# The Identification of Rocks

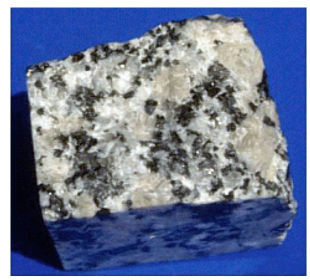
This lab introduces the identification of igneous, sedimentary and metamorphic rocks based on mineralogy (composition) and texture.

## I. Classification of Igneous Rocks

### Textures of Igneous Rocks

For igneous rocks, texture refers to the size, shape and geometry of adjacent minerals in a rock. The texture of an igneous rock is predominantly controlled by composition of the magma/lava and the cooling rate (intrusive v. extrusive).

***Phaneritic*** Texture (coarse grained)
Individual crystals are all large enough to be visible to the naked eye and are all approximately the same size.



***Porphyritic-Phaneritic*** Texture
There are two distinct crystal sizes where both populations of crystals are large enough to be visible to the naked eye. The smaller crystals constitute a *matrix* or *groundmass* and the larger crystals are known as *phenocrysts*.

***Aphanitic*** Texture (fine grained)
Individual crystals are so small that they are not visible to the naked eye

***Porphyritic-Aphanitic*** Texture
There are two distinct crystal sizes where the smaller *groundmass* crystals are too small the be visible to the naked eye and the larger *phenocrysts* are visible to the naked eye.

***Vesicular*** Texture
The sample contains cavities (known as vesicles) from escaping gas. Vesicular texture is common in extrusive rocks and is not a primary texture. Rocks with vesicular texture are commonly *aphanitic* or *porphyritic-aphanitic* in texture. *Phaneritic* rocks are never vesicular.



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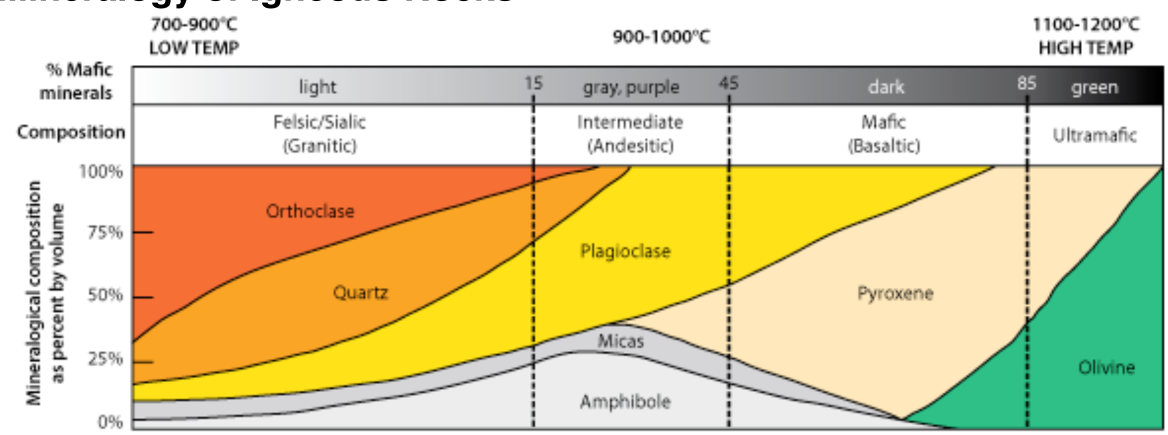
***Glassy*** Texture
Has a glassy appearance and may occur as a massive rock or have a thread-like mesh that resembles spun glass.

***Pyroclastic*** Texture
Consists of broken, angular fragments of ash, glass, pumice and broken crystals.

## Mineralogy of Igneous Rocks




| Texture | Rock names | | | |
|---|---|---|---|---|
| Coarse-grained | Granite | Diorite | Gabbro | Peridotite |
| Fine-grained | Rhyolite | Andesite | Basalt | Uncommon (rarely encountered) |
| Pyroclastic | Rhyolite Tuff | Andesite Tuff | Basalt Tuff | |
| Glassy | Obsidian | | | |
| Vesicular | Pumice (like meringue) | | Scoria | |

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There are three major mineralogic criteria used to classify igneous rocks:

1. presence or absence of quartz - quartz is an essential component of felsic rocks.
2. composition of feldspars - orthoclase (potassium feldspar) and Na-rich plagioclase feldspar are essential minerals in felsic rocks. Ca-rich plagioclase feldspar is characteristic of mafic rocks.
3. proportions of ferromagnesium minerals - mafic rocks are rich in ferromagnesium minerals. Olivine is restricted to mafic and ultramafic rocks. Pyroxene is present in

mafic to ultramafic rocks. Amphibole is most common in intermediate rocks but may occur as an accessory mineral in felsic and mafic rocks. Biotite is a common accessory mineral in felsic to intermediate rocks.

**Recognizing Common Minerals in Igneous Rocks**

| Mineral | Properties |
|---|---|
| K-feldspar (feldspar group) | Usually white to pink/orange<br>Equidimensional crystals |
| Plagioclase (feldspar group) | Usually white (in Na-rich varieties) to dark gray (in Ca-rick varieties).<br>Equidimensional crystals<br>Crystals may show striations |
| Quartz | Colorless to gray<br>Irregular crystal shape<br>May form equidimensional crystals as phenocrysts in extrusive rocks |
| Biotite (mica group) | Shiny and black<br>One perfect direction of cleavage<br>Forms platy crystals |
| Muscovite (mica group) | Shiny and silvery to tan<br>One perfect direction of cleavage<br>Forms platy crystals |
| Hornblende (amphibole group) | Black with shiny, splintery appearance<br>Elongate crystals |
| Augite (pyroxene group) | Black to greenish black to brownish black<br>Glassy to dull luster<br>Blocky crystals |
| Olivine | Light green to yellow-green<br>Glassy luster<br>Small equidimensional crystals |

## II. The Identification of Sedimentary Rocks

The two types of sediment that are produced by weathering are the basis for classifying sedimentary rocks into two categories:

1. Detritral sedimentary rocks are made from solid particles derived from outside the depositional basis
2. Chemical sedimentary rocks are formed by precipitation of ions from solution within the depositional basin.

### Detrital Sedimentary Rocks

Detrital rocks predominantly consist of fragments (rock fragments and mineral grains) that are the debris from other rocks. Detrital rocks are classified by grain size with some subdivisions based on the composition and the shape of the detrital particles.

<table>
<tr><th colspan="2">Rock's Textural and other distinctive properties</th><th colspan="2">Rock Name</th></tr>
<tr><td rowspan="2">Mainly gravel (≥2 mm)</td><td>Rounded grains</td><td colspan="2">Conglomerate</td></tr>
<tr><td>Angular grains</td><td colspan="2">Breccia</td></tr>
<tr><td rowspan="3">Mainly sand (1/16 - 2 mm)</td><td>Mostly quartz</td><td>Quartz Sandstone</td><td rowspan="3">Sandstone</td></tr>
<tr><td>Mainly feldspar and quartz</td><td>Arkose</td></tr>
<tr><td>Sand mixed with silt and clay</td><td>Graywacke</td></tr>
<tr><td>Mostly silt (1/256 - 1/16 mm)</td><td>Breaks into blocks or layers</td><td colspan="2">Siltstone</td></tr>
<tr><td rowspan="2">Mostly clay (≤1/256 mm)</td><td>Breaks into layers (fissile)</td><td colspan="2">Shale</td></tr>
<tr><td>Breaks into blocks</td><td colspan="2">Mudstone</td></tr>
</table>

***Conglomerate*** and ***Breccia*** consist of coarse fragments (>2 mm) that are held together by a matrix of sand, clay and cements (commonly calcite or silica). Conglomerates have rounded particles (pebbles) that indicated that they were transported a long distance from the source region of the sediment. Breccia consists of angular particles;

the angular particles indicate that the sediment was deposited in a region that is close to the source of the sediment (not rounded by transport).

***Sandstone*** is formed from the deposition of sand and are commonly composed of quartz grains. The individual quartz grains may be rounded indicating the degree of transport from the source region. Calcite, silica, and iron oxides are common cements in sandstones.
***Arkose*** is a type of detrital sedimentary rock like sandstone but is composed of >25% feldspar grains. Arkose indicates that the sediment was not transported very far from the source region (otherwise feldspar would have been significantly weathered to form clay minerals).
***Graywacke*** commonly has a darker color than quartz sandstone due to the presence of clay and other minerals (in addition to quartz). Graywacke may be thought of as dirty sandstones and are commonly formed in marine environments from sediment-laden currents carrying sediment from a shelf region downslope to deeper water.

***Siltstone*** is a fine-grained detrital rock composed of clay and silt-sized particles. The silt particles in siltstone commonly feel more abrasive than finer clay particles. Geologist commonly grind a small amount of the material between their front teeth; it feels gritty if it is siltstone and feels slippery or smooth if it is shale or mudstone).
***Shale*** is a fine-grained detrital rock composed of clay particles (<1/256 mm). Shales characteristically have fine bedding where it breaks into layers (due to the alignment of clay particles in the rock) know as fissility.
***Mudstone*** is similar to shale except that it lacks fissility and breaks into irregular blocks (due to the lack of alignment of the clay particles.

## Chemical Sedimentary Rocks

Chemical rocks are precipitated directly from water. Precipitation may be the result of *inorganic* processes such as evaporation. Some chemical sedimentary rocks are the result of biochemical precipitation of minerals by organisms (ex. calcite) to form shells.

**Limestone** is a varied family of chemical sedimentary rocks that are composed predominantly of calcite. The mineral calcite my form inorganically by precipitation from seawater or by biochemical processes where organisms secrete calcite to form shells. Since limestone are composed of calcite, they readily react to acid. There are many varieties of limestone.

***Micritic limestone*** (or micrite) is composed of calcite crystals that are too small to be seen with the naked eye. It is commonly yellow to buff in color.

***Coquina*** limestone is composed of almost entirely of shells and shell fragments that are loosely cemented.

***Chalk*** is composed of microscopic shells (mostly foraminifera) and has a soft, porous, fine-grained texture. It is formed from the accumulation of microscopic shells in a shallow-water environment. Chalk is commonly white to buff in color.

***Oolitic limestone*** is composed of small spherical grains known as oolites that may have a concentric structure. Oolites range in size up to 2 mm in diameter and form by the precipitation of calcite around a grain nucleus composed of another particle or shell. Oolites form by successive precipitation of calcite in shallow water where waves and currents agitate the particles as they form.

<table>
<tr><th colspan="2">Composition</th><th colspan="2">Description</th><th colspan="2">Rock Name</th></tr>
<tr><td rowspan="4">Biochemical</td><td>Mainly plant fragments or charcoal-like</td><td>Black</td><td>dense and brittle or porous and sooty</td><td colspan="2">coal</td></tr>
<tr><td rowspan="5">Mainly fossils shells, fragments or microfossils and calcite crystals<br><br>Effervesces in HCl</td><td colspan="2">Mostly very fine grained to microcrystalline calcite and/or microfossils</td><td rowspan="5">Limestone</td><td>Micritic limestone</td></tr>
<tr><td colspan="2">Porous, poorly cemented mass of shells and shell fragments</td><td>Coquina</td></tr>
<tr><td colspan="2">Mostly very fined grained, earthy, chalky, light-colored mass of microfossils</td><td>Chalk</td></tr>
<tr><td rowspan="5">Inorganic</td><td colspan="2">Spherical grains like tiny beads with concentric laminations</td><td>Oolitic limestone</td></tr>
<tr><td colspan="2">Mostly medium to coarse crystals of calcite</td><td>Crystalline limestone</td></tr>
<tr><td>Mainly dolomite $CaMg(CO_3)_2$</td><td>Micro-crystalline</td><td>Effervesces in HCl if powdered</td><td colspan="2">Dolostone</td></tr>
<tr><td>Mainly varieties of silica</td><td>Micro-crystalline Conchoidal fracture</td><td>scratches glass</td><td colspan="2">Chert</td></tr>
<tr><td>Mainly gypsum $CaSO_4 \cdot 2H_2O$</td><td>Crystals formed as inorganic chemical precipitation</td><td>Can be scratched with your fingernail</td><td colspan="2">Rock Gypsum</td></tr>
</table>



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***Crystalline limestone*** is composed of tight interlocking calcite crystals that are large enough to see with the naked eye. Crystalline limestone is commonly formed in shallow seas.

***Dolostone*** is a chemical sedimentary rock that is similar to limestone but is composed predominantly of a different carbonate mineral dolomite (instead of calcite). The mineral dolomite may be distinguished from calcite with the acid test. Whereas calcite readily reacts to acid, dolomite reacts when powdered.

***Chert*** is a commonly chemical sedimentary rock that forms from the precipitation of silica (microcrystalline quartz). It may have a wide range of colors. Since is is composed of quartz, it is characterized by a hardness of 7 and the common presence of conchoidal fracture.

***Rock Gypsum*** is a chemical precipitate that is composed almost exclusively of the mineral gypsum. Gypsum commonly ranges in color from orange to light red and is characterized by the low mineral hardness of gypsum (Mohs hardness = 2). Gypsum forms from evaporation of seawater in a closed basin and arid environment.

***Coal*** is composed of highly altered plant remains that forms from the burial of swamp deposits. It is opaque and ranges in color from brown to black. Coal does not neatly fit into our categories of rocks and is commonly considered a chemical sedimentary rock.

**Recognizing Common Minerals in Sedimentary Rocks**

| MIneral | Properties |
|---|---|
| Quartz | White to light gray<br>Hardness = 7 |
| Chert (microcrystalline quartz) | White, gray, black, red, green<br>Extremely fine-grained<br>Smooth, conchoidal fracture |
| Feldspar | K-feldspar most common in sedimentary rocks.<br>White to pink in color<br>Commonly angular |
| Clay | White, gray, green, red, black<br>Very fine particles<br>Soft (H = 1 - 2.5) |
| Iron Oxide (hematite common) | Yellow to orange to red and is strong coloring agent<br>Mainly found as cement in sedimentary rocks |

| MIneral | Properties |
|---|---|
| Calcite | White to gray to black<br>Essential constituent of limestones<br>Hardness = 3<br>Reacts vigorously to acid |
| Dolomite | Gray to buff in color<br>Hardness = 3.5<br>Bubbles slowly in acid but more vigorously when powdered |
| Gypsum | White to orange to light red<br>Soft (H = 1) |

## III. The Identification of Metamorphic Rocks

Metamorphic rocks form from rocks that were previously igneous, sedimentary or other metamorphic rocks through the process of *metamorphism.* Metamorphism changes the character of the rock because of a change in the environmental conditions such as increased temperature, pressure and the presence of chemically active fluids. Metamorphism occurs incrementally, from slight change (low-grade) to dramatic change (high-grade) from the *parent rock*. The *parent rock* is the original rock before metamorphism.

### Metamorphic Textures

The degree of metamorphism that a rock is subjected to is reflected in its mineralogy and texture (shape and orientation of minerals).

There are two major types of textures that develop during metamorphism:

1. Foliated texture. The orientation of the minerals in some metamorphic rocks will align themselves, giving the rock a layered or banded appearance. The mineral grains realign and recrystallize perpendicular to stress. *Foliated* texture is characteristic of differential stress and regional metamorphism. The image to the right shows a gneiss where the minerals are oriented in the same direction.
2. Non-foliated texture. Not all metamorphic rocks develop a foliated texture — there are a number of metamorphic rocks with nonfoliated texture where there is no

alignment of the minerals. Nonfoliated texture is characteristic of uniform confining pressure and contact metamorphism.

## Common Foliated Metamorphic Rocks

***Slate*** is a low-grade, very fine grained foliated rock composed of microscopic grains of quartz, mica and other minerals. The alignment of the platy minerals gives slate excellent *rock cleavage*. Shale, mudstone, and siltstone are the common parent rocks of slate.

***Phyllite*** is a low- to moderate-grade foliated rock composed of microscopic grains of quartz, mica, and other minerals. Although the crystals are microscopic, they are large enough to give it a shiny luster relative to slate. It commonly breaks along wavy surfaces. Phyllite is the result of the progressive metamorphism of a slate, thus the parent rock is slate (although the original parent of the slate was a fine-grained sedimentary rock).

***Schist*** is a moderate- to high-grade rock where the platy minerals (micas) (>50%) are large enough to see with the naked eye. Schist commonly forms crystals that are characteristic of metamorphism (such as garnet or staurolite). Schist is the result of the progressive metamorphism of a phyllite, thus the parent rock is phyllite.

***Gneiss*** is a high-grade metamorphic rock where the minerals have segregated into alternating bands of light and dark minerals and may or may not possess rock cleavage. Gneiss may form from the progressive metamorphism of schist or from the high-grade metamorphism of granitic rocks. Common minerals include feldspars, quartz, micas and other metamorphic minerals (such garnet).

## Common Non-foliated Metamorphic Rocks

***Marble*** is a metamorphic rock that forms from the metamorphism of limestone or dolostone (parent rock).

Although there may be some change in mineralogy, they contain the same minerals (calcite or dolomite) as the parent rock. Marble is commonly white, gray or pink and may have a texture that is fine- to coarse-grain.

***Quartzite*** is formed from metamorphosed quartz sandstone. During metamorphism, the quartz sand grains to fuse together to form a rock with a fine- to coarse-grain. Since quartzite is composed of fused quartz, it is a very hard rock.

## Recognizing Common Minerals in Metamorphic Rocks

| MIneral | Properties |
|---|---|
| K-feldspar | White to pink; commonly forms crystals that are stubby (equidimensional) crystals or rounded; cleavage in 2 directions |
| Plagioclase feldspar | White to gray; commonly forms crystals that are stubby (equidimensional) or elongate; striations may be visible; cleavage in 2 directions |

| | |
|---|---|
| Quartz | Commonly colorless or grey in metamorphic rocks; crystals are irregular in shape; glassy luster |
| Biotite Mica | Black to brown; excellent cleavage in one direction forms platy crystals; flat crystals align with direction of foliation |
| Muscovite Mica | Silvery to tan; excellent cleavage in one direction forms platy crystals; flat crystals align with direction of foliation |
| Hornblende Amphibole | Commonly black in metamorphic rocks; elongate crystals may look splintery; 2 good directions of cleavage not at 90°; elongate crystals align with direction of foliation |
| Garnet | Red to brown common; forms equidimensional or 12-sided (soccer ball) or rounded shapes; characteristic of metamorphic rocks |
| Staurolite | Brown to black; may form elongate crystals that are cross- or x-shaped crystals; vitreous luster |
| Kyanite | Light blue to gray; forms elongate blade-shaped crystals that may look splintery |
| Talc | White to gray or green; pearly luster; soft H=1 |
| Serpentine | Commonly multi-colored mass ranging from black to green to greenish gray; commonly does not form good distinct crystal shapes; when present, it dominates the rocks (few other minerals) |
| Calcite | Usually white but may be gray or pink, forms fine-grain aggregate to large crystals; 3 directions of cleavage not at 90°; reacts to acid |
| Dolomite | Usually white to pink; fine-grained aggregate to large crystals; 3 directions of cleavage not at 90°; reacts to acid when powdered |