GY 111: Physical Geology

Lecture 23
Regional Metamorphism

Instructor: Dr. Douglas W. Haywick
Last Time

Metamorphism 1
1. Agents of Metamorphism
2. Types of metamorphism
3. Hydrothermal fluids (webnotes only)

Web notes: 22
The Rock Cycle

Metamorphic Loop

Sedimentary Loop

Igneous Loop
Metamorphism

Metamorphism: a solid state change (recrystallization) of a parent rock by physical “agents” using operating deep within the interior of the Earth.

Shale (Parent Rock)  Slate (Metamorphic Rock)
Metamorphism

Agents of Metamorphism

1. **Heat** (25°C to 800°C; up to the point of melting)

Geothermal Gradient: the increase in ambient temperature with depth.

15 to 30°C/km under stable continental rocks

200°C/km under mid oceanic ridges
Metamorphism

Agents of Metamorphism

1. **Heat** (25°C to 800°C; up to the point of melting)

2. **Pressure** (1 bar to 12 kbars)

1 bar = 1 atmosphere
12 kbar = 12,000 atmospheres

http://www.geol.ucsb.edu/faculty/hacker/geo102C/lectures/hydrostat.jpg
Metamorphism

Agents of Metamorphism

1. **Heat** (25°C to 800°C; up to the point of melting)
2. **Pressure** (1 bar to 12 kbars)
3. **Chemically active fluids** (AKA hot water)

Types of Metamorphism

- **Regional** (heat and pressure)
  Associated with convergent plate boundaries

1) Isobars
2) Isotherms
3) Isograds (upcoming lecture)
Types of Metamorphism

- **Contact** (heat only)

Metamorphic aureoles
Types of Metamorphism

- **Cataclastic** (pressure only)

  Mylonites
  Shear zones

http://www.cliffshade.com/colorado/homestake/hsz01.jpg
Today’s Agenda

Regional Metamorphism
A) Foliated rocks
B) Non-foliated rocks

Web notes: 23
Regional Metamorphism

Involves both heat and pressure
Regional Metamorphism

Pressure causes certain minerals (clays) to deform and change their orientation in the original parent rock.

e.g., shale (sedimentary)  Kaolinite (a clay)
Regional Metamorphism

The most stable configuration for platy minerals like clays and micas is perpendicular to the stress direction.
Regional Metamorphism

The most stable configuration for platy minerals like clays and micas is \textbf{perpendicular} to the stress direction.
Regional Metamorphism
Foliated Rocks

This is a low grade form of metamorphism and does not impose great changes in the rock (e.g., color stays the same)

e.g., slate (metamorphic)
Foliated Rocks

But it can develop rock cleavage
Foliated Rocks

As metamorphic grade increases (especially pressure), minerals begin to alter and new minerals start to grow (e.g., Kaolinite is unstable at all but Low P/T and turns into micas).
Foliated Rocks

Higher P/T causes minerals to grow large enough to be visible. Metamorphic minerals include: garnet, talc, graphite, chlorite, kyanite, staurolite etc.

Low                                Medium                    Med-High
Shale                         slate                    phyllite                   schist

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<th>slate</th>
<th>phyllite</th>
<th>schist</th>
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Foliated Rocks

Higher P/T causes minerals to grow large enough to be visible. The highest pressure can cause mineral separation (distinct bands e.g., quartz, biotite, feldspars).
Foliated Rocks

Terminology Hell:
Rock cleavage, foliation, schistososity, gneissosity (sp?)

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Foliated Rocks

Slate
Foliated Rocks

Phyllite
Foliated Rocks

Garnet-Mica schist
Foliated Rocks

Kyanite schist
Foliated Rocks

Gneiss
Non-foliated Rocks

Foliations can only develop during metamorphism if there was mica and/or clay in the original parent rocks.

But what about clean limestones?
Non-foliated Rocks

Foliations can only develop during metamorphism if there was mica and/or clay in the original parent rocks.

Marble (non-foliated)
Non-foliated Rocks

Quartz arenite sandstones also produce non-foliated rocks when subjected to high grade metamorphism.
Non-foliated Rocks

**Warning**: marble can look *exactly* the same as quartzite

Marble (non-foliated)    Quartzite (non-foliated)
Today’s Homework

1. GY Photo assignment (due next Friday by 5PM)

Next Time

1) Quiz (fill in the blanks)
2) Contact metamorphism