Lecture # 6

Engineering Geology and Seismology

Geological Identification of Rocks

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Characterizing Rocks

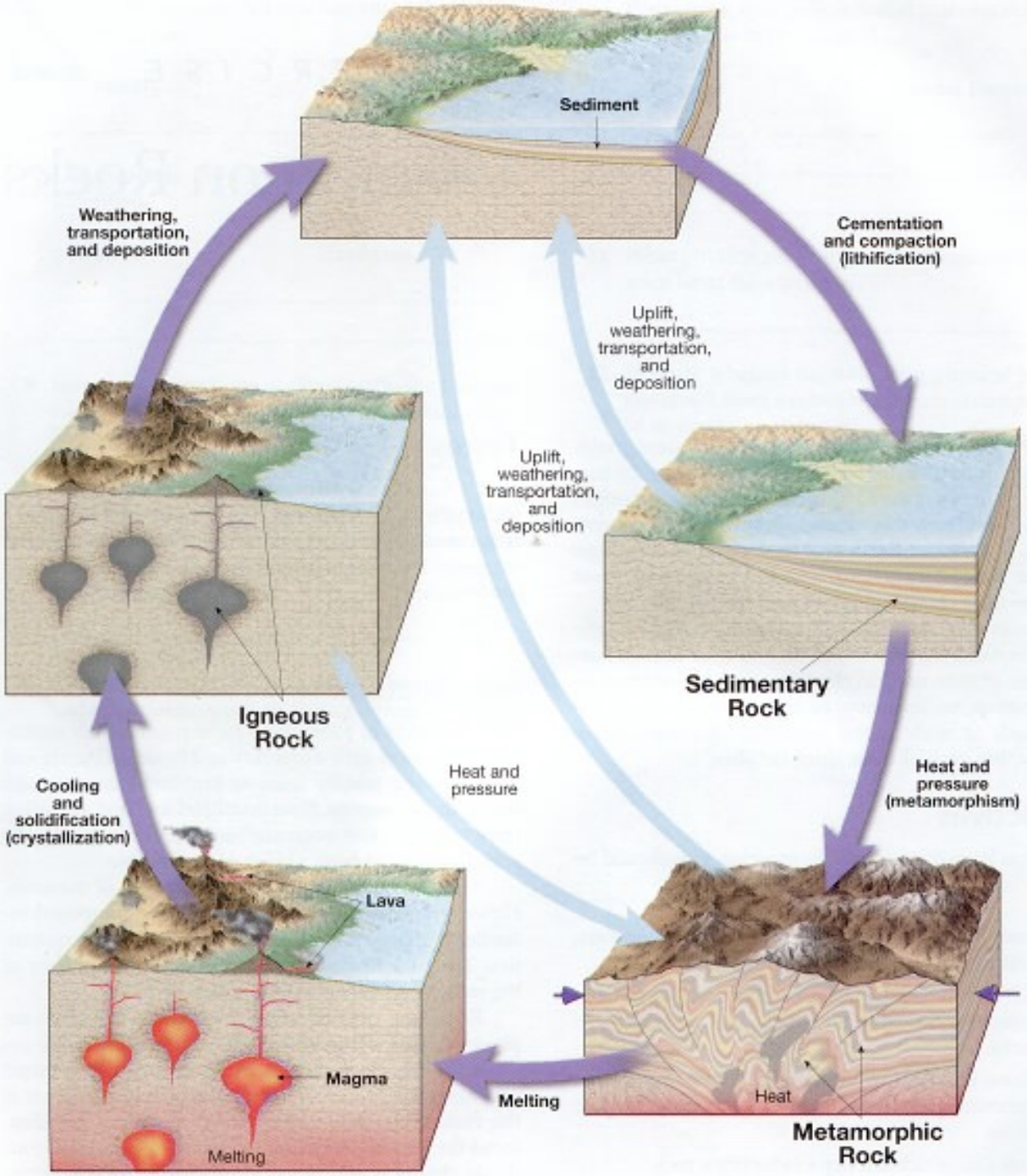
As already discussed, there are 3 major types of rocks

IGNEOUS – formed from molten magma

SEDIMENTARY – formed from sediment (soil, sand, etc,)

METAMORPHIC – formed by applying heat and pressure to other existing rocks

The Rock Cycle – a representation of the interrelationship between different types of rocks.



Characterizing Rocks

The three major characterizing features of rocks are:

- Color
- Composition (Mineralogy/Chemistry)
- Texture

Note: Even the most sophisticated geological classification schemes are based on these features

Characterizing Rocks

Classification by Color

Color Index (used mainly for igneous rocks)

- **Leucocratic – light color**
- **Mesocratic – intermediate color**
- **Melanocratic – dark color**

  and/or

- **Felsic – rich in light colored minerals**
- **Mafic – rich in dark colored minerals**

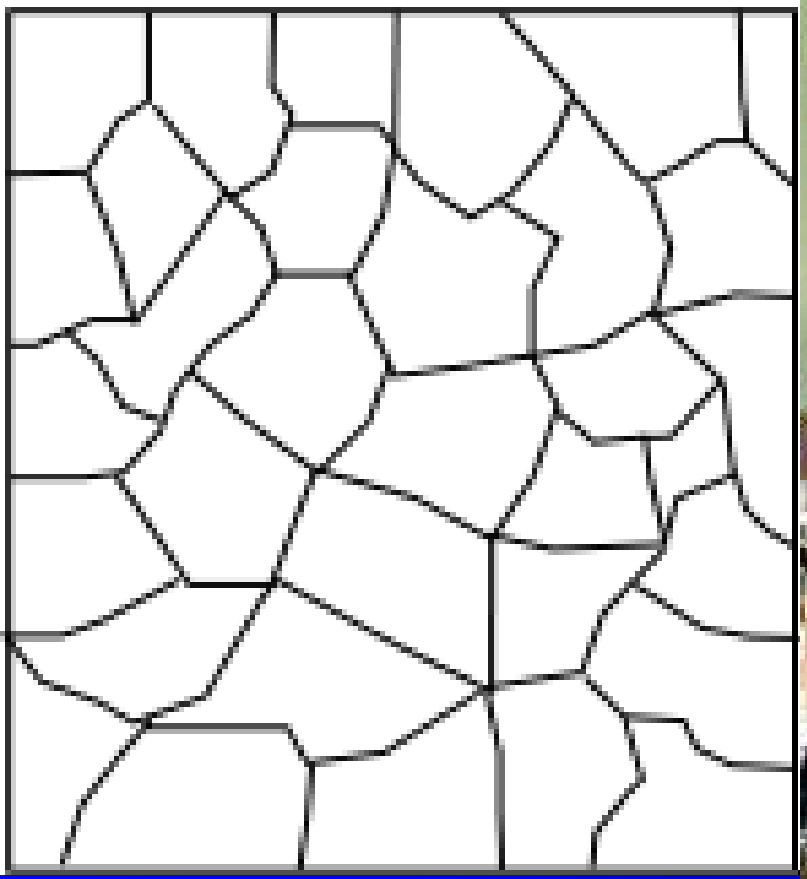
Igneous Rocks

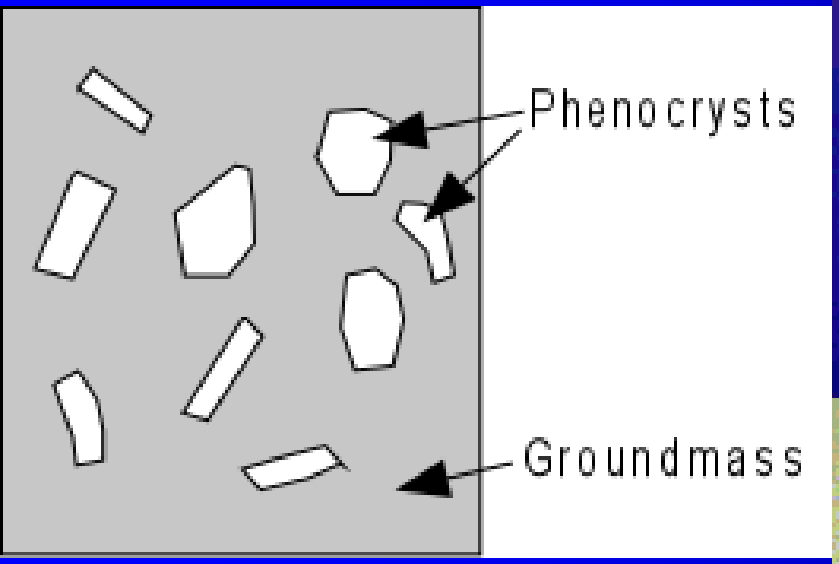
Textures of Igneous Rocks

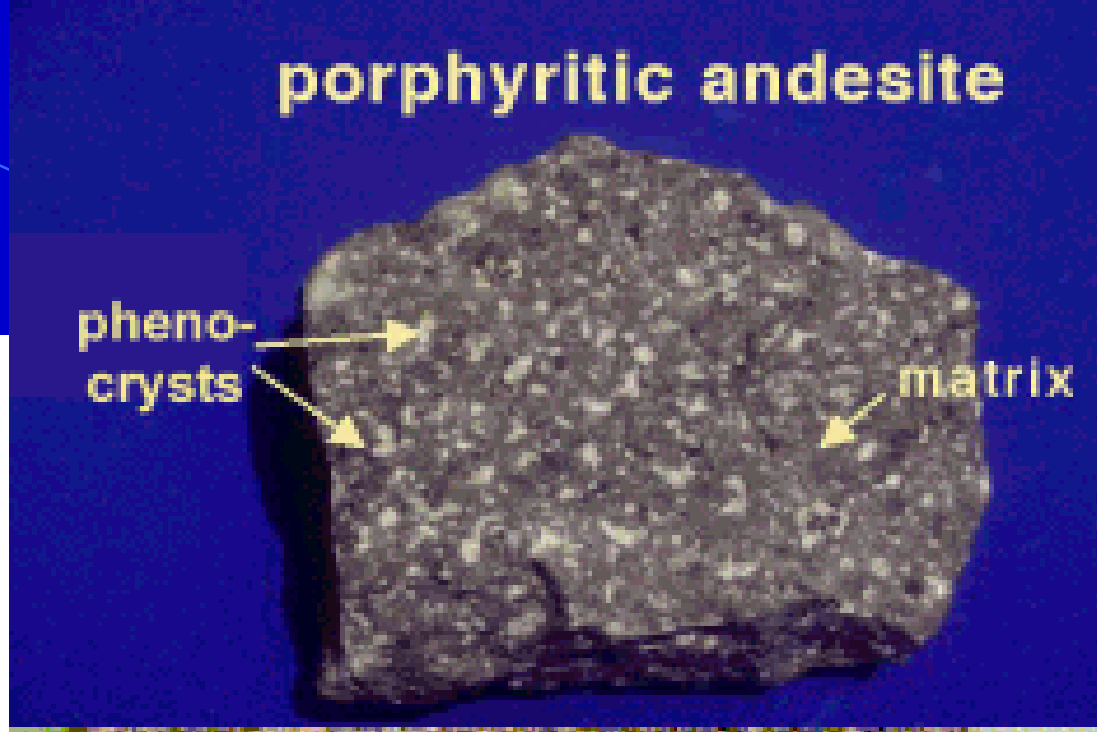
- Aphanitic – fine-grained. Individual grains can't be seen with naked eye
- Phaneritic - grains easily seen with the naked eye
- Porphyritic – larger grains in finer grains
- Inclusions
  - > Xenoliths
  - > Xenocrysts

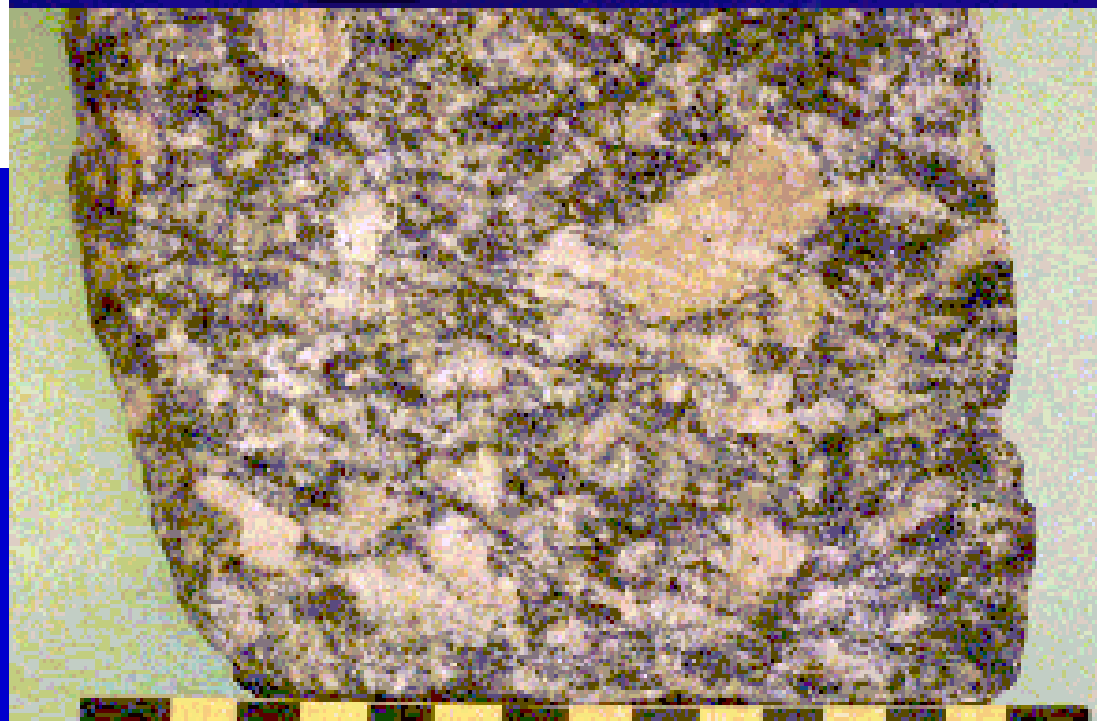
Aphanitic Texture

Phaneritic Texture

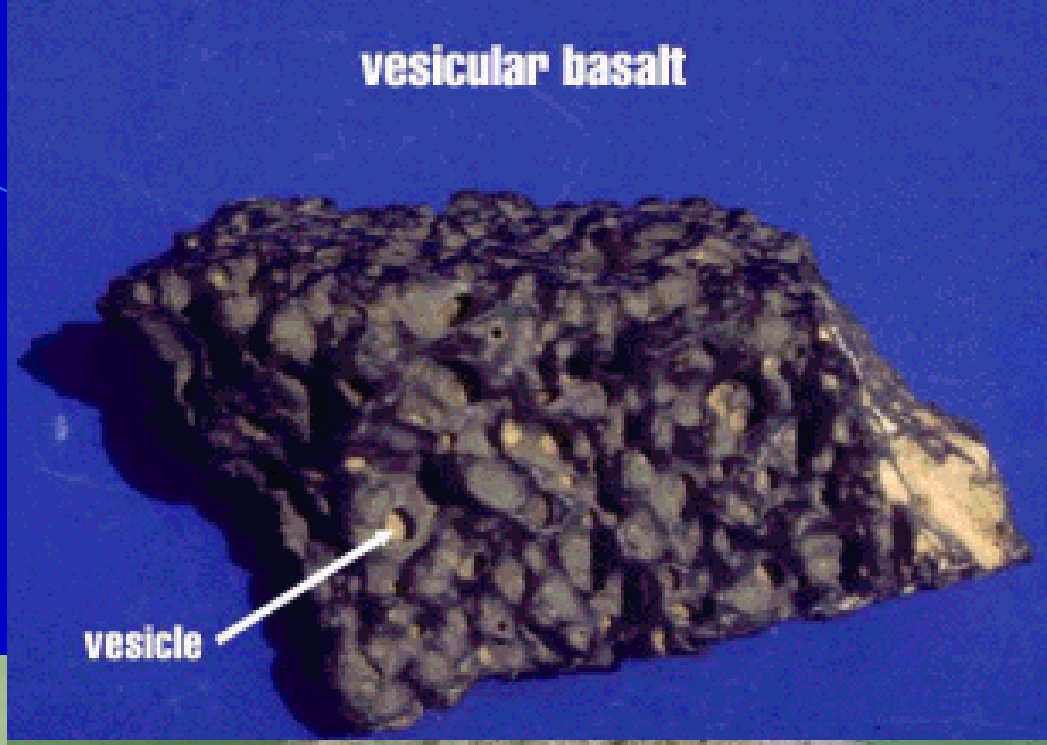


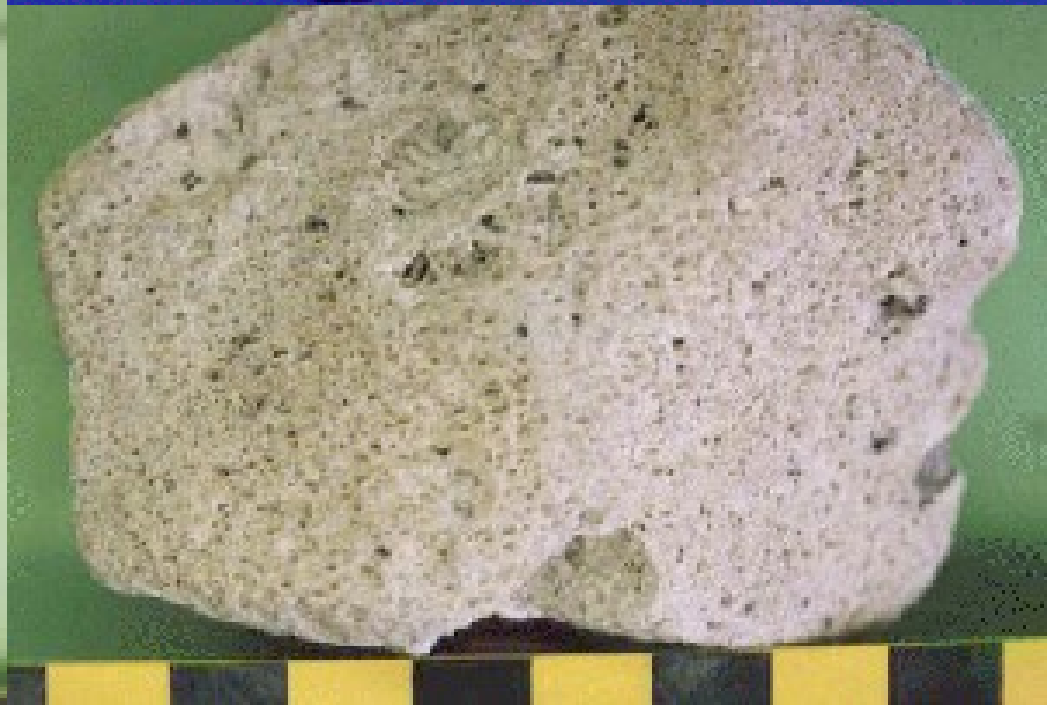

Phenocrysts
Groundmass


porphyritic andesite
pheno-
crysts
matrix

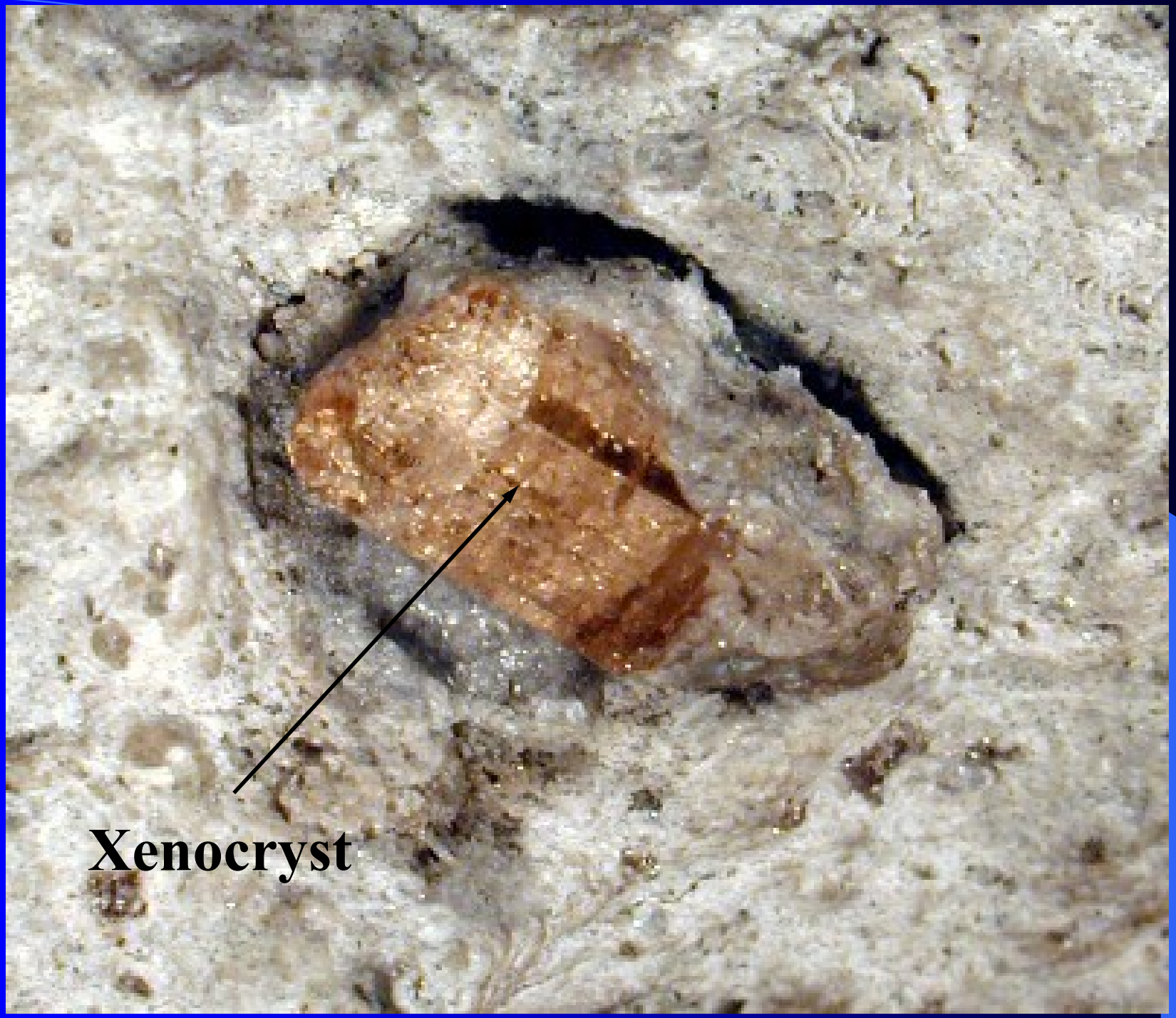


Vesicular & Glassy Textures






Xenoliths


Xenocryst

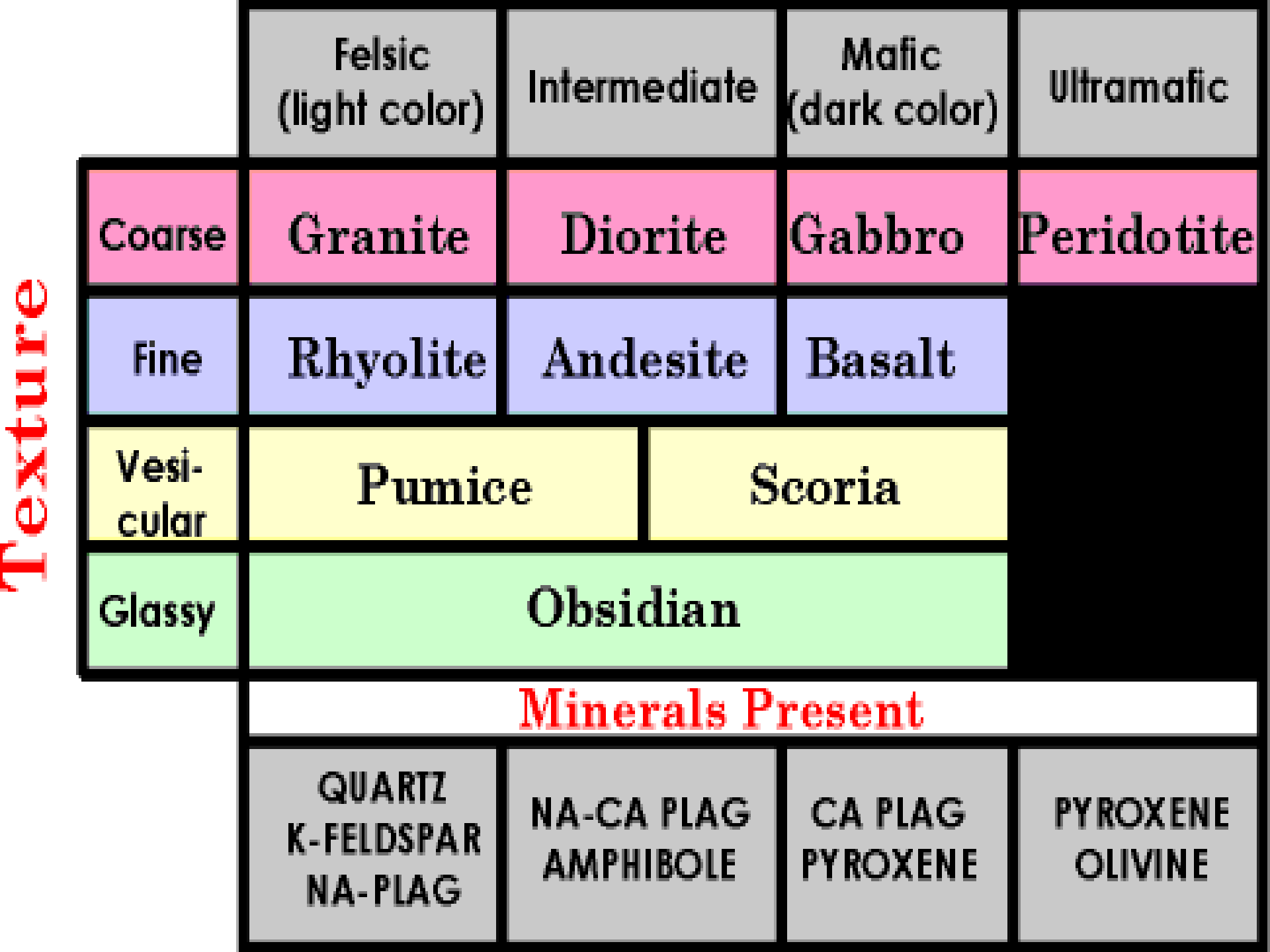
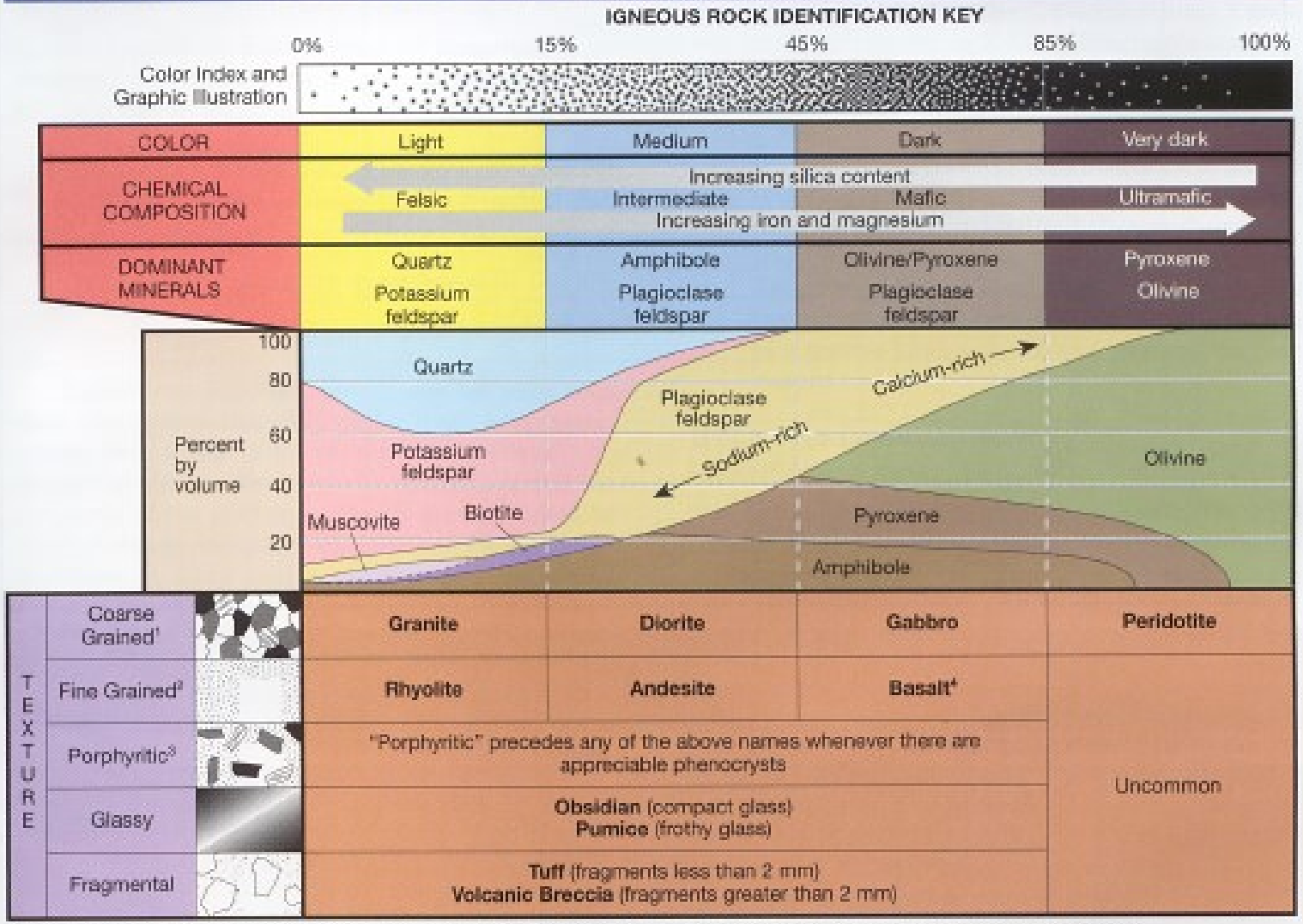

Texture
Felsic (light color)
Intermediate
Mafic (dark color)
Ultramafic
Coarse
Granite
Diorite
Gabbro
Peridotite
Fine
Rhyolite
Andesite
Basalt
Vesi-cular
Pumice
Scoria
Glassy
Obsidian
Minerals Present
QUARTZ
K-FELDSPAR
NA-PLAG
NA-CA PLAG
AMPHIBOLE
CA PLAG
PYROXENE
PYROXENE
OLIVINE

Table 2.1 Igneous rock identification key. Color, with associated mineral composition, is shown along the top axis. Each rock in a column has the color and composition indicated at the top of the column. Texture is shown along the left side of the key. Each rock in a row has the texture indicated for that row.
To determine the name of a rock, intersect the appropriate column (color & mineral composition) with the appropriate row (texture) and read the name at the place of intersection.



[1] Also called *phaneritic*. Crystals generally 1–10 mm (1 cm). The term pegmatite is added to the rock name when crystals are greater than 1 cm; e.g. granite-pegmatite.

[2] Also called *aphanitic*. Crystals generally less than 1 mm.

[3] For example, a granite with phenocrysts is called *porphyritic granite*.

[4] Basalt with a cinder-like appearance that develops from gas bubbles trapped in cooling lava (a texture referred to as *vesicular*) is called *scoria*.

Sedimentary Rocks

Detrital & Chemical Rock Classification

Detrital Rocks	Chemical Rocks
Conglomerate	Limestone
Sandstones	Chert (Flint)
Siltstone	Salt (Evaporite)
Shale	

Detrital Sedimentary Rocks

Detrital rocks are classified based on particle size and grain shape

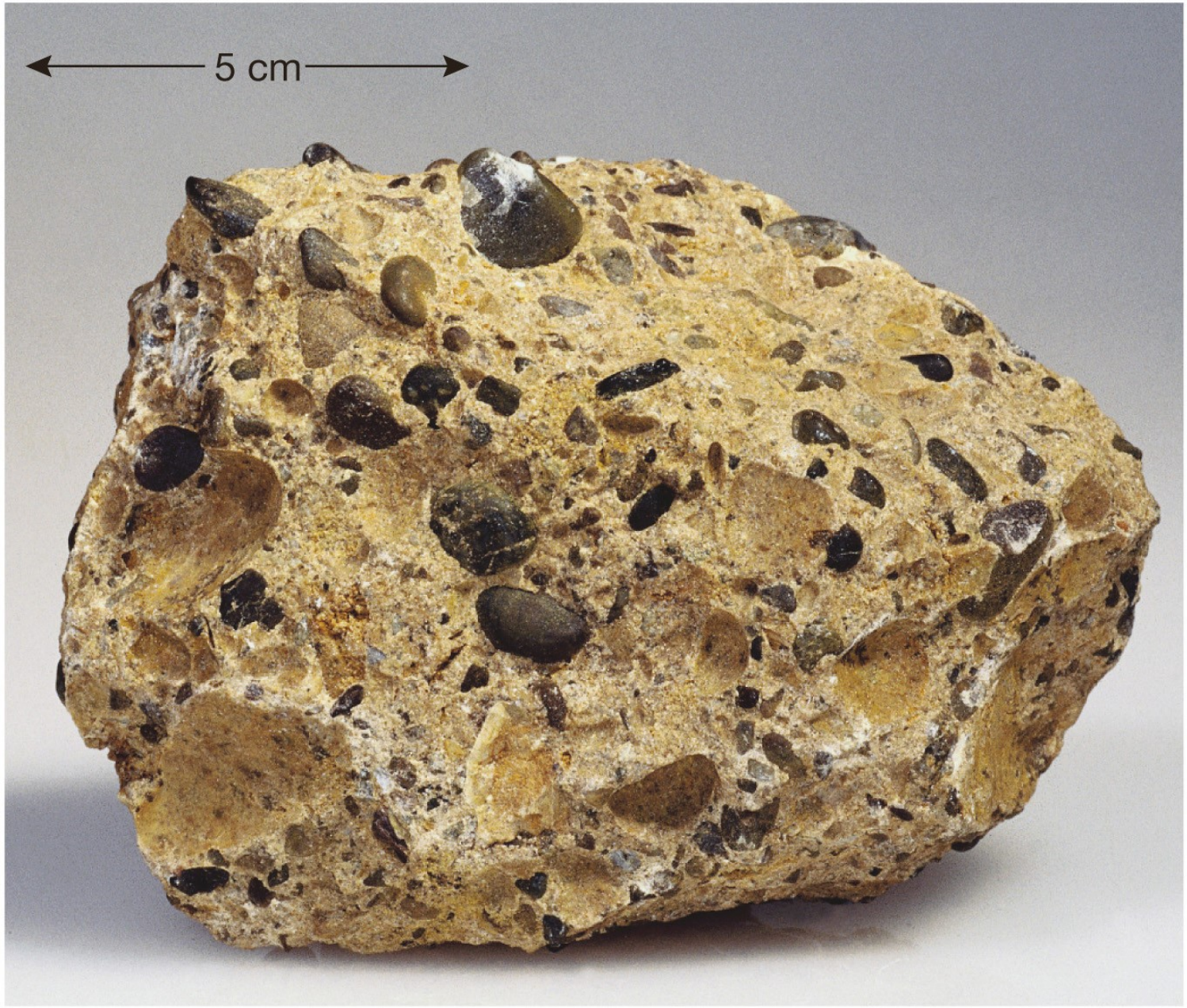
TABLE 7.1 Particle Size Classification for Detrital Rocks

Size Range (millimeters)	Particle Name	Common Sediment Name	Detrital Rock
>256	Boulder		
64–256	Cobble	Gravel	Conglomerate or breccia
4–64	Pebble		
2–4	Granule		
1/16–2	Sand	Sand	Sandstone
1/256–1/16	Silt	Mud	Shale, mudstone, or siltstone
<1/256	Clay		

Detrital Sedimentary Rocks

- Conglomerates
  - Poorly Sorted particle sizes
  - Well-rounded particles
  - Usually particles are gravel sized

(a)



Close up

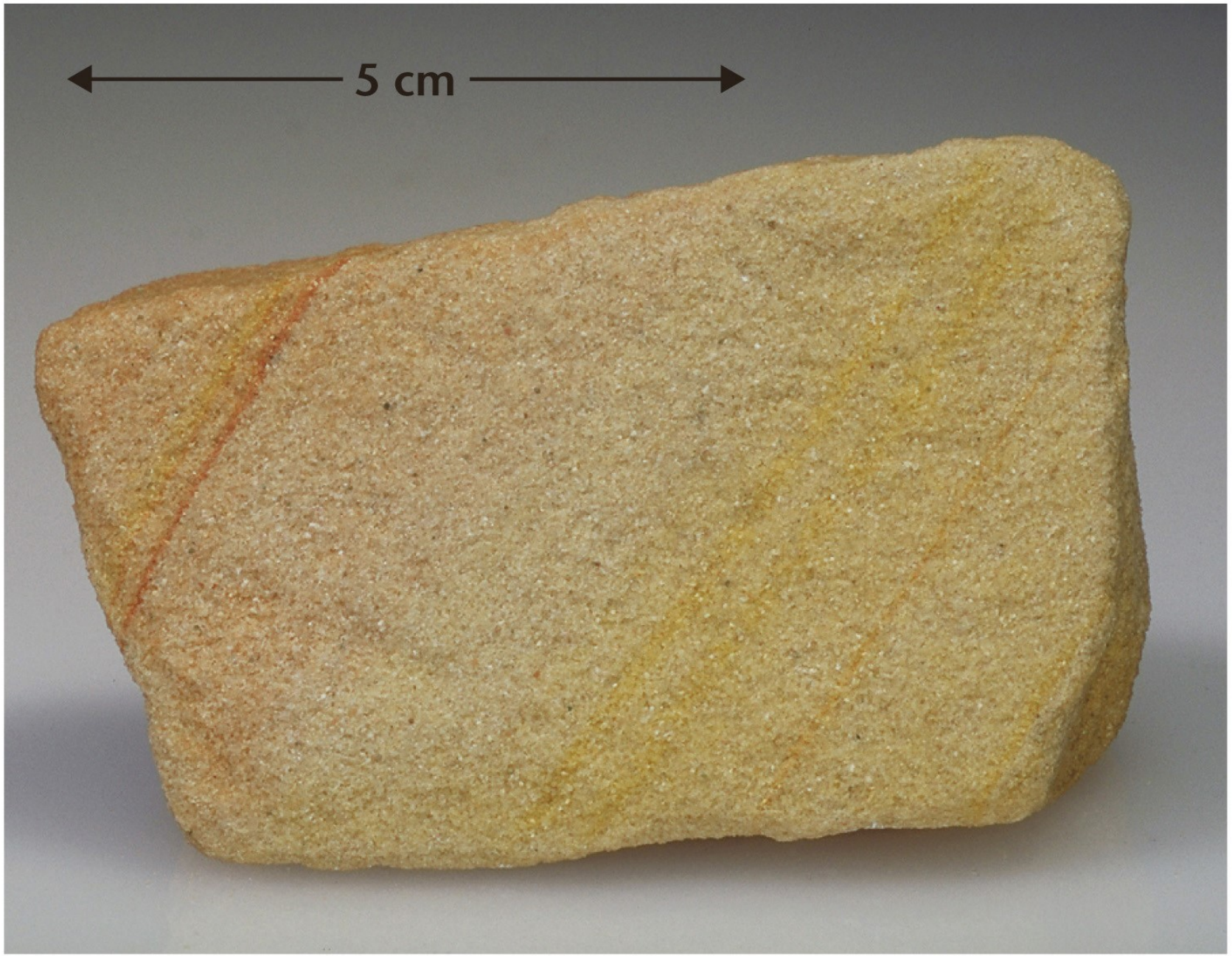
Detrital Sedimentary Rocks

- Breccia
  - Poorly sorted grains
  - Angular grains
  - Gravel sized grains

Close up

Detrital Sedimentary Rocks

- Sandstone
  - Well sorted particles
  - Particles can be angular to rounded
  - Sand-sized Particles



Close up

Detrital Sedimentary Rocks

- Shale
  - Microscopic grain size
  - Consist of silt and clay size grains
  - Cannot see grains with naked eye
  - Occur in “quiet” depositional environments


DNAG
CM
IN
mm

Chemical Sedimentary Rocks

- Classification
  - Inorganic - Not produced by living things.
  - Biochemical - Are produced by or are remnants of living things (e.g. shell fragments, coral reefs, etc)

Chemical Sedimentary Rocks

- Limestone
  - Most abundant chemical rock
  - Inorganic (oolitic limestone, Travertine) or Biochemical (Chalk, Coquina)

Limestone (Chemical Rocks)

- Travertine
  - Common in caves
  - Happen when calcium carbonate is precipitated out of groundwater

Limestone (Chemical Rocks)

- Coquina
  - Consists of loosely cemented shell fragments

Close up

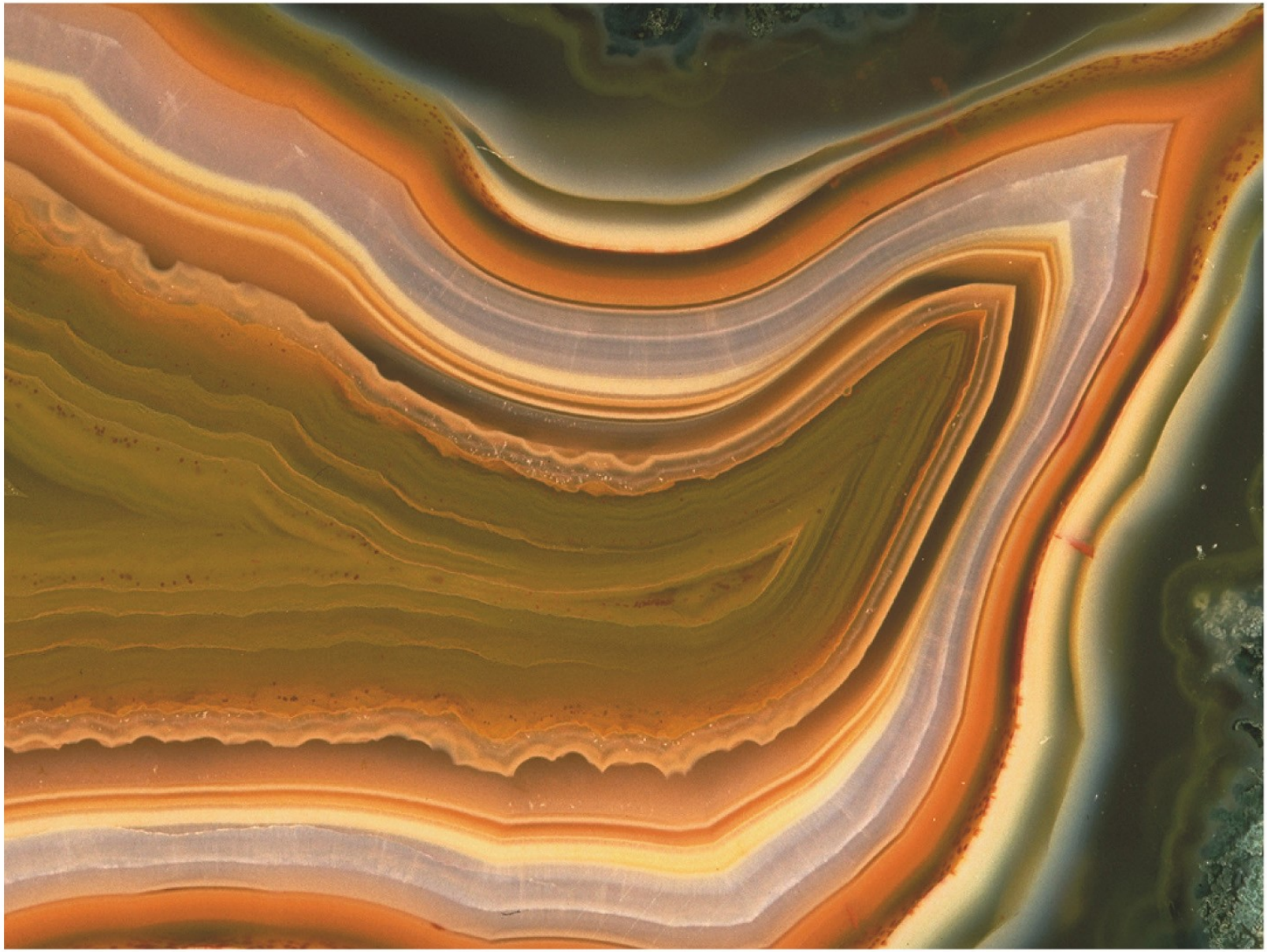

Fossiliferous limestone


Limestone


Fine-grained limestone

Chemical Sedimentary Rocks

- Chert (Flint)
  - Consists of Microcrystalline Silica
  - Two major occurrences of chert
    - Irregular shaped nodules in limestone
    - layers of rock
  - Most likely Biochemical

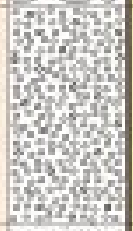
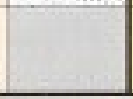


A. Cross-section through a geoid showing silica layering

B. Flint

Table 2.3 Sedimentary rock identification key. Sedimentary rocks are divided into two groups, detrital and chemical, depending upon the type of material that composes them. Detrital rocks are further subdivided by the size of their grains, while the subdivision of the chemical rocks is determined by composition.

DETRITAL ROCKS

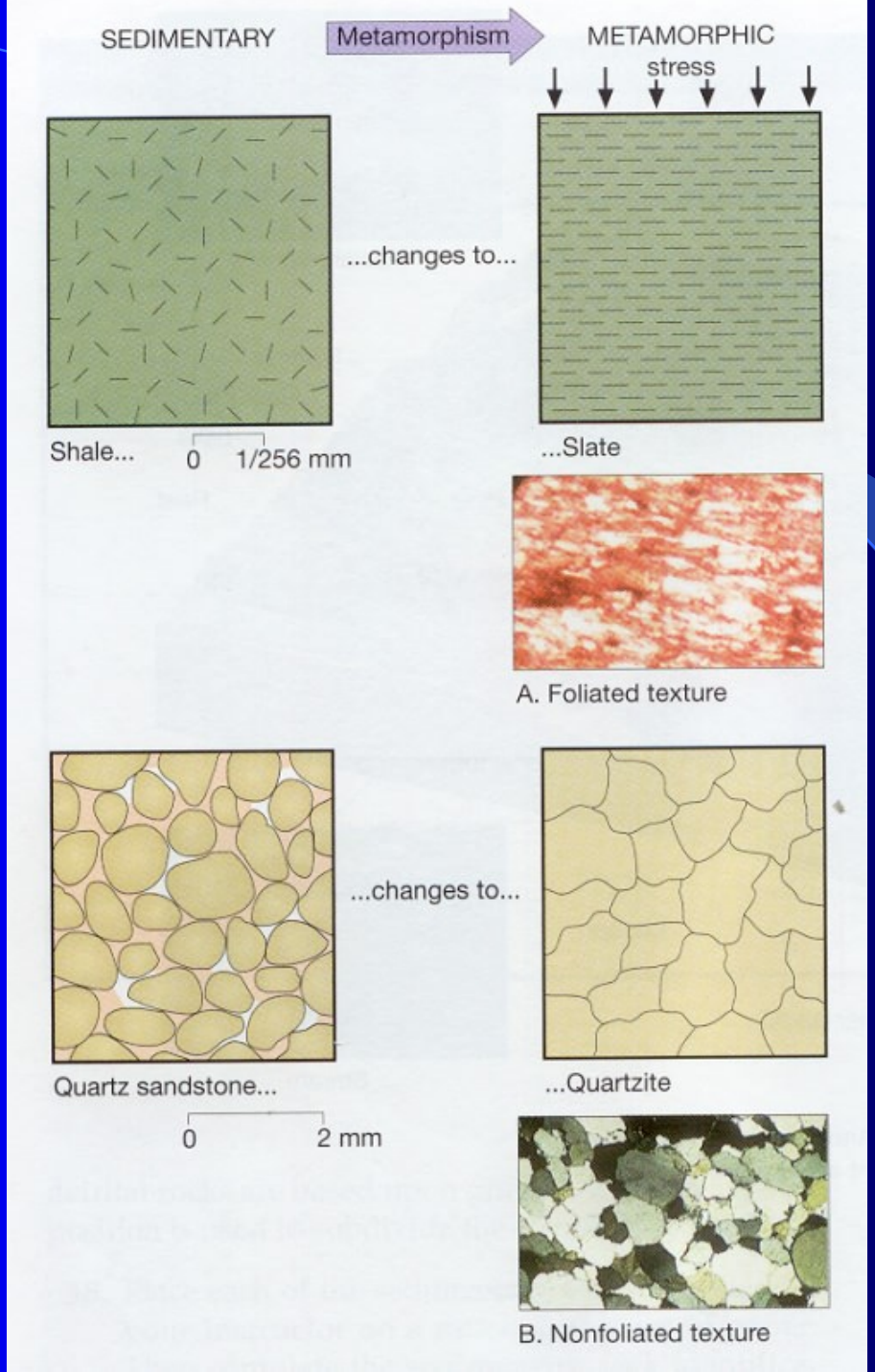
Texture (grain size)		Composition	Rock Name
Coarse (over 2 mm) with large grains		Rounded fragments of quartz and/or chert	**Conglomerate**
		Angular fragments of quartz and/or chert	**Breccia**
Medium (1/16 to 2 mm) feels "sandy"		Quartz usually dominates (If abundant feldspar is present the rock is called **Arkose**)	**Sandstone**
Fine (1/16 to 1/256 mm)		Quartz and clay	**Siltstone**
Very fine (less than 1/256 mm)		Quartz and clay	**Shale**

CHEMICAL ROCKS

Composition	Texture (grain size)	Rock Name	
Calcite, $CaCO_3$ (will effervesce)	Fine to coarse crystalline	**Crystalline Limestone**	
	Visible shells and shell fragments loosely cemented	**Coquina**	Biochemical Limestone
	Various size shells and shell fragments cemented with calcite cement	**Fossiliferous Limestone**	
	Microscopic shells and clay	**Chalk**	
Dolomite $CaMg(CO_3)_2$ (will effervesce if powdered)	Fine to coarse crystalline	**Dolostone**	
Quartz, SiO_2	Very fine crystalline	**Chert (light colored) Flint (dark colored)**	
Gypsum $CaSO_4 \cdot 2H_2O$	Fine to coarse crystalline	**Rock Gypsum**	
Halite, NaCl	Fine to coarse crystalline	**Rock Salt**	
Altered plant fragments	Various size fragments	**Bituminous Coal**	

Metamorphic Rocks

- Classified into two main groups
  - Foliated Rocks
  - Non-foliated Rocks


SEDIMENTARY
Metamorphism
METAMORPHIC
stress
...changes to...
Shale...
0
1/256 mm
...Slate
A. Foliated texture
...changes to...
Quartz sandstone...
0
2 mm
...Quartzite
B. Nonfoliated texture

Metamorphic Rocks

Foliated Rocks

- Progression of Shale to Gneiss
  - Slate — Low Metamorphic Grade
  - Phyllite
  - Schist
  - Gneiss — High Metamorphic Grade

Metamorphic Rocks

Foliated Textures

- Slaty - very fine-grained, fissile
- Phyllitic - fine-grained, foliated, shinny
- Schistose - foliated, large grains visible
- Gneissic - light and dark bands

Slate

- Parent Rock
  - Shale
- Slaty Cleavage

(a) Slate

Phyllite

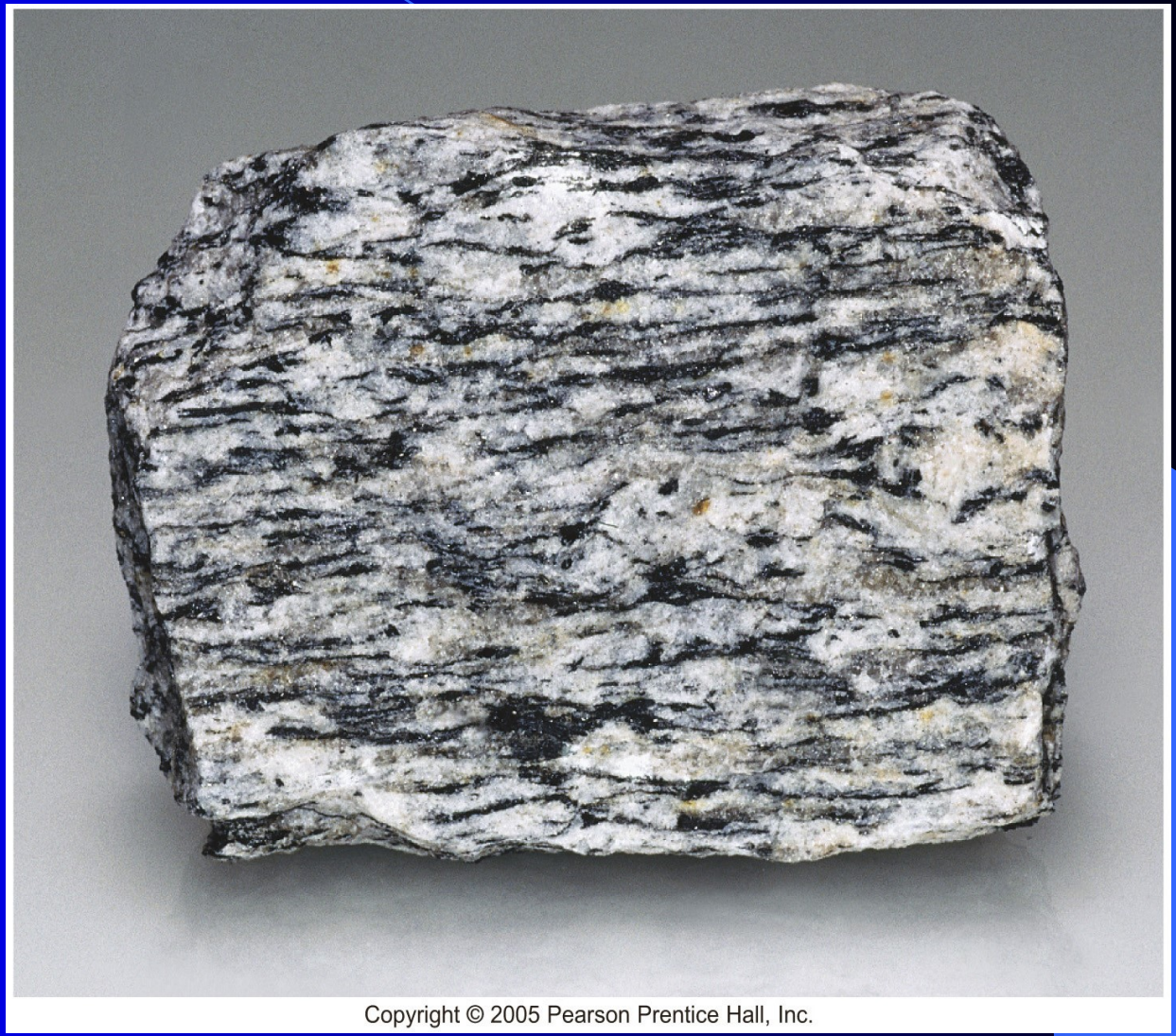
- Parent Rock
  - Slate
- Characteristic sheen/shine
- Phyllitic Texture

Schist

- Parent Rock
  - Phyllite
- Characteristic scaly appearance
- Schistosity

Gneiss

- Parent Rock
  - Schist
- Characteristic of light and dark banding
- Gneissic Texture



Metamorphic Rocks

Non-foliated Rocks

- Rocks that show no Foliation
  - Crystalline Rocks
  - Marble
  - Quartzite
  - Anthracite (coal)

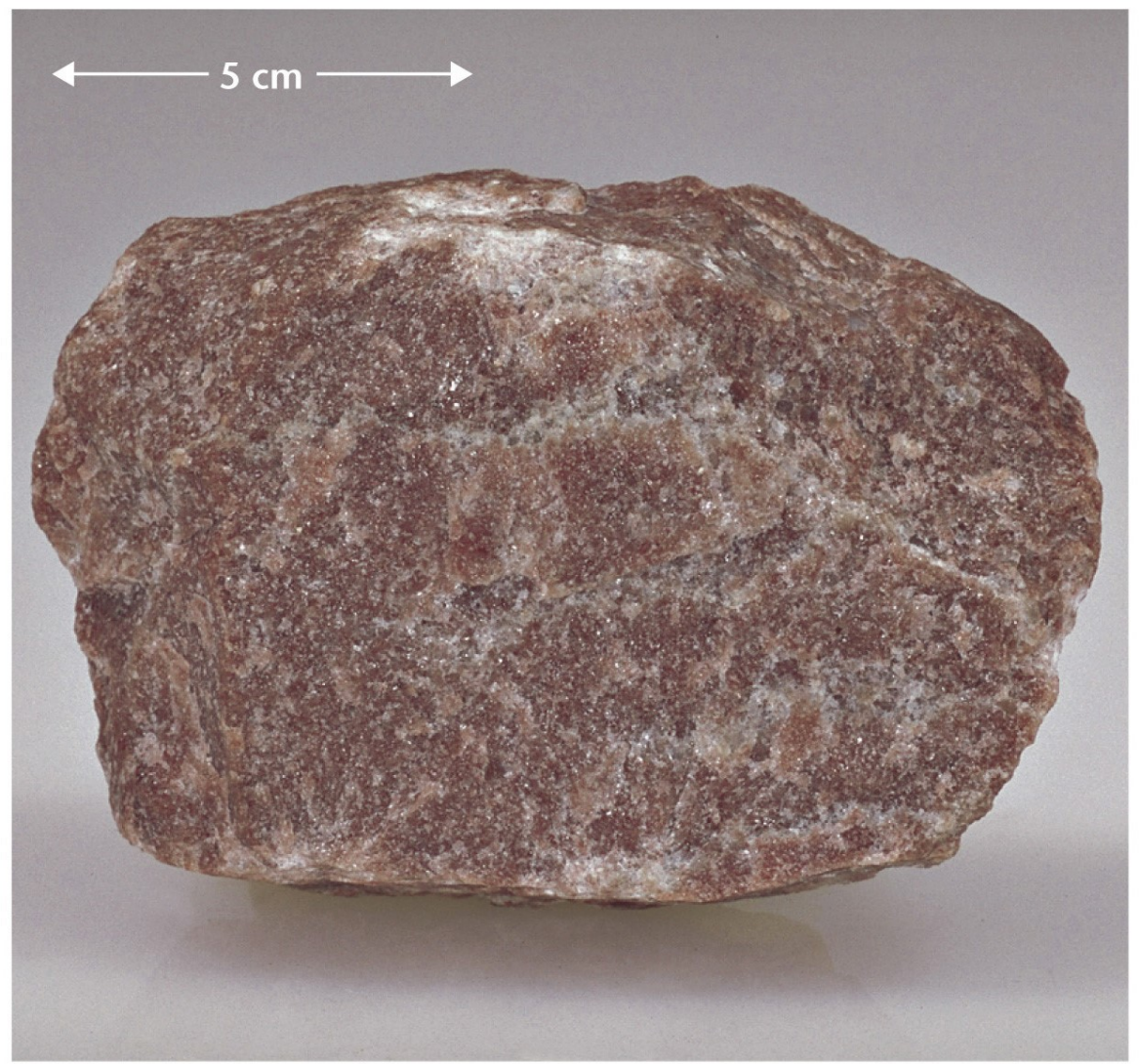
Marble

- Parent Rock
  - Limestone or Dolostone
- Reacts to Acid

(b) Marble

Quartzite

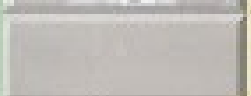
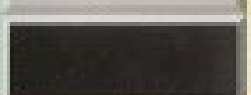
- Parent Rock
  - Sandstone
- Moderate to high metamorphism
- Very Hard



Anthracite (coal)

- Parent material
  - Plant matter
- High metamorphism
- Shinny and hard

Table 2.5 Metamorphic rock identification key. Metamorphic rocks are divided into the two textual groups, foliated and nonfoliated. Foliated rocks are further subdivided based upon the size of the mineral grains.

Foliated	Oriented		Very fine	Slate	Increasing Metamorphism	Excellent rock cleavage, smooth dull surfaces	Shale, mudstone, or siltstone
			Fine	Phyllite		Breaks along wavey surfaces, glossy sheen	Slate
			Medium to Coarse	Schist		Micaceous minerals dominate, scaly foliation	Phyllite
	Banded		Medium to Coarse	Gneiss		Compositional banding due to segregation of minerals	Schist, granite, or volcanic rocks
			Medium to Coarse	Migmatite		Banded rock with zones of light-colored crystalline minerals	Gneiss
Nonfoliated			Medium to Coarse	Marble		Interlocking calcite or dolomite grains	Limestone, dolostone
			Medium to Coarse	Quartzite		Fused quartz grains, massive, very hard	Quartz sandstone
			Fine	Hornfels		Usually, dark massive rock with dull luster	Any rock type
			Fine	Anthracite		Shiny black rock that may exhibit conchoidal fracture	Bituminous coal
			Medium to very coarse	Fault breccia		Broken fragments in a haphazard arrangement	Any rock type