rich sandstone. Non-foliated. Crystals look shinier and flatter. Quartz grains grow together.</i> |
| marble | <i>Metamorphism of calcite rich limestone. Non-foliated. Will fizz with hydrochloric acid.</i> |

3. Contrast the two major categories of metamorphic rocks: foliated and non-foliated
Foliated metamorphic rocks are those rocks that show a parallel alignment of mineral grains. Foliated rocks are layered like sheets of paper, each mineral takes up a new layer. Non-foliated rocks comprise mostly of one mineral and show non-layering.
4. Contrast the two types of metamorphism: contact and regional
Contact metamorphism refers to a magma intrusion that comes into contact with the surrounding country rock and alters the rock due to its heat. The adjacent rocks will be metamorphosed. It is a local phenomenon. Because contact metamorphism commonly occurs without deformation or any stress, the rocks are non-foliated (i.e. quartzite and marble.)

Regional metamorphism affects broad areas of the crust, usually due to tectonic activity and mountain building. Rocks affected by regional metamorphism will be subjected to a lot of directed stress. The rocks will be foliated (i.e. slate, phyllite, schist.)

5. Describe changes that occur in the country rock and in the intrusion at a contact
The country rock that comes into contact with an intrusion will be altered; the rock closest to the intrusion will be altered the most. Higher temperature metamorphic minerals will be found next to the intrusion and lower temperature metamorphic minerals will be found further away. The intrusion will cool more quickly at the boundary and will have smaller crystals than those further from the boundary.

6. Relate metamorphic rock type to the concept of metamorphic grade
Shale(sedimentary) is the parent rock of slate(metamorphic.) When shale undergoes some heat and pressure it metamorphoses into slate. Slate is a low-grade metamorphic rock. If more temperature and pressure is applied the rock becomes phyllite. More temperature and pressure results in a rock called schist; the most amount of temperature and pressure before the rock melts results in a rock called gneiss.

shale \Rightarrow slate \Rightarrow phyllite \Rightarrow schist \Rightarrow gneiss
parent rock low grade \Rightarrow high grade

7. What are the most distinguishing features of a metamorphic rock compared with those of an igneous rock or sedimentary rock?

Many metamorphic rocks show foliation; the mineral grains are arranged in parallel and show a layering. Non-foliated rocks are comprised of mostly one mineral. In all metamorphic rocks the mineral grains look flattened and squashed. Metamorphic rocks are rather sparkly and dense.

8. What kinds of changes occur in a rock as it is metamorphosed?

*The **texture** of a rock can change because as the rock is metamorphosed the mineral grains grow and their shapes change. A layered texture will arise when a rock is subjected to both increased temperature and deformation called foliation.*

*The **mineral composition** of the rock can also change because there is sufficient heat to allow atoms to recombine to form new minerals.*

9. Why are fossils less likely to be found in metamorphic rocks than in the rocks from which they were derived?

Many fossils would be deformed or destroyed during the process of metamorphism.

10. Which of the following factors involved in metamorphism is likely to produce strong foliation in a metamorphic rock?

- a) Increased directed stress
- b) Increased confining pressure
- c) Presence on hot fluids passing through the rock
- d) Increased temperature

11. Which of the following causes a chilled margin of fine-grained igneous material to be found at the edges of plutons?

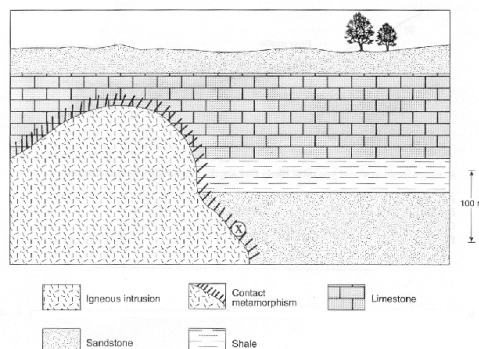
- a) Rapid cooling
- b) Partial melting
- c) Contact metamorphism
- d) Fractional crystallization

When hot magma intrudes much cooler country rock, the melt near the contacts is rapidly cooled. The result is a chilled margin recognizable because the rock near the margin is finer grained than the interior of the

Use the following diagram to answer question #12

12. Which of the following rocks would you expect to find at location X in the diagram?

- a) Chert
- b) Schist
- c) Marble
- ☐ d) Quartzite



Use the following sketch of the texture of a metamorphic rock to answer question 13.



13. Which directions of maximum compressive stress **most likely** caused the alignment of the elongate crystals in the metamorphic rock?

a) $\Rightarrow \Leftarrow$

b) $\Leftarrow \Rightarrow$

Mineral grains grow at right angles to the directed stress.

c) $\Uparrow \Downarrow$

d) $\Downarrow \Uparrow$

14. Which of the following pairs shows the correct relationship between a metamorphic rock and its parent rock?

| | Parent Rock | Metamorphic Rock |
|----|-------------|------------------|
| a) | shale | quartzite |
| b) | limestone | marble |
| c) | gypsum | phyllite |
| d) | sandstone | slate |

15. Which of the following would be an **unlikely** result of regional metamorphism?

- ☐ a) Greater rock porosity
- b) Formation of foliation
- c) Increased rock density
- d) Formation of a new mineral

Metamorphism squeezes the rock, which decreases the pore space between the minerals.

16. Contact metamorphism leads to nonfoliated rock types because the

- a) temperature is not high enough
- b) mineralogy is not correct
- ☐ c) pressure is not sufficient
- d) water content is not high enough

17. In a rock, metamorphism increases the
- a) volume
 - ☒ b) density
 - c) porosity
 - d) solubility
18. Which of the following rocks represents the highest degree of metamorphism?
- a) Shale
 - b) Phyllite
 - c) Slate
 - ☒ d) Schist
19. The chemical compositions of metamorphic rocks depend on the
- a) temperature to which they have been raised
 - b) pressures to which they have been subjected
 - c) effects of both pressure and temperature
 - ☒ d) composition of the original rock
20. The most likely result of the metamorphism of granite is
- a) marble
 - b) slate
 - ☒ c) gneiss
 - d) quartzite
21. In comparison with slates, schists have
- a) a deeper colour
 - b) a lower mica content
 - ☒ c) larger crystals
 - d) no foliation
22. In which type of metamorphic rock are fossils most likely to be preserved?
- ☒ a) Slate
 - b) Schist
 - c) Gneiss
 - d) Phyllite

All other rock types have a greater degree of metamorphism. The fossil will likely be destroyed.