



Foliation in a metamorphosed conglomerate



Note flattened pebbles

Note the planar fabric in the matrix



Sketch of the origin of this fabric



The foliation is called **Gneissosity** if feldspars dominate




It is called **Schistosity** if micas or hornblende dominate

The matrix of metamorphic rocks

	Shale	Limestone	Q. ss or chert	Granite	basalt
Increasing metamorphism ↓	Slate				greenschist blueschist
	Phyllite	Marble	Quartzite	Gneiss	
	Schist				amphibolite
	Gneiss				

Slate




Slate is a very weakly metamorphosed shale that breaks along distinct planes

Minerals in a slate are still mostly clay and quartz.

Slate tiles on a roof


Phyllite




Phyllite, like slate, is a very weakly metamorphosed shale

It is distinguished from slate because the foliation surface of a phyllite has a distinct sheen. This is because fine-grained mica has begun to form.

Schist



In schist one can see individual micas on the foliation surface




**Gneiss**


At very high grades metamorphosed shales may melt

Melting decreases the abundance of micas in the rock and increases the amount of feldspars - making the rock a gneiss

High-T, (and partially melted) metamorphosed shale

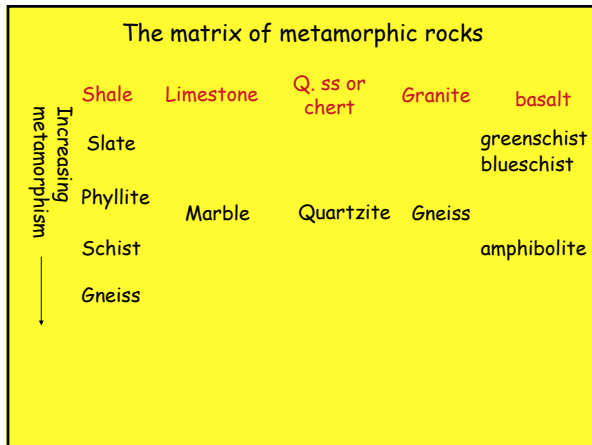


A granite has no planar fabric




A granitic gneiss has a planar fabric

This is simply a deformed granite




**Marble**

Marble is usually more coarse-grained than limestone and much lighter colored



**Quartzite**

A quartzite can be distinguished from a sandstone because the cement is as strong as the grains.

Thus the rock fractures across the grains.

**Greenschist**

Greenschist is a metamorphosed basaltic rock that is composed of green amphiboles



**Blueschist**

A blueschist is a metamorphosed basaltic rock that contains blue amphiboles



**Amphibolite**

Amphibolite is a metamorphosed basaltic rock where the major mineral is hornblende (a black amphibole).

White plagioclase is commonly visible.

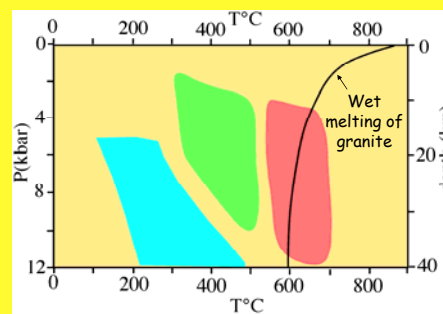


**Metamorphic facies** are named after the rocks that would form from a metamorphosed basaltic rock at the given T and P.

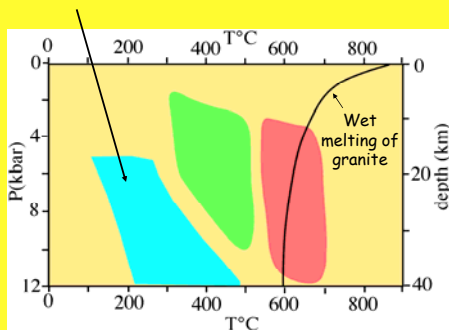
The three most important are:

- Greenschist
- Blueschist
- Amphibolite

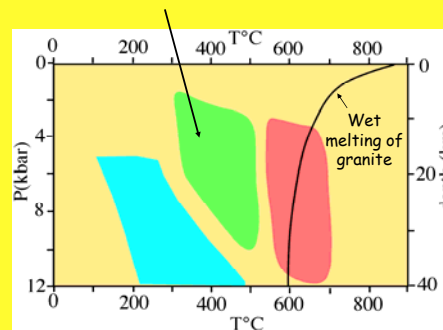
**P - T conditions of metamorphic facies**



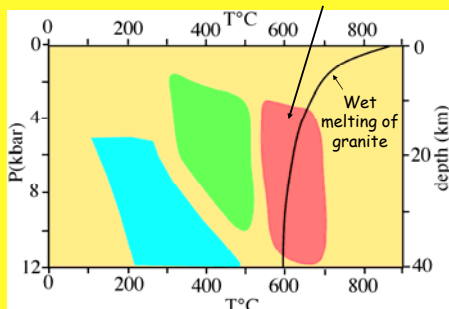
Blueschist facies occurs at Low T and high P



Greenschist occurs at moderate P and low T



Amphibolite facies indicates high T (with a range of pressures), melting may be present



Things to remember from this lecture

Foliation, schistosity and gneissosity

Slate, phyllite, schist, gneiss

Marble, quartzite

Greenschist, blueschist, amphibolite

Metamorphic facies:

Blueschist: low T, Hi P

greenschist: low T, moderate P

amphibolite: hi T, moderate to hi P

Metamorphic rocks occur in the following environments

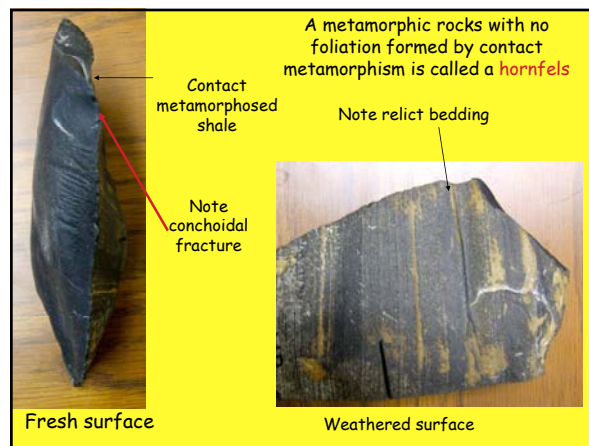
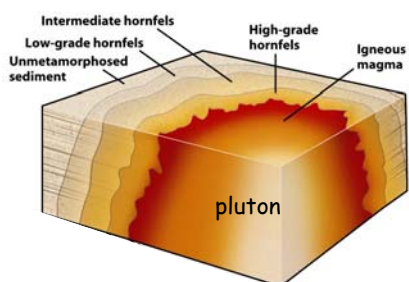
- 1) Thermal aureoles around igneous plutons
- 2) Areas of mountain building
- 3) Sea-floor
- 4) Exposures of "basement"

Emplacement of hot magmas in shallow levels of the crust will "cook" the rocks into which they were intruded

This is called **contact metamorphism**

Rocks subjected to contact metamorphism commonly have no foliation

Cross section of a typical contact aureole



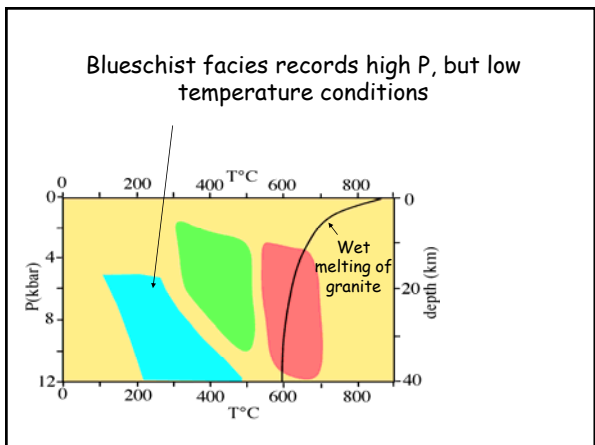
In contrast to contact metamorphism, which is of local (km-scale) extent, the other types of metamorphism occur in regional metamorphic belts, which cover scales of 10s or 100s of km.

The Earth is hot because it contains radioactive elements and because of residual heat from accretion of the earth.

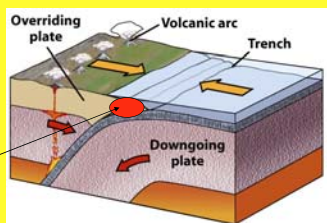


When a rock gets buried during a mountain building event it undergoes both an increase in pressure AND in temperature

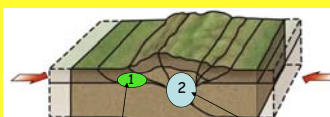
Metamorphic rocks, therefore record the P-T history of mountain belts



Blueschist metamorphism occurs where cold, wet oceanic sediments are thrust beneath a continent or island arc

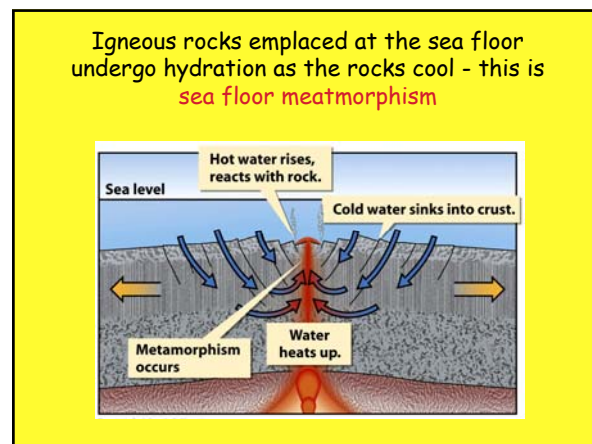
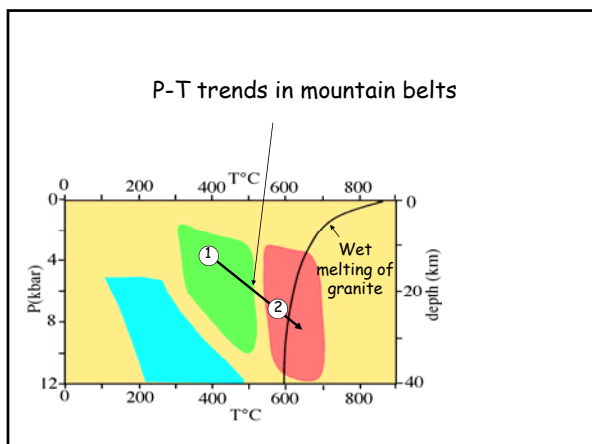


When continents collide the collision zone will be subjected to greenschist or amphibolite metamorphism.



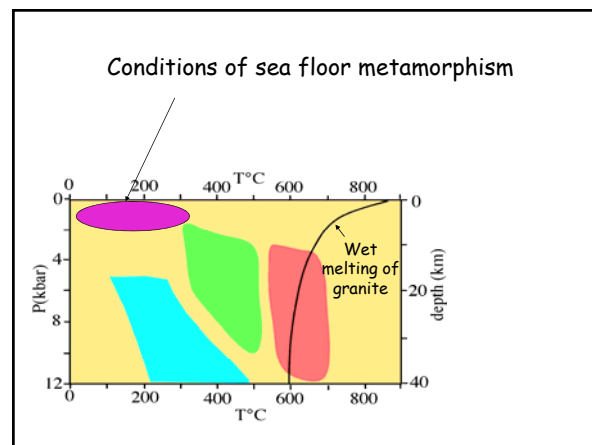
Greenschist facies Amphibolite facies

Some rocks in the core of a mountain belt may melt



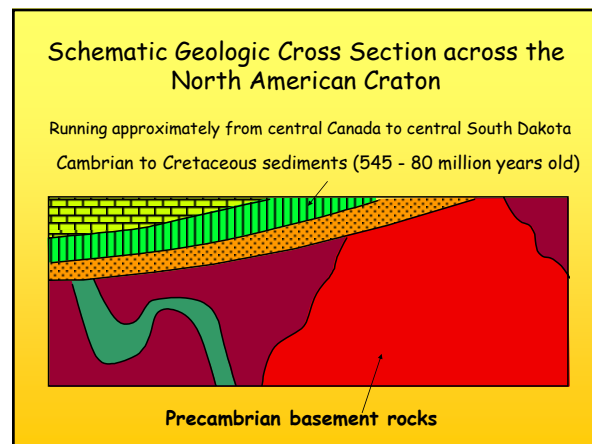
Sea floor metamorphism differs from other types of metamorphism in that:

- 1) Sea floor metamorphism involves cooling and hydration rather than heating and dehydration.
- 2) Rocks subjected to sea floor metamorphism generally have no foliation.

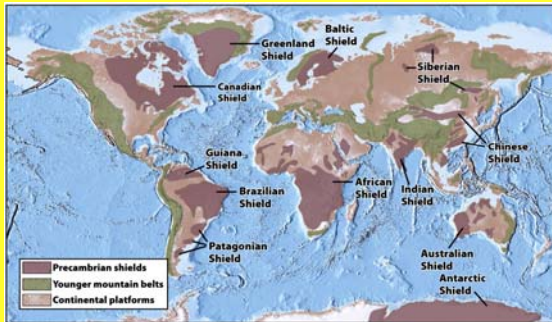


If you go deep enough beneath continents (like under Kansas for example) you will find metamorphosed (mostly granitic) rocks we refer to as basement.

These are called **Precambrian** rocks because they lie beneath (i.e. are older than) the oldest rocks with fossils - the Cambrian.

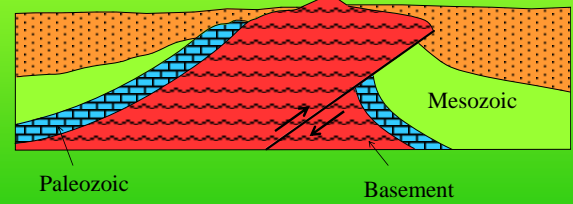


Distribution of Precambrian rocks on Earth

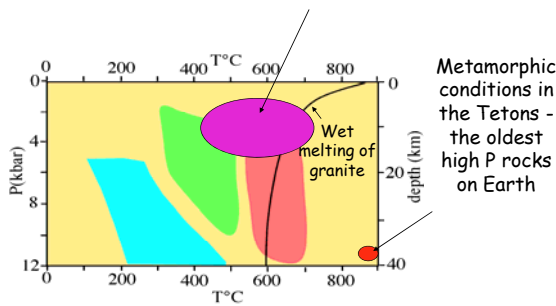


In Wyoming the basement is exposed in large folds that occurred when the Rocky Mountains formed

Examples include: Wind River range, Bighorn mountains, Laramie Range, Medicine Bow Mountains

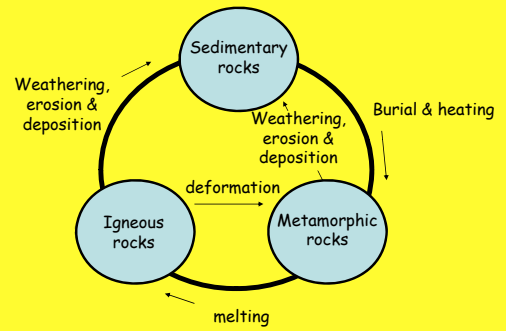


Metamorphic conditions in Precambrian shields

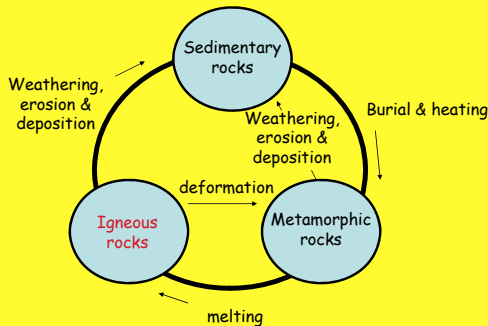


Metamorphic conditions in the Tetons - the oldest high P rocks on Earth

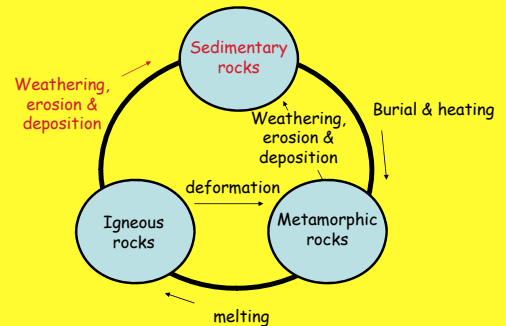
The Rock Cycle

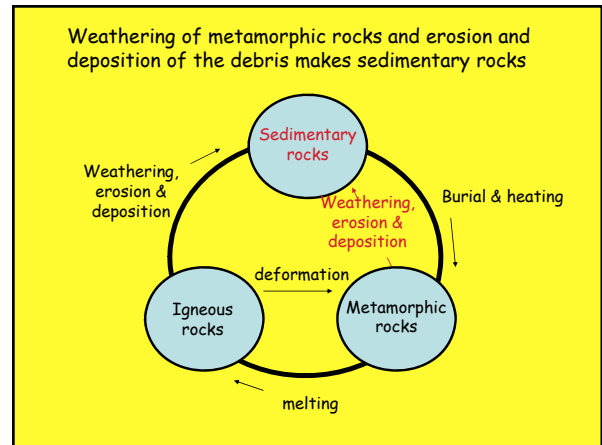
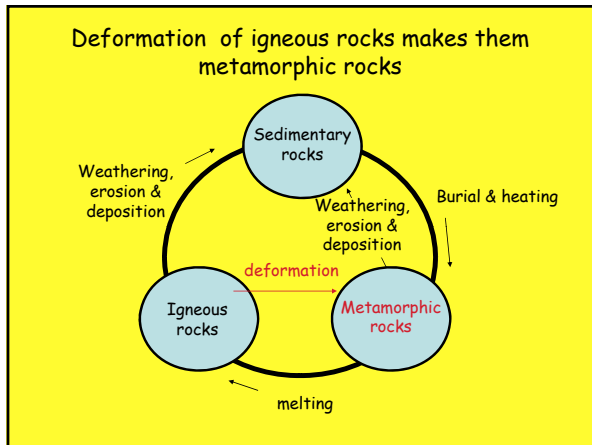
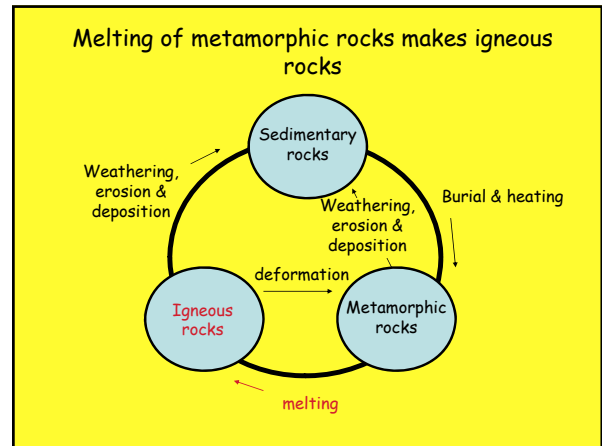
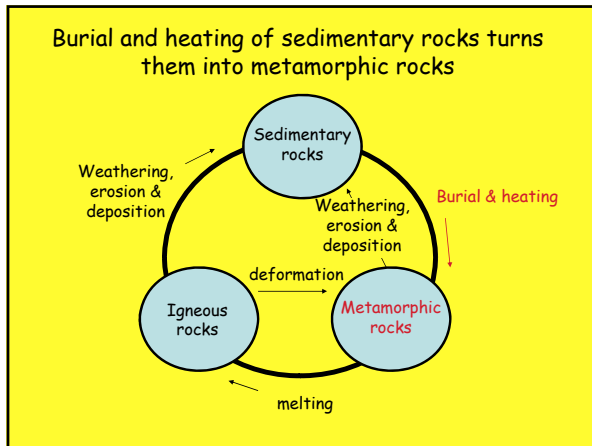


Igneous rocks from from crustal or mantle melts



Weathering, erosion, and deposition cause debris for igneous rocks to become sedimentary rocks





Things to remember from this lecture

Contact metamorphism    Hornfels

Regional metamorphism:

Hi-P, low T metamorphism, mountain belts, seafloor metamorphism, Precambrian shields

The Rock Cycle