

Metamorphic textures and structures



Controls of metamorphism

- Temperature
- pressure,
- Time
- Fluids
- These changes are due to variations in temperature, pressure, tectonic stress, and the amount of reactive water

TEXTURE AND STRUCTURE OF METAMORPHIC ROCKS

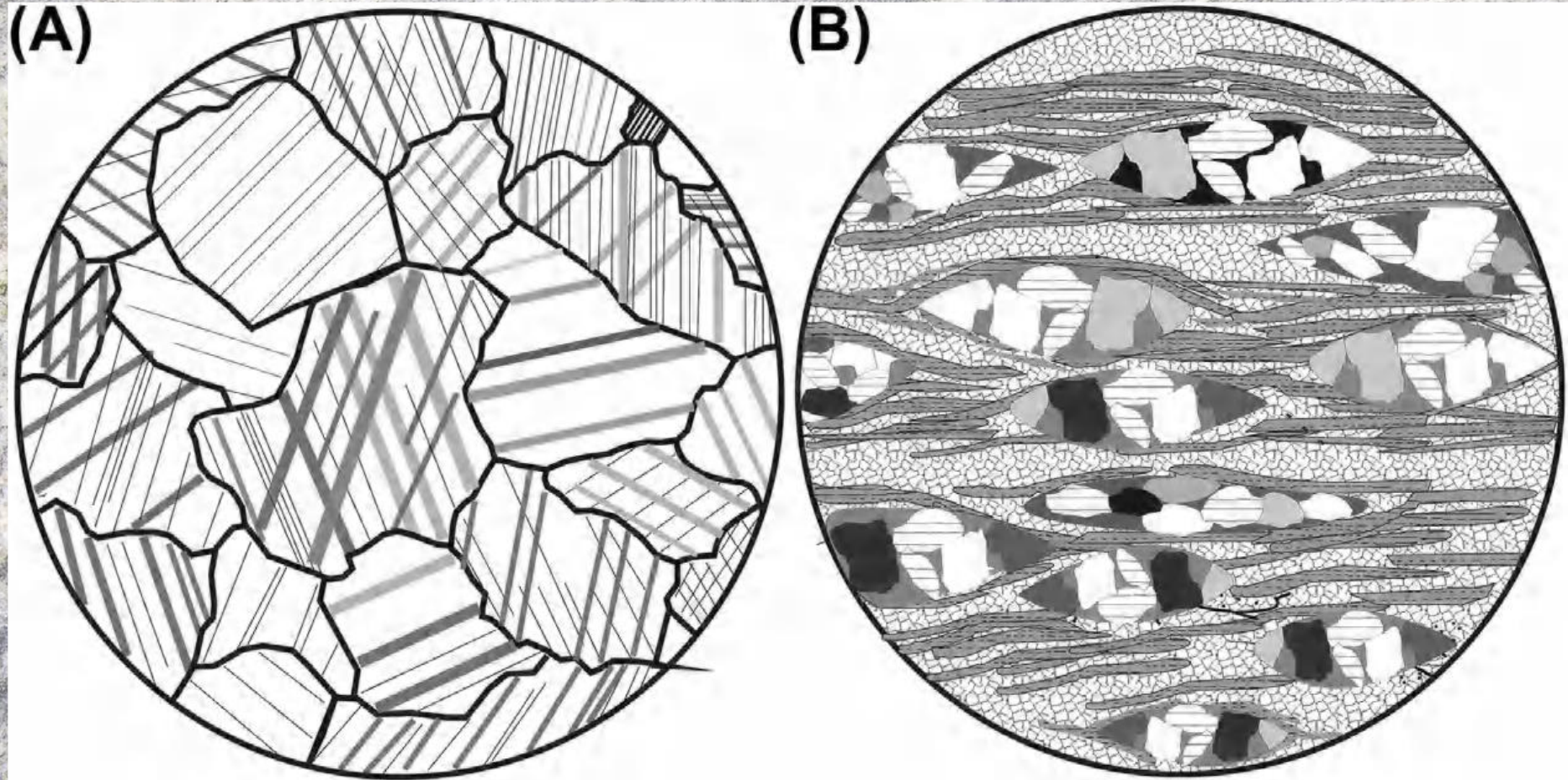
- **Textures** are the relationships of crystals at the smallest scale such as fine-, medium- and coarse grained poikiloblastic, granoblastic, xenoblastic, porphyroblastic or snowball etc.
- **Structures** are larger scale features, at times requiring a whole outcrop to fully describe such as foliated, lineated, cleavage, layered or banded, schistose, gneissose, slaty, crenulated or small-scale regular folds.

Foliation

- Under pressure, minerals are often recrystallize.
- The plate-, leaf- and stick-like minerals occur in parallel rows under the influence of unidirectional pressure during metamorphism.
- newly formed metamorphic rocks attain schistose textures; leaf-like or stick-like structures
- The rocks of metamorphic family are crystalline and resemble sedimentary rocks in having parallel lamellar structure with well-defined foliation that simulates bedding.
- The varieties of foliation are recognized as (1) gneissic, (2) schistose and (3) slaty.

Textures

- At great depths, pressure acts on all sides (called hydrostatic pressure) and that results in formation of new minerals with higher density than the density of the original minerals.
- The new minerals occur in isometric shapes and oppose the pressure striving to be as close to a sphere shape
- The newly created metamorphic minerals (such as calcite in the marble and quartz in the quartzite) have no preferred orientation or schistosity.
- These result in mosaic or granoblastic textures. **Granoblastic is an anhedral phaneritic equigranular metamorphic rock texture.**
- The characteristics granoblastic textures include grains visible to the unaided eye, sutured boundaries and approximately equidimensional grains.
- The grain boundaries intersect at 120 degree triple junctions (next slide)



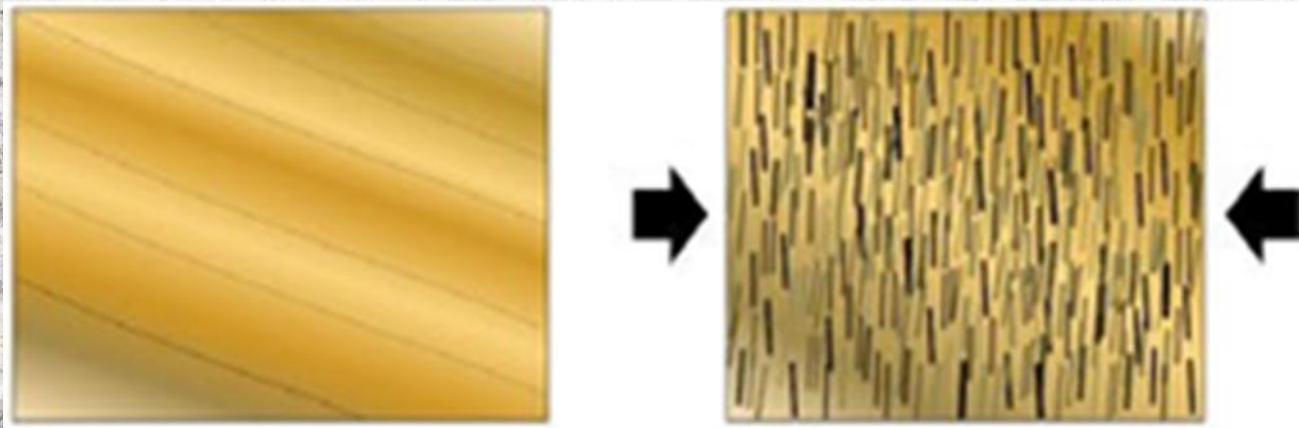
Conceptual diagrams showing (A) granoblastic marble texture characterized by large granoblastic calcite

(B) structure of gneiss such as network of eye-like large granoblastic quartz and feldspars clusters surrounded by mica and other matrix minerals

Formation of textures

- The textures of metamorphic rocks are the result of recrystallization of the original minerals subjected to metamorphic processes.
- Minerals formed from metamorphic processes are called blasts (Greek meaning “lump”).
- Many types of structures of metamorphic rocks have a suffix of blast.
- Metamorphic recrystallization forms main mineral components of metamorphic rock, which can be large, and named as granoblasts and porphyroblasts.
- The minerals without correct crystal form are called xenoblasts
- The smaller share of minerals which have a typical crystalline form are called idioblasts, for example, magnetite, rutile, garnet, andalusite and staurolite.

Foliation and Crystal Habit



Effects of squeezing and aligned mineral growth during metamorphism. Left; Protolith with diagonal bedding. Right, Metamorphic rock derived from the protolith. Elongated mica crystals grew perpendicular to the main stress direction. The original bedding is obscured.

Most foliation develops when new minerals are forced to grow perpendicular to the direction of greatest stress. This effect is especially strong if the new minerals grow in platy or elongated shapes



Foliated rock

Phyllite

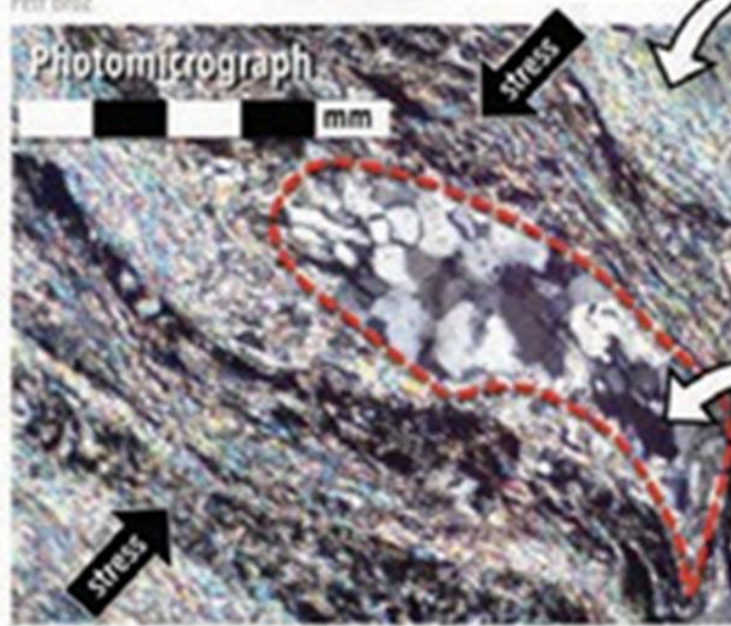
Not to scale



Proyktura

Petr Bral

Photomicrograph



Stacks of plate-shaped mica crystals

1 cm



Rob Lawnsky/istocks.com

Quartz

1 cm

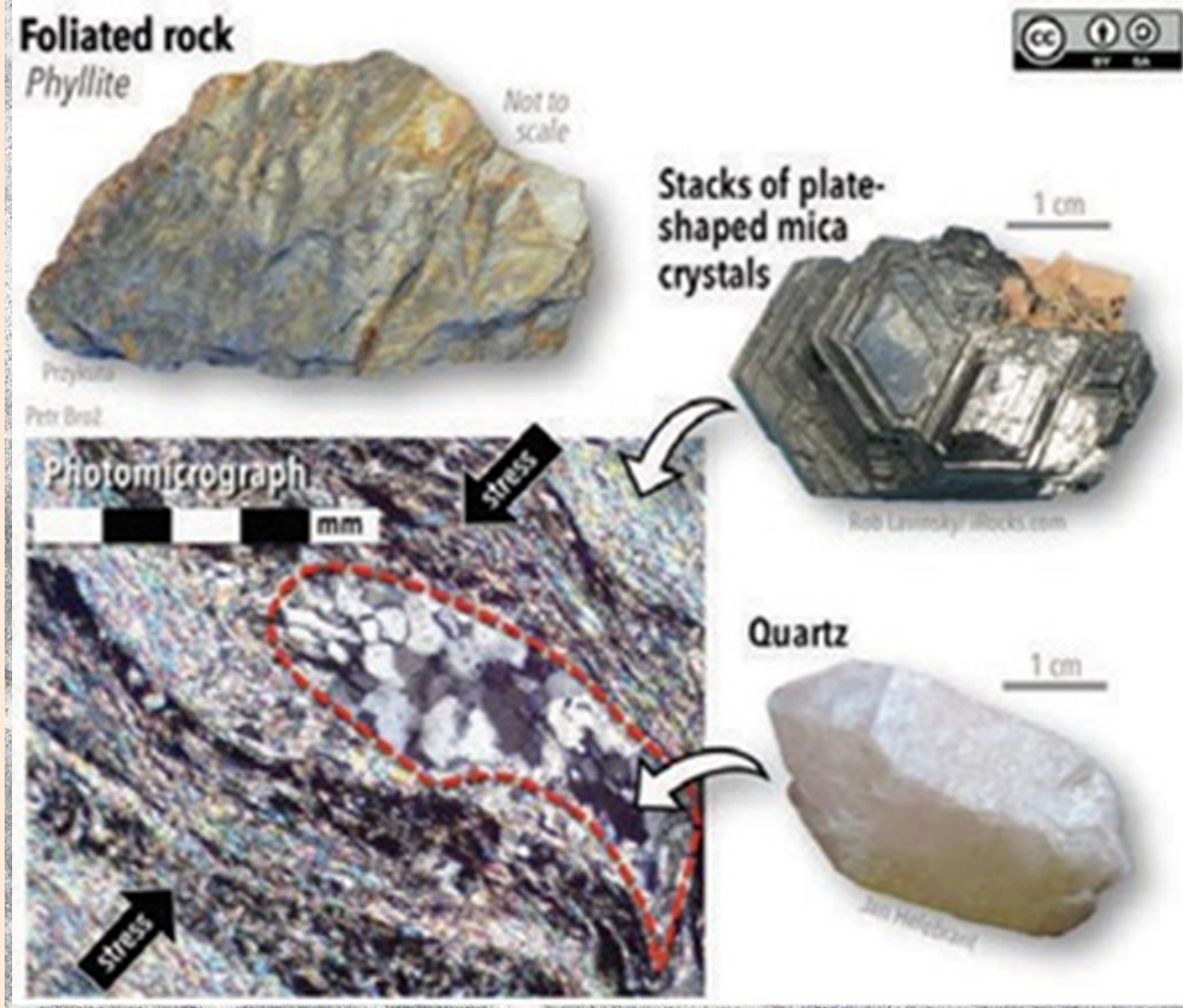


Jan Hefelkamp



- A foliated metamorphic rock called phyllite
- The satin sheen comes from the alignment of minerals.
- Lower left; view of the same kind of rock under a microscope showing mica crystals (colourful) aligned in bands.
- The region outlined in a red dashed line shows a lens of quartz crystals that do not display alignment.
- Upper right- stacks of platy mica crystals.
- Lower right- a blocky quartz crystal.

- Not only is the mineral composition different, it is quartz, not mica but the crystals are not aligned. The quartz crystals were subjected to the same stress as the mica crystals, but because quartz grows in blocky shapes rather than elongated ones, the crystals could not be aligned in any one direction.

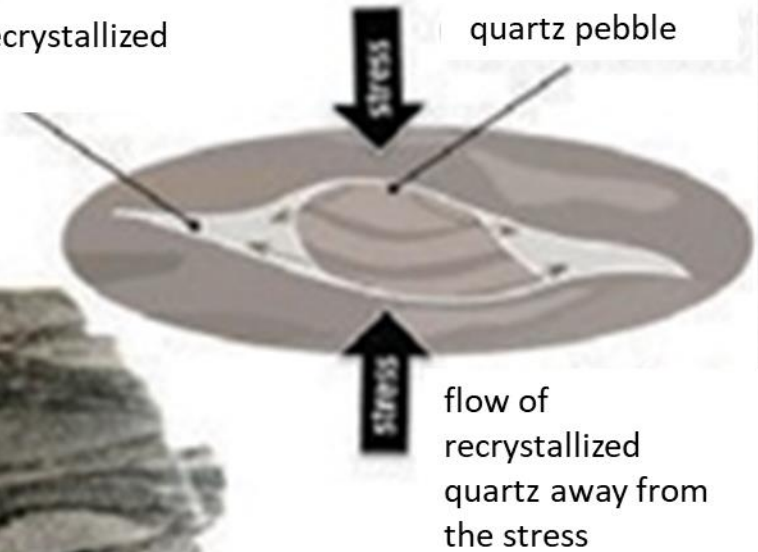


Stress indicators

Metaconglomerate
Protolith: Conglomerate



Wings of recrystallized quartz



Review Questions

1. What are the main agents of metamorphism, and what are their respective roles in producing metamorphic rocks?
2. What types of metamorphic rocks will form if a mudrock experiences very low, low, medium, and high-grade metamorphism?
3. Why doesn't granite change very much at lower metamorphic grades?
4. Describe the main process of foliation development in a metamorphic rock such as schist.
5. What process contributes to metamorphism of oceanic crust at a spreading ridge?

Answers to Review Questions

1. Heat and pressure are the main agents of metamorphism. Heat leads to mineralogical changes in the rock. Pressure also influences those mineralogical changes, while directed pressure (greater pressure in one direction) leads to foliation.
2. Very low grade: slate; low grade: phyllite; medium grade: schist; high grade: gneiss.
3. Granite remains largely unchanged at lower metamorphic grades because its minerals are still stable at those lower temperatures.
4. Foliation develops in schist when new platy minerals grow with their longest dimension at a right angle to the direction of greatest pressure.
5. At a spreading ridge the heat from volcanism leads to the development of a groundwater convection system in the rock of the oceanic crust. Heated water rises in the hot regions and is expelled into the ocean, while cold ocean water is drawn into the crust to replace it. The heated water leads to the conversion of olivine and pyroxene into chlorite and serpentine.



End

Effects of volatiles

- An extremely significant factor of the metamorphism is the presence of water in rocks, especially the water in the form of (OH groups) and crystalline water (H_2O), that exists and associates within silicate minerals by solid molecular bonds.
- The water squeezes out of hydrosilicate minerals and changes to anhydrous silicate minerals by increasing the pressure and temperature to particular level.
- For example, the clayey sediments containing chlorite, kaolinite, and smectite montmorillonite with increasing temperature will transform into a cluster of andalusite, quartz, cordierite, biotite and Na-plagioclase, i.e. the rock hornfels