First year of Geomatics Department
Engineering Geology 2020
Lecture 7

METAMORPHIC ROCKS

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Metamorphic Rocks

Definitions

- **Metamorphic Rock**
  - **"Meta"= Change** ***(Grk)***
  - **"Morph"= form** ***(Grk)***
  - **a rock that has been changed from its original form (parent) by heat , pressure , and fluid activity into a new rock (daughter).**

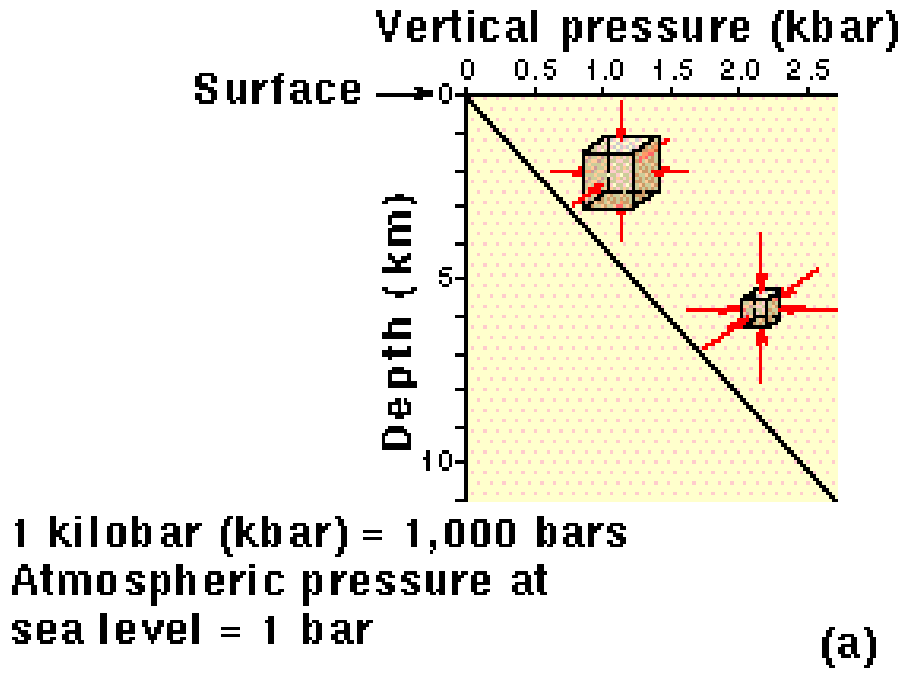
Heat

Sources Include.....

- **Magma**
  - **temperature of magma**
  - **composition of magma**
- **Geothermal gradient**
  - **temperature increases with depth of burial**
  - **core of Earth is warmer than outer crust**

Uniform Pressure

- Lithostatic
  - "Lithos"= rock, static= unchanged (pressure)
  - uniform (aka non-directed)
  - equal intensity from all directions by rocks



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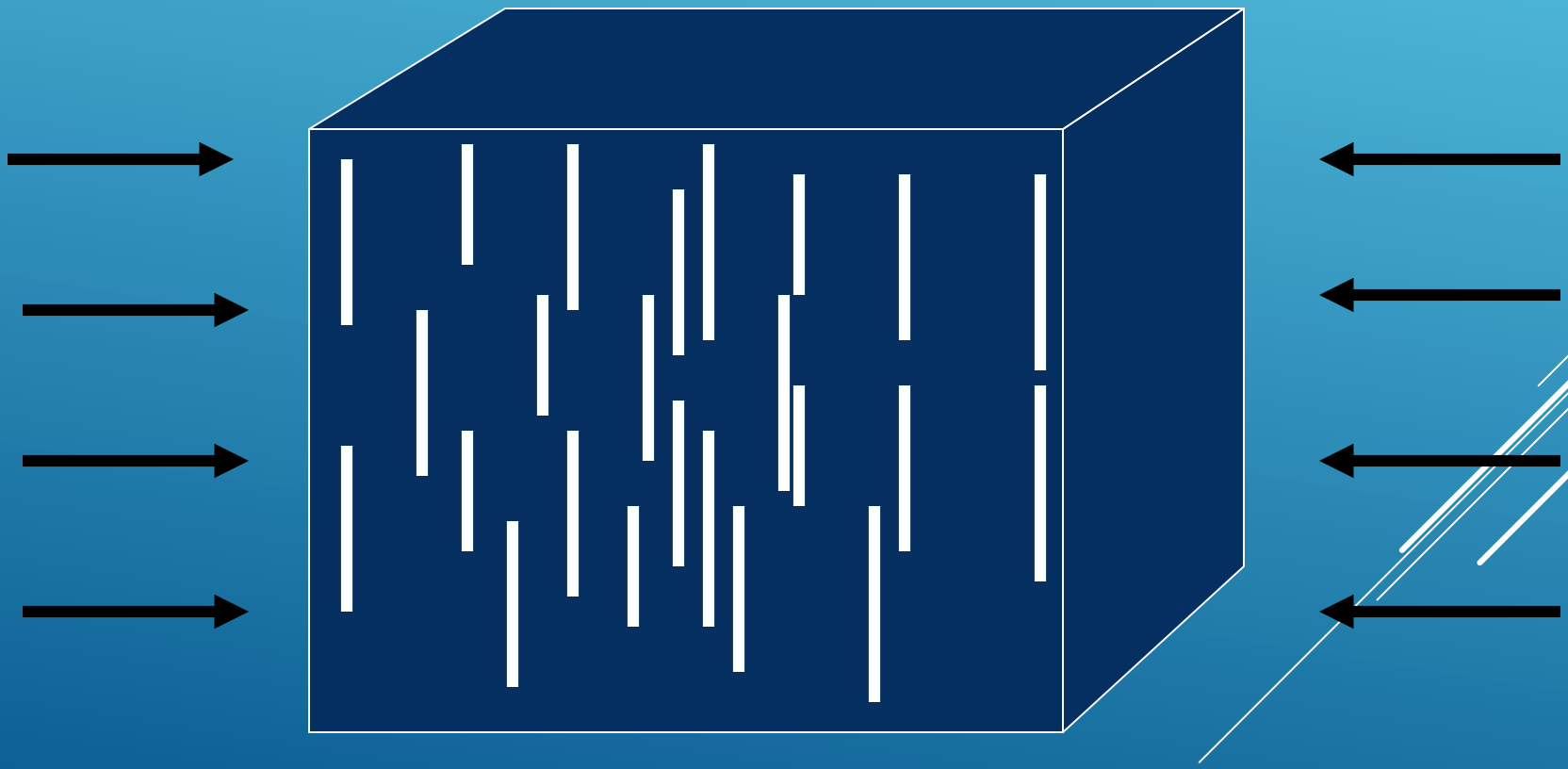
Directed Pressure

one direction of squeezing is much stronger than the others

Minerals align themselves to reduce stress.



Types of Metamorphism

- **Contact**
  - **caused by igneous activity**
- **Dynamic**
  - **aka cataclastic**
  - **associated with faults & earthquake zones**
- **Regional**
  - **caused by tremendous pressures associated with tectonic plate activity**

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Contact Metamorphism

- **Igneous Intrusions**
  - **size and type of magma important**
    - **mafic magma hotter than felsic**
  - **heat decreases away from magma**
    - **forms a zone of altered country rocks called** **Aureoles**

Sometimes creates a metamorphic rock called a hornfels -in essence a "cooked" rock

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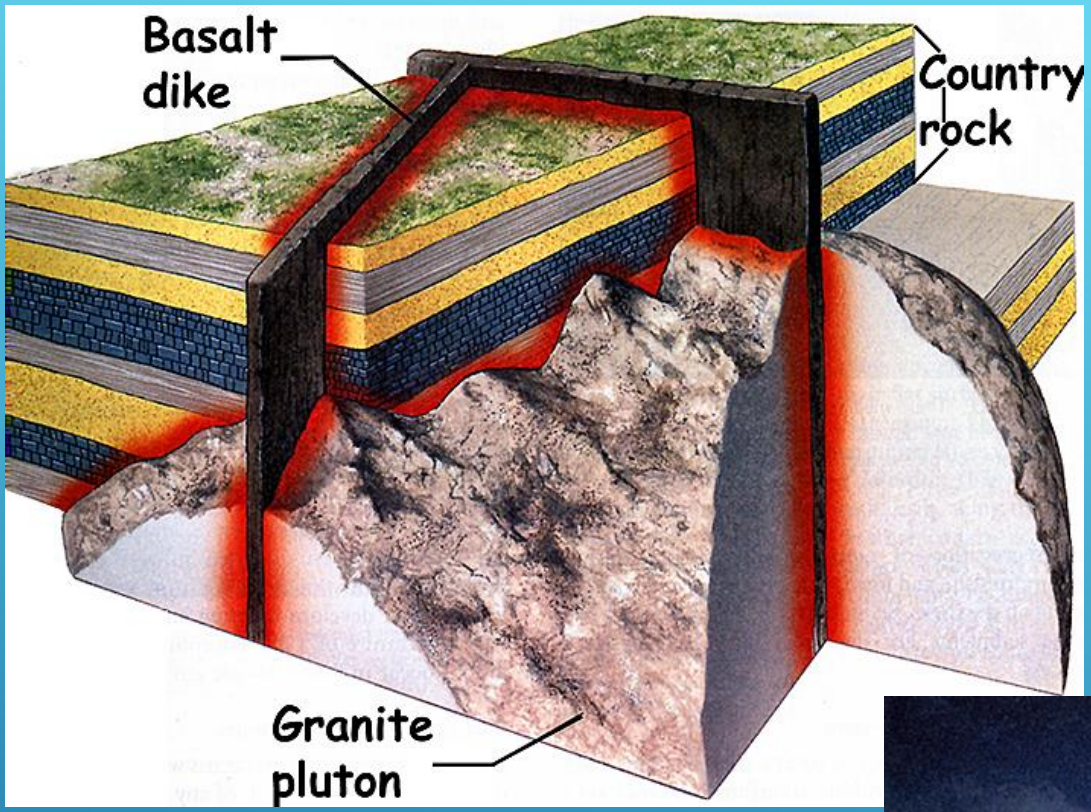
Basalt
dike
Country
rock
Granite
pluton

Dynamic Metamorphism

- Cataclastic Metamorphism
- associated with Fault Zones
  - Places where the Earth's crust ruptured
  - Rock pulverized
    - heat and pressure come from movement along the Fault
- resultant rock is known as a *Mylonite*

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Regional Metamorphism

- Most common form of metamorphism
- caused by large scale forces
  - lithospheric plate collision
- covers very large areas
  - metamorphic belts or zones
  - Zones are characterized by ***Index Minerals***
    - form under specific temperatures and pressures
    - metamorphic facies
- commonly associated with
  - shields: stable areas of crystalline rocks

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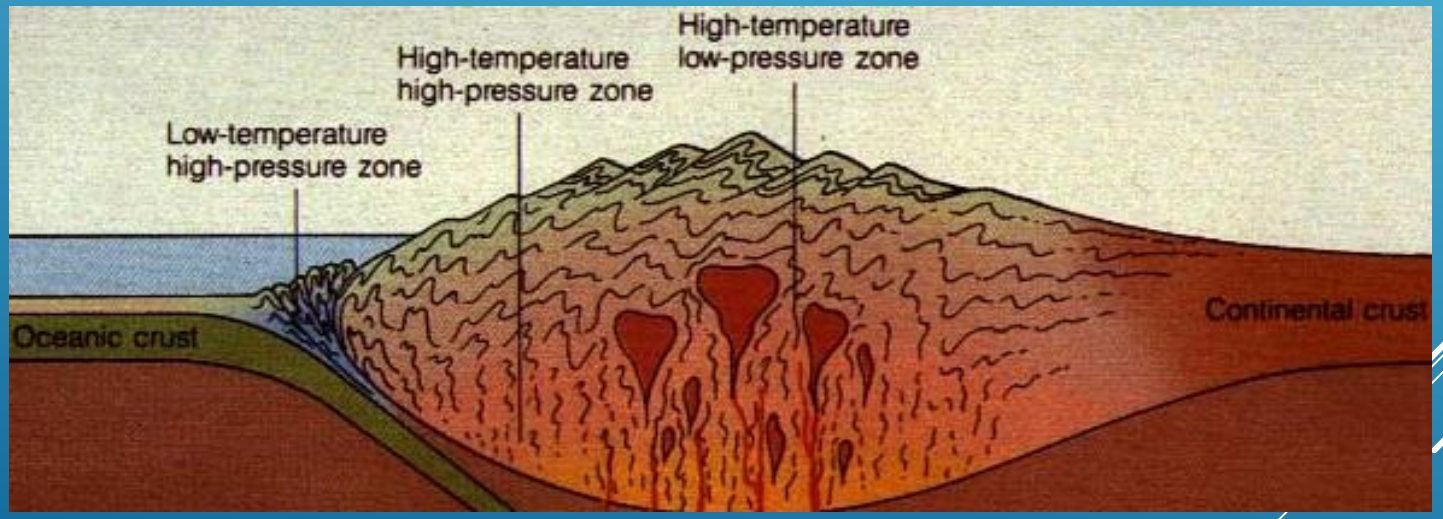
CONDITIONS THAT CAUSE ROCK TO UNDERGO METAMORPHISM INCLUDE

- Heat - Under conditions of high temperature from magma contacting pre-existing rock.
- Pressure - Deep burial and pressure from mountain formation.



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TYPES OF METAMORPHIC ROCKS

- Foliated: rocks with mineral crystals arranged in cable-like distorted layers/structures
  - Mineral Alignment
  - Banding
  - Animation: Foliation
- Nonfoliated: rocks with recrystallized minerals; no layering
  - Recrystallization: This is the growth of new mineral crystals from other rocks.

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Scheme for Metamorphic Rock Identification

Texture		Composition	Type of Metamorphism	Comment	Rock Name
FOLIATED	MINERAL ALIGNMENT	Mica	Regional (Heat and Pressure increase w/ depth)	Low-Grade metamorphism of SHALE	Slate
		Mica, Quartz, Feldspar, Amphiboles, Garnet		Foliation surfaces shiny from microscopic mica crystals	Phyllite
		Mica, Quartz, Feldspar, Amphiboles, Garnet, Pyroxene		Platy mica crystals visible	Schist
	BAND-ING	Mica, Quartz, Feldspar, Amphiboles, Garnet, Pyroxene		Compact, may split easily	Gneiss

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Progression of Metamorphism

Start with a shale and then hit it with heat and pressure!

More Heat & Pressure

Rock Name	Rock Type	Grade of Metamorphism
Shale	Sedimentary	-----
Slate	Metamorphic	Low
Phyllite	Metamorphic	Low/Intermediate
Schist	Metamorphic	Intermediate/High
Gneiss	Metamorphic	High
Molten Rock	Cools into Igneous Rock	-----

Shale
(Sedimentary Rock)

Heat
&
Pressure

Slate
(Metamorphic Rock)

Slate
(Metamorphic Rock)

Heat
&
Pressure

Phyllite
(Metamorphic Rock)

Phyllite
(Metamorphic Rock)

Heat
&
Pressure

Schist
(Metamorphic Rock)

WITH EVEN MORE HEAT & PRESSURE
(HIGH-GRADE METAMORPHISM)

… you end up with something that is really Gneiss!

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Scheme for Metamorphic Rock Identification

Texture	Composition	Type of Metamorphism	Comment	Rock Name
NONFOLIATED	Variable	Contact (Heat)	Various rocks changed by nearby magma/lava	Hornfels
	Quartz	Regional (Heat & Pressure) ↓	Metamorphism of Quartz Sandstone	Quartzite
	Calcite and/or Dolomite		Metamorphism of Limestone or Dolostone	Marble
	Various minerals in particles and matrix		Pebbles may be distorted or stretched	Metaconglomerate

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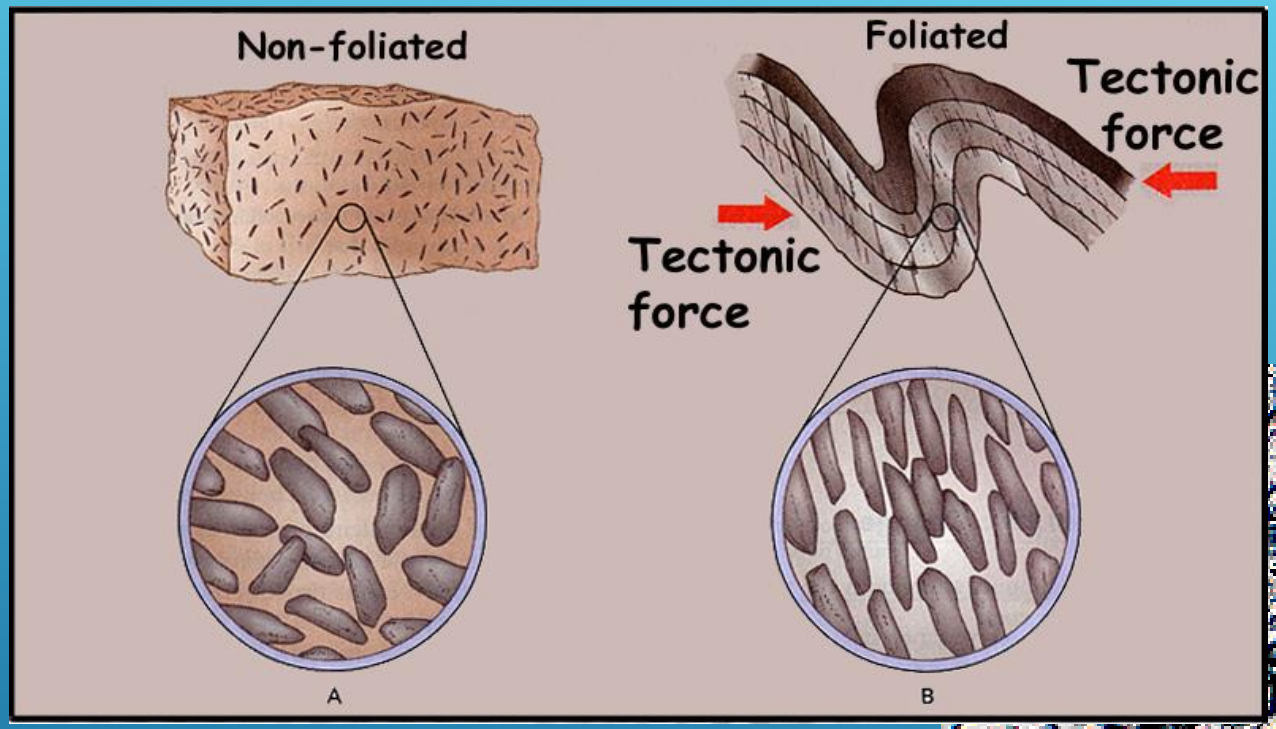
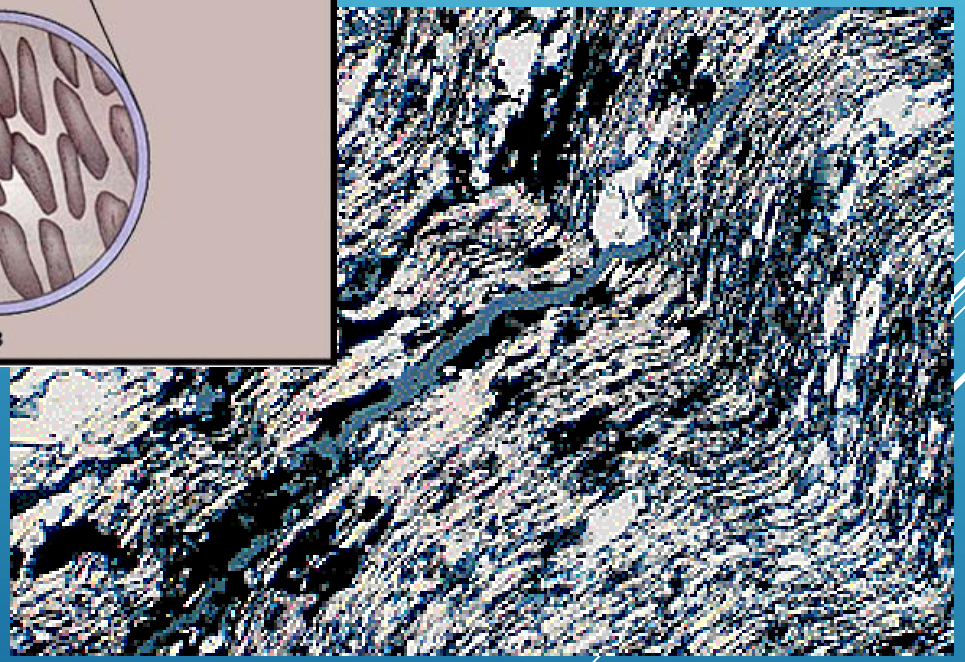
Foliated Texture





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Foliated Textures

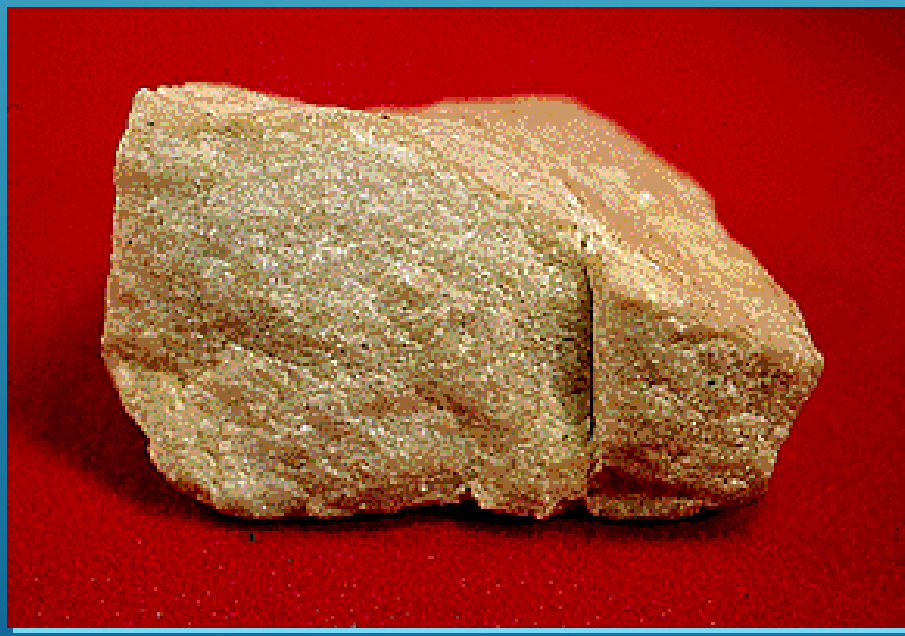
- **Slatey**
  - looks like blackboard
    - dull surface
  - smooth, thin layering
  - breaks into flat slabs
    - referred to as slatey cleavage
  - no mineral grains visible
- **Phyllitic**
  - looks like waxed surface
    - has a "sheen" to it
  - may have little "waves" on surface
    - referred to as *crenulations*
  - some small grains visible
- **Schistose**
  -
  - visible grains
    - garnets, staurolites
  - may have shiny appearance
    - due to mica minerals
- **Gneissic**
  - larger grains
  - may look like igneous rock
  - may have crude banding
    - intensely distorted
  - different minerals than schistose

Foliated MM Rocks

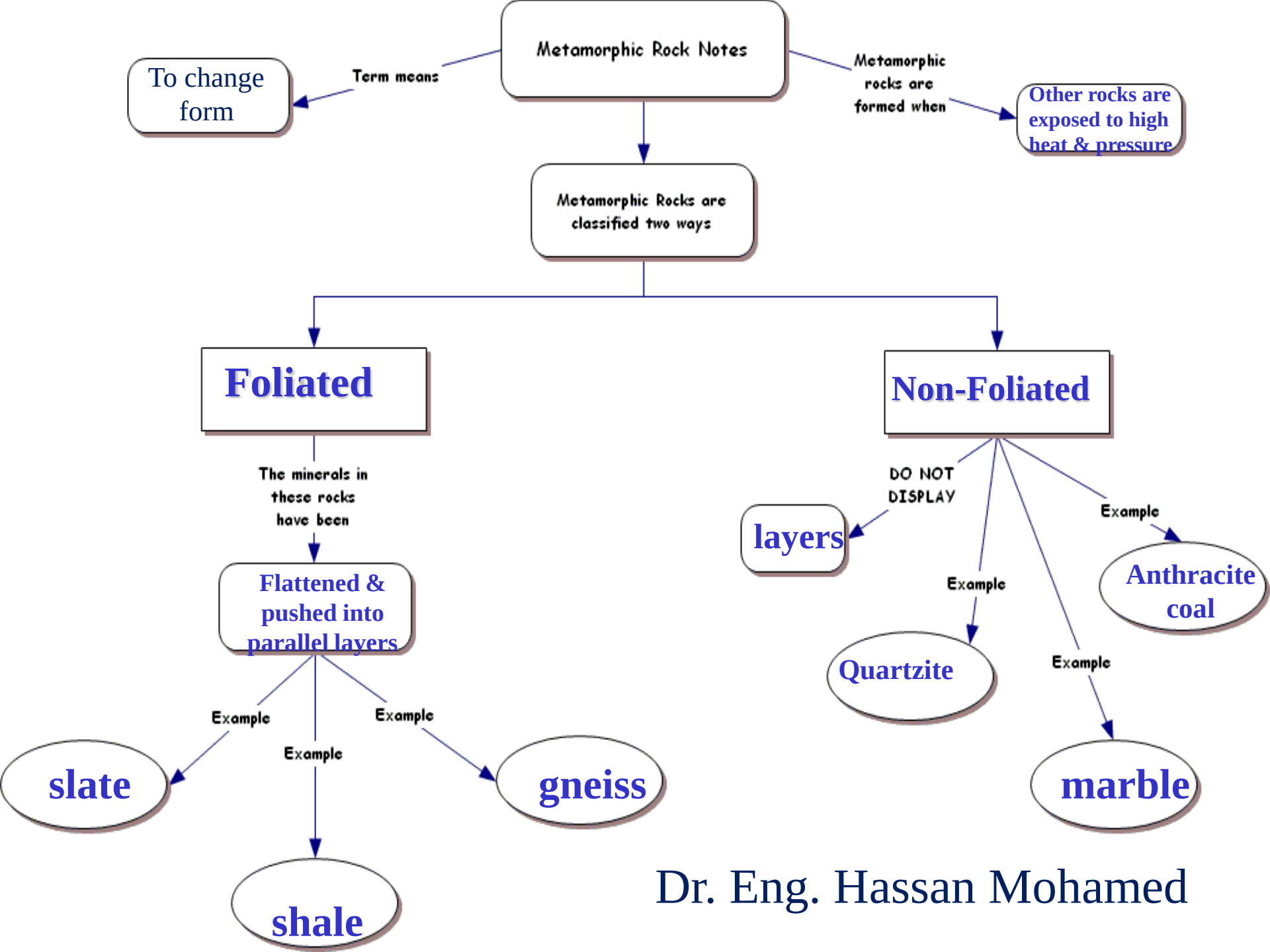
MM Rocks that could form as a shale (sedimentary) parent rock is exposed to increasing directed pressure and temperature

Non-foliated Rocks

- **Marble:**
  - metamorphosed limestone



- **Quartzite:**
  - metamorphosed quartz sandstone



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GNEISS

Gneiss is made of coarse-grained interlocking crystals. Crystals line up in pale and dark layers to give the rock a banded texture.

Metamorphic Gneiss has many uses as a building material such as flooring, ornamental stones, gravestones, facing stones on buildings and work surfaces.

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SCHIST

Schist is made of medium-grained interlocking crystals. Its shiny appearance is due to the mineral mica. Crystals line up to give the rock wrinkly layers – this is called foliation.

Although a very attractive stone, schist is rarely used as a building material as it is not very strong.

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SLATE

Slate is made of fine-grained interlocking crystals which lie flat in the same direction, known as the cleavage direction, along which the rock easily splits.

Slate has many uses such as snooker tables, roofing, gravestones, flooring and garden decorations.

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MARBLE

Marble (metamorphosed limestone) is made of calcium carbonate (fizzes with acid). It has medium-grained Interlocking crystals with no alignment.

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THANKS

Please visit the following links:

https://en.wikipedia.org/wiki/Metamorphic_rock

http://www.onegeology.org/extra/kids/metamorphic.html

https://www.youtube.com/watch?v=1oQ1J0w3x0o

https://www.youtube.com/watch?v=Ncr-46YX-N0

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