METAMORPHIC ROCKS

INTRODUCTION

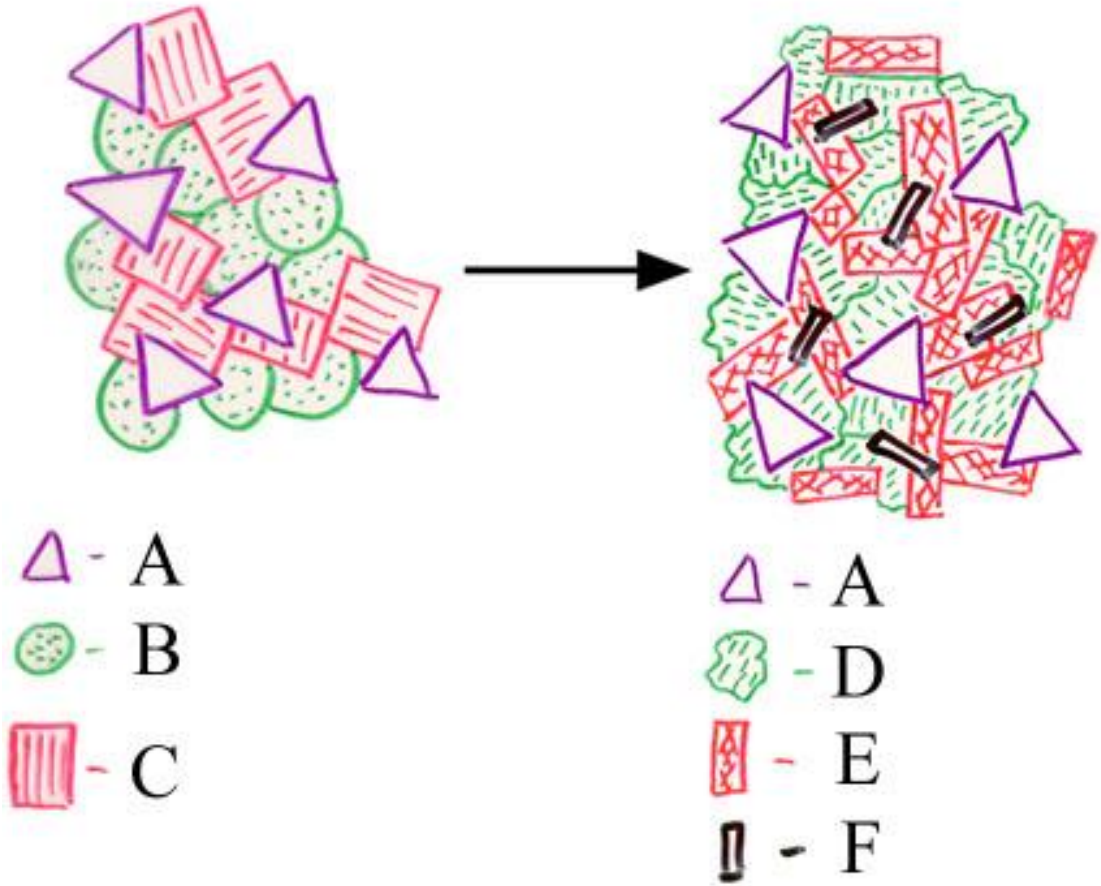
- Metamorphic rocks are those whose original texture, composition and mineralogy have been changed by conditions of high pressure and temperature (higher than conditions of formation of starting material).
- The materials from which metamorphic rocks form are igneous rocks, sedimentary rocks, and previously existing metamorphic rocks. Mineralogical and textural changes during metamorphism occur essentially in the solid state. Metamorphic rocks form when the precursor materials (igneous, sediment, etc.) are buried deeply and are consequently brought into an environment of high pressure and temperature.
- The type of metamorphic rock produced depends on the original rock material that was metamorphosed and the temperature and pressure conditions which were imposed.

METAMORPHIC PROCESS

- Metamorphism of rocks (meta=change, morphs=form; example: caterpillar to butterfly) manifests itself in a series of changes in texture and composition (mineral composition mainly) that are the result of readjustment to new environmental conditions (P & T). Readjustment occurs because the new conditions (e.g. increased pressure and temperatures upon burial in a sedimentary basin) render the original set of rock components (minerals and pore fluids) unstable. A new set of minerals (or mineral assemblage) will form that is stable under the new conditions.

- Schematic depiction of a **metamorphic change of mineral assemblage.** The initial rock (at left) consists of minerals A, B, and C that are stable under the initial conditions. Upon heating and burial minerals B and C become unstable and react to form a new set of minerals, D, E, and F, that are stable under the new conditions. Mineral A is stable over a wide range of conditions and did not change. The rock looks now mineralogically and texturally very different from before.

B+C=D+E+F



CONTROLLING PARAMETERS

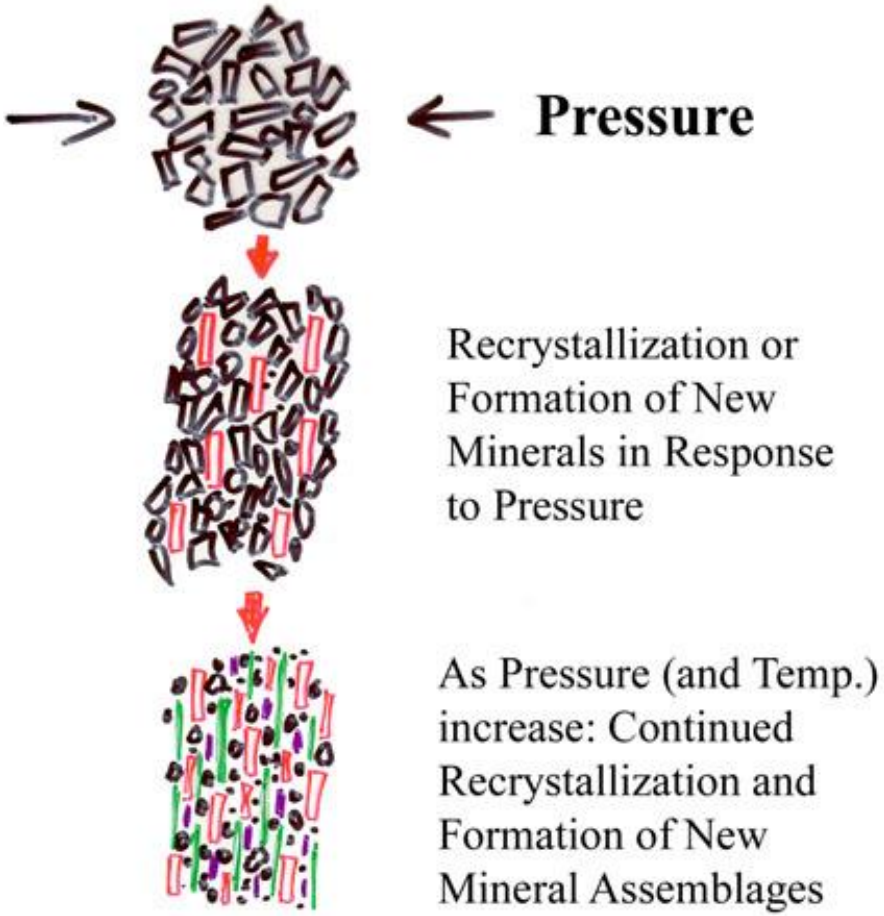
- Temperature
- Pressure
- Chemical Composition

INFLUENCE OF TEMPERATURE

- With rising temperature water that is contained in minerals (crystal water) will be expelled into the pore spaces, fractures and crystal boundaries. As the pore fluid content increases, chemical changes mediated through the pore fluids will speed up as well. The rate of diffusion also increases with temperature. Thus, new mineral assemblages will appear faster than at lower temperatures. At temperatures below 200 degrees Celsius, chemical changes proceed so very slow that essentially no changes occur within geologically significant time spans. At temperatures of about 700 to 800 degrees Celsius we approach eutectic conditions for most rocks of the continental crust, and a vapor-rich (water, possibly CO_2) partial melt will form.

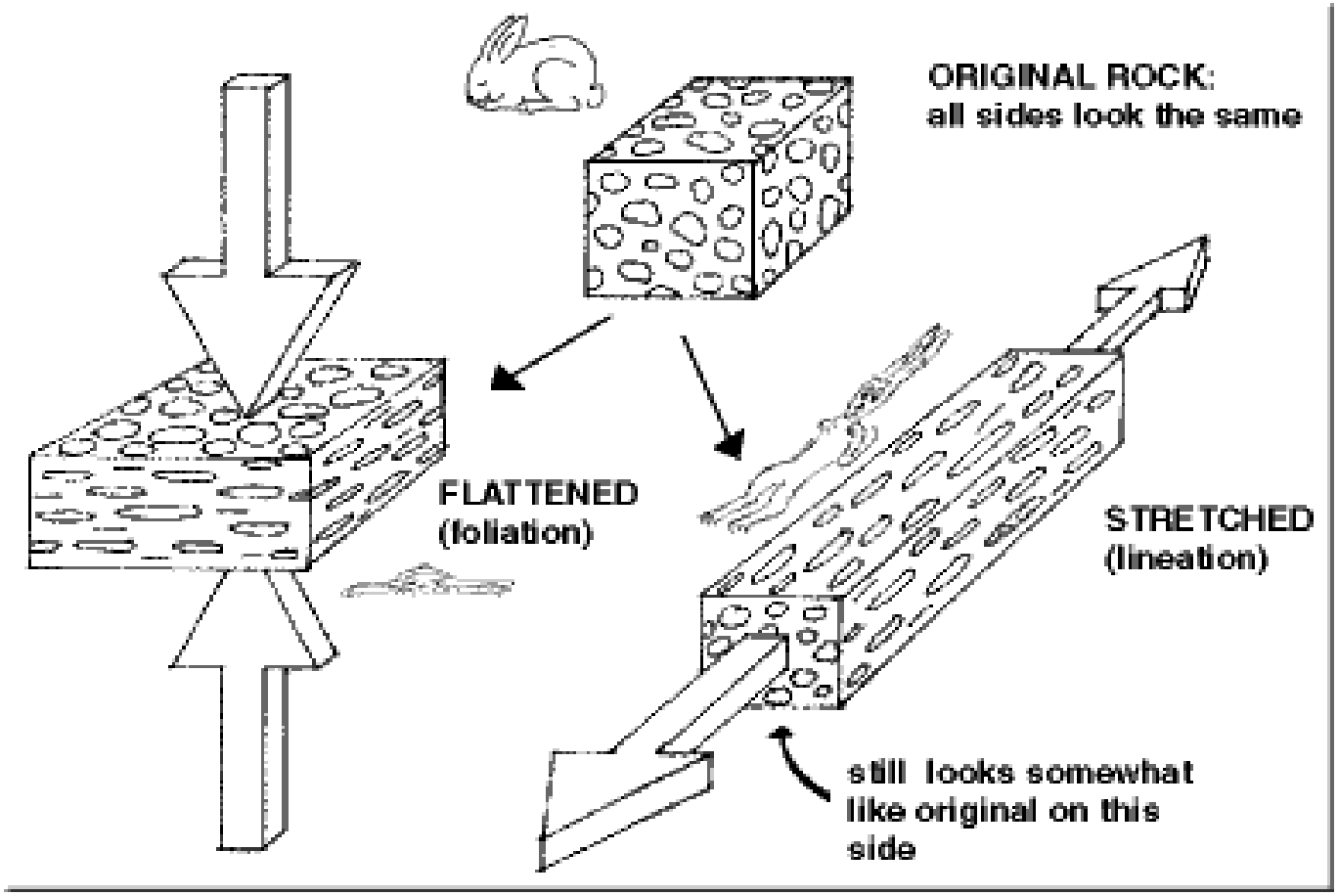
INFLUENCE OF PRESSURE

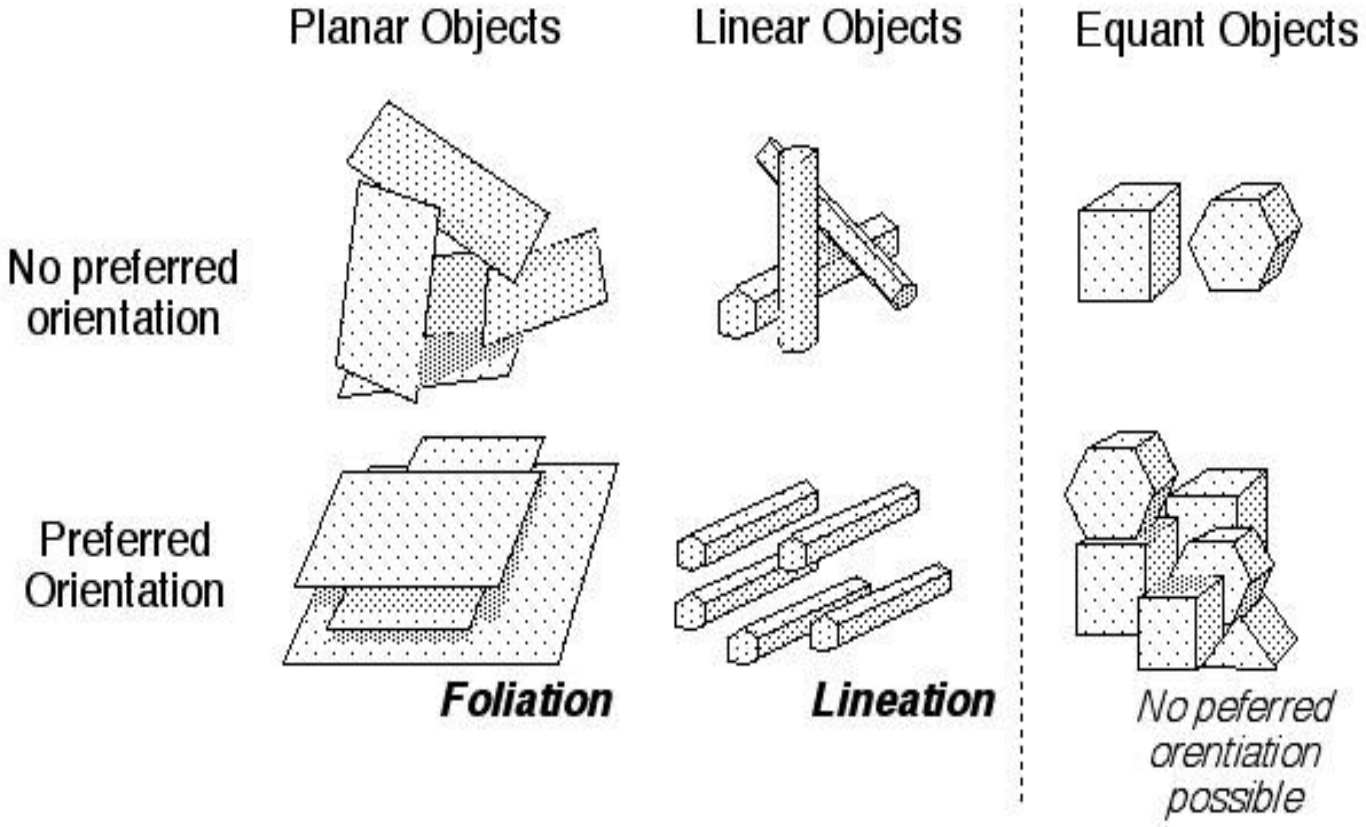
- An increase in pressure tends to favor minerals of higher density, because their atoms are more tightly packed and the minerals occupy less space. An increase in pressure can be produced by deep burial of the rock (lithostatic pressure), or by directed (horizontal) pressure (stress) at convergent plate margins (subduction zones). Minerals will not grow in the direction of highest pressure, but rather in the direction of the lowest pressure. Therefore in rocks that were subject to high pressures, the metamorphic minerals will be elongated perpendicular to the direction of highest pressure.



Mineral Growth under Stress

- **Foliation** in geology refers to repetitive layering in metamorphic rocks. Each layer may be as thin as a sheet of paper, or over a meter in thickness.


ORIGINAL ROCK:
all sides look the same
FLATTENED
(foliation)
STRETCHED
(lineation)
still looks somewhat
like original on this
side


Planar Objects
Linear Objects
Equant Objects
No preferred orientation
Preferred Orientation
Foliation
Lineation
No peferred orentiation possible
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