12.001 Introduction to Geology
Spring 2008

Regional metamorphism changes rock TEXTURE

1 Metamorphic causes sedimentary rocks, such as shale, to form slaty cleavage planes perpendicular to their bedding planes.

2 The original bedding in a sample can be seen from the thin sandy layers.

3 Regional metamorphism causes cleavage planes-foliation-to develop in the shale, making slate.

Regional metamorphism changes rock TEXTURE

4 Foliation is the result of compressive forces.

5 Mineral crystals in the rock grow or are deformed to become elongate perpendicular to the compressive force.

6 Foliated rocks develop because they contain platy minerals that align along a preferred orientation.

Regional metamorphism changes rock TEXTURE

8 Foliated rocks are classified by the degree of cleavage, schistosity, and banding, which corresponds to the intensity of metamorphism.

Contact metamorphism does not create foliation

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Contact metamorphism does not create foliation

Elkins-Tanton, 2002

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Porphyroblasts (vs. phenocrysts): May be formed in shearing deformation

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Classification of Metamorphic Rocks by Texture

Classification	Characteristics	Rock Name	Typical Parent Rock
Foliated	Distinguished by slaty cleavage, schistosity, or gneissic foliation; mineral grains show preferred orientation	Slate Phyllite Schist Gneiss	Shale, sandstone
Granoblastic (nonfoliated)	Granular, characterized by coarse or fine interlocking grains; little or no preferred orientation	Hornfels Quartzite Marble Argillite Greenstone Amphibolite* Granulite**	Shale, volcanics Quartz-rich sandstone Limestone, dolomite Shale Basalt Shale, basalt Shale, basalt
Porphyroblastic	Large crystals set in fine matrix	Slate to gneiss	Shale

**Typically contains much amphibole, which may show alignment of long, narrow crystals.*

**High-temperature, high-pressure rock.*

Figure by MIT OpenCourseWare.

1 Index minerals define metamorphic zones. Laboratory studies have determined the temperature and pressure at which various rocks and minerals have formed.

2 Isograds-lines that plot the transition from one mineral to another-can be used to plot the degree of metamorphism (temperature and pressure) over an area such as New England.

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6 Metamorphic facies correspond to particular combinations of pressure and temperature,…

7 …and these combinations of P and T can be used to indicate specific tectonic environments.

Major Minerals of Metamorphic Facies Produced from Parent Rocks of Diffrent Composition

Facies	Minerals Produced from Shale Parent	Minerals Produced from Basalt Parent
Greenschist	Muscovite, chlorite, quartz, albite	Albite, epidote, chlorite
Amphibolite	Muscovite, biotite, garnet, quartz, sillimanite	Amphibole, plagioclase feldspar
Granulite	Garnet, sillimanite, albite, orthoclase, quartz, biotite	Calcium-rich pyroxene, calcium-rich plagioclase feldspar
Eclogite	Garnet, sodium-rich pyroxene, quartz/coesite, kyanite	Sodium-rich pyroxene, garnet

Figure by MIT OpenCourseWare.

Increasing metamorphism grade creates different assemblages of minerals, which define ***metamorphic facies.***

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8 Tectonic transport moves rocks through different pressure-temperature zones, from shallow to deep levels in the crust,…

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9 …and then transports them back to the shallow crust or even to the surface of the Earth.

1 During metamorphism, a garnet crystal grows, and its composition changes as the temperature and pressure around it change.

2 Composition of crystal can be plotted on the P-T path as it grows from 1 in its center to 2 as its edge.

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3 As rock is carried deeper in earth's crust and is subjected to higher temperatures and pressures (the **prograde** path), the garnet crystal initially grows in a schist but ends up growing in a gneiss as metamorphism processes.

4 The **retrograde** path indicates decreasing temperatures and pressures as rocks are carried toward Earth's surface.

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Elkins-Tanton