GLG 101 – CHAPTER 8 - METAMORPHIC ROCKS

- **Metamorphism** is the change in form from one rock type to another, in the solid state (i.e., without melting).
- **Metamorphism** causes a re-crystallization and change from minerals that are out of equilibrium to minerals that are in equilibrium with temperature and pressure conditions. **Crystal size generally increases** with increasing levels of metamorphism.
- There are three **agents** of metamorphism: heat**, pressure,** and **chemically active fluids**.
- Heat is the main metamorphic agent in **contact metamorphism**. Contact metamorphism occurs locally in an **aureole** adjacent to cooling magma bodies, where the **country rocks** around the intrusion are baked and altered.
- Contact metamorphic rocks have a crystalline, **non-foliated** (i.e., non-layered) texture.
- The pre-existing rock that is to be metamorphosed is called the **protolith**. **Limestone** is the protolith for the metamorphic rock **marble**. **Quartz sandstone** is the protolith for the metamorphic rock **quartzite**.
- Pressure is the main metamorphic agent in **regional metamorphism**. The increased pressure associated with deep burial of sediments or sedimentary rocks, particularly along **convergent** plate boundaries, where there is greatly increased pressure produced by the colliding plates, can produce extensive (1000s of km long and 100s of km wide) belts of metamorphic rocks along and adjacent to the major mountain belts of the world.
- The pressure in regional metamorphism will gradually align the minerals in these rocks to form a layered or **foliated** texture. The protolith **shale** will be transformed into the metamorphic rock **slate**, in which the pre-existing clay grains will be aligned **perpendicular to** the direction of maximum compression. Clay grains will be transformed into **mica** crystals, which will retain this alignment and grow with increased pressure and time.
- Increasing **metamorphic grade** in regional metamorphism can be seen as mica crystals grow to become visible to the naked eye, and the **foliation** of the rocks becomes coarser. Shale will be transformed into **slate, phyllite,** and **schist** with increased metamorphic grade. At the **highest metamorphic grade**, micas will become unstable and quartz, feldspars and amphibole will crystallize in segregated layers. This light (quartz and feldspars) and dark (amphibole) layered foliated rock is called **gneiss**.
- When temperature increases so that metamorphic rocks begin to melt, but don't melt completely, a rock with both igneous and metamorphic textures, called a **migmatite**, can form. This rock looks like a swirly version of a gneiss.
- Because particular minerals form only under very specific temperature and pressure conditions, geologists can use the presence of such minerals (e.g., garnets) to determine the past conditions experienced by rocks during metamorphism. This makes it possible to see evidence for long-erased convergent plate boundaries, where the mountains themselves have been completely eroded away.
- Hot fluids (primarily water) expelled during the final phases of crystallization of magma bodies will be extremely chemically active. This active water will rise through fractures toward the Earth's surface. Chemical reactions and metamorphism of a type called **metasomatism** will occur in the country rock adjacent to these fractures. Economically important metallic ores often form in this way, as dissolved metal ions are concentrated and crystallized along fracture zones above magma bodies. The major copper deposits in Arizona, called copper porphyry deposits, were primarily formed in this way.
- Small amounts of shattered (near the surface) or stretched (at greater depths) metamorphic rocks can also be formed locally along faults due to the extreme stresses there. These relatively uncommon rocks (uncommon because active faults occupy a very small volume of the crust) are called **cataclastic** metamorphic rocks.