Dynamic Earth Study Guide

Chapter 8, 10, 12, 16, 17, 19, 23

Chapter 8

Review Questions

1. How are metamorphic rocks different from igneous and sedimentary rocks?
    a. **A metamorphic rock is one that forms when a preexisting rock (Protolith) undergoes a solid state change (Metamorphism). It does NOT form by solidification. Igneous rock is formed through the cooling and solidification of magma or lava. Sedimentary rocks are types of rock that are formed by the deposition of material at the Earth's surface and within bodies of water. Sedimentation is the collective name for processes that cause mineral and/or organic particles (detritus) to settle and accumulate or minerals to precipitate from a solution.**
2. What two features characterize most metamorphic rocks?
    a. **First, it can possess metamorphic minerals. Second, metamorphic rocks can have a metamorphic texture.**
3. What phenomena cause metamorphism?
    a. **Change in temperature and/or pressure as hydrothermal fluids pass through rock, or in response to squeezing, shear, and shock.**
4. What is metamorphic foliation, and how does it form
    a. **Metamorphic foliation is the parallel alignment of platy material and/or the presence of alternating light-colored and dark layers. Foliated metamorphic rocks are formed from a multi-mineral, mica-rich rock that is subjected to progressively greater heat and direct pressure.**
5. How is a slate different from a phyllite? How does a phyllite differ from schist? How does schist differ from gneiss?
    a. **A slate is formed from the metamorphism of mudstone or shale. Contains slaty cleavage foliation by recrystallization (look like roofing shingles): Finest-grained.**
    b. **A phyllite is caused by a foliation of fine grained mica by neocrystallization: Fine grained.**
    c. **A schist possesses a type of foliation called schistosity defined by the preferred orientation of large mica flakes. (Medium grained).**
    d. **Gneiss is composed of alternating dark colored and light colored layers of metamorphic rock, predominantly felsic minerals for the light layers and mafic materials for the dark layers.**
6. How does prograde metamorphism differ from retrograde metamorphism?

a. **Prograde metamorphism is when a rock gets buried progressively deeper and the temperature and pressure increases. Retrograde is when the rock moves back towards the Earth's surface.**

7. Describe the geologic settings where thermal and dynamic metamorphism takes place.

   a. **Thermal metamorphism develops where there is heat without a change in pressure and without differential stress. Dynamic metamorphism takes place anywhere that faulting occurs at the depth in the crust.**

8. Why does metamorphism happen at the site of meteor impacts and along mid-ocean ridges?

   a. **Hot magma rises beneath the axis of mid ocean ridges, so when the cold-water sinks through the cracks down into the oceanic crust along ridges, it heats up and transforms into hydrothermal fluid, causing hydrothermal metamorphism. When meteorites slam into the Earth, a vast amount of kinetic energy instantly transforms into heat. This heat may be enough to melt and transform rock, causing shock metamorphism.**

9. How does plate tectonics explain the peculiar combination of low-temperature but high-pressure minerals found in a blue schist?

   a. **Shearing along plate boundaries causes dynamic metamorphism; and igneous plutons in rifts cause thermal metamorphism. Unusual metamorphic rocks called blueschists form at the base of accretionary prisms.**

10. Where would you go if you wanted to find exposed metamorphic rocks? How did such rocks return to the surface of the Earth after being at depth in the crust?

    a. **You would go to an outcrop which is caused by exhumation: When two continents push against each other, cause the rock to be squeezed upward, then the mountain range grows, making the rock softer, and finally erosion, weathering, landslides and river flows take place at the surface.**

Key Terms

- ***Burial Metamorphism:*** Causes the organic molecules of oil to break up; for this reason oil drillers stop drilling when the bottom of the hole reaches depths at which burial metamorphism has begun.
- ***Contact Metamorphism:*** See Thermal Metamorphism
- ***Differential Stress:*** When a material is squeezed or stressed *unequally* from different sides. The push or pull in one direction differs in magnitude from the push or pull in another direction. Two kinds:
  - Normal Stress: Pushes or pull perpendicular to the surface. We can the push compression, and the pull tension. Compression flattens a material and tension stretches a material
  - Shear Stress: or shear moves one part of a material sideways, relative to another. For example, you place a deck of cards on a table, then set your hand on top of the deck and move your hand parallel to the table you shear the deck.
- ***Dynamic Metamorphism:*** At greater depths, rock is so warm that is behaves like soft plastic as shear in the rock recrystallize. This occurs as a consequence of shearing alone under metamorphic conditions, without requiring a change in foliation that roughly parallels the fault.

- ***Dynamothermal Metamorphism:*** Metamorphism that occurs as a consequence of shearing alone, with no change in temperature or pressure.
- ***Exhumation***: The process that returns deeply buried rocks to the surface.
- ***Foliation:*** Refers to an assemblage of parallel planar surfaces and or layers in a metamorphic rock. It gies metamorphic rocks a striped or streaked appearance in an outcrop, and/or gives them the ability to splits into thin sheets.
- ***Gneiss:*** Is a compositionally layered metamorphic rock. Typically composed of alternating dark colored and light colored layers that range in thickness from millimeters to meters. This is formed at high temperatures, however, does not contain mica, because at high temperatures, mica react to form other minerals. Gneissic banding can also form when the protolith undergoes an extreme amount of shearing under conditions in which the rock can flow like soft plastic.
- ***Hornfels***: This is a fine-grained nonfoliated rock that contains a variety of metamorphic minerals. The specific minerals assemblage in a hornfels depends on the composition of the protolith and on the temperature and pressure of metamorphism.
- ***Index Mineral:*** The presence of certain minerals in a rock indicates the approximate metamorphic grade of the rock. The line on a map along which this mineral first appears is called an isograd.
- ***Marble:*** This is created from the metamorphism of limestone. During the formation, calcite composing the protolith recrystallizes, so fossil shells, pore space, and the distinction between grains and cement disappear. Typically consists of a fairly uniform mass of interlocking calcite crystals.
- ***Metaconglomerate:*** Under the metamorphic conditions that produce slate or phyllite, a protolith of conglomerate becomes this. Specifically, the pressure solution and plastic deformation flatten pebbles and cobbles into pancake like shapes. The alignment of inequant clasts defines a foliation.
- ***Metamorphic aureole:*** Distinct belt of metamorphic rock that forms around an igneous intrusion, or contact aureole.
- ***Metamorphic Facies***: These are a set of metamorphic mineral assemblages indicative of a certain range of pressure and temperature. Each specific assemblage in a facies reflects a specific protolith composition.
- ***Metamorphic Foliation:*** The metamorphic texture results in this and is defined by the parallel alignment of platy minerals (like mica) and/or the presence of alternating light-colored and dark-colored layers.
- ***Metamorphic Grade:*** In a somewhat informal way to indicate the intensity of metamorphism, meaning the amount or degree of metamorphic change. Classification of metamorphic grade depends primarily on temperature, because temperature plays the dominant role in determining the extent of recrystallization and neocrystallization during metamorphism.
- ***Metamorphic Minerals:*** New Minerals that grow in place within the solid rock only under metamorphic temperatures and pressures.
- ***Metamorphic Rock:*** It's a preexisting rock, or protolith, undergoes a solid-state change in response to the modification of its environment.
- ***Metamorphic Texture:*** Metamorphic rocks can have this and it is defined by the arrangement of mineral grains.