etracy11037 2021 SSSS Rocks and Minerals Notes

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Borates

Ulexite

- Named after George Luxwig Ulex (Germany), who first discovered it
- Forms in arid regions (saline lakes and salt playas)
- Yellow-white under UV
- Extremely fibrous
- Processed into borax
- Acicular (“bunny’s tail”) form: has thin, radiating needles coming out of the main rock, very rare
- Generally found just above the borax in mines, which is much more desirable so the ulexite is mined through and often destroyed
- Optical (“TV rock”) form: the needles grow parallel to each other. When cut perpendicular to the needles and placed over a paper, the words appear to be transmitted to the top of the mineral
- Clam Shell Variety: found at top of borax in the blue/green/tan shale. Resembles a clam shell and is not particularly desirable
- Popcorn Ulexite: looks like cauliflower. Made of white, knobby masses of parallel fibers and is often found in boron mud

Carbonates

Azurite

- Used as ore for copper, pigment, and gemstone
- Formed when carbon dioxide filled waters get into the earth and react with copper ores and dissolves part of the copper. This copper eventually might become azurite in the right conditions
- Generally forms in pores or cavities in other rocks
- Usually massive and nodular
- Very rarely monoclinic
- Azurmalachite forms when azurite and malachite form in the same place (formed by similar process)
- Found in Arizona, New Mexico, and Utah. Plus France and Namibia
- Slight fizz (effervescence) with dilute hydrochloric acid
- Often found in rocks above copper ore (indicator mineral)
- Not modernly used as copper ore, but can be smelted into copper if necessary (Egyptians did it)
- Azurite granite (“K2 granite): named after the mountain it was found near. Made of white granite with blue orbs of azurite inside
- Ground and used as blue pigment and paint
- Azurite blueberries: small nodules of azurite, weathered out of loose sandstone
- Color sometimes fades

Crystal azurite

azurite granite

Azurite blueberries

azurite with a bit of malachite

Malachite

- Luster:
    - Crystals: vitreous (rare)
    - Fibrous: silkey
    - Massive: dull and earthy
    - Polishes well
- Copper ore (one of the first used)
- Small quantities found today, so rarely used for mining
- Color never fades
- Forms in oxidation zones shallowly underground (see azurite for more)
- Can often form within limestone
- Found in Egypt and Israel once, now only in Ural Mtns (russia), Congo, Australia, France, and Arizona
- Effervesces in dilute HCL to produce green liquid
- Often found as stalactites or botryoidal (grape-like) coverings on underground cavities
- Tabular crystals (thin, flat crystals) are rare but possible
- Used as a green pigment (sometimes called copper green)
- Azurmalachite forms when azurite and malachite form in the same place (formed by similar process)
- Banded malachite: bands are found inside of the botryoidal structure

Banded

stalactic

botryoidal

polished/cut

Aragonite

- A stable form of calcium carbonate, similar to calcite but with different structure
- Orthorhombic crystals separate it from calcite
- Most crystals are twinned (repeated) growths of pseudohexagonal (hexagon shape, but not hexagon crystals) trillings (3 orthorhombic crystals that twin at the center and form a pseudohexagon)
- Sometimes grows unstable and turns into calcite, while retaining the original shape (the new calcite is called a pseudomorph)
- Sometimes copper is also a pseudomorph of aragonite
- Brown color comes from sand inclusions
- Softer than calcite
- Forms in hot, mineral-rich springs when the water flows out of the spring but leaves the calcium carbonate behind (when banded, these deposites are called onyx marble)
- Forms pearl and coral
- Found and named by Abrahan Gottlieb Werner after Molina de Aragón, Spain

Needle spray

pseudohexagon

onyx marble

Interconnected group

elongated crystal

Calcite

- Main component of limestone and marble
- Limestone formation traps and stores carbon dioxide
- Some consider it an “ubiquitous mineral” or one that is found everywhere
- Often forms twinning scalenohedrons (shape with 3+ pains of scalene triangle faces)
- Nailhead spar: shallow rhombohedral terminations shape (rhombus shaped)
- Optical spar: highly transparent
- Name comes from latin for burnt lime (calx), referring to its use in lime
- Effervesces in cold HCL
- Generally found in shallow marine places, hot springs, hydrothermal veins
- Used in paper, paint, tires, plastic, animal shells, food for animals, and as limestone for construction
- All water contains dissolved calcium and carbon dioxide (calcite dissolves into these ions easily)
- Double refracts light (when placed on paper it creates 2 sets of words)



Dolomite

- Primary component of dolostone and dolomitic marble
- Rarely found outside of rock form
- Most rocks containing dolomite started with lots of magnesium and were deposited in calcium carbonate mud
- Often found in hydrothermal veins
- Rhombohedral crystals with rounded faces
- Very little reaction to cold dilute HCL, more reaction when powdered or the HCL is warm
- Slightly stronger than calcite
- Yellow with iron, pink with manganese
- Dolostone is used in roads, but no use for dolomite other than acid neutralization
- Often a host rock for lead, zinc and copper. When acidic water with those minerals goes upward and encounters dolomite, it reacts and the minerals precipitate out (as the dolomite neutralizes the acid)
- When calcium turns to dolomite, pores form in the mineral, which is often filled with oil or natural gas

Crystals

dolomitic marble

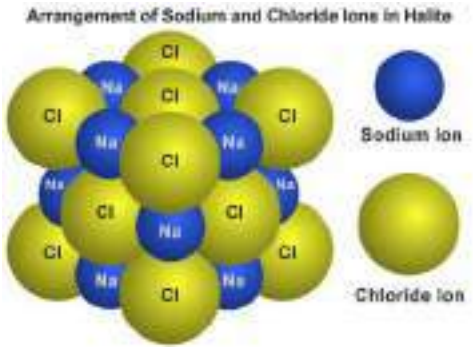

dolostone

Dolomite aggregate (dolostone used for paving)

Halides

Halite

- Literally just salt
- Rock salt is a rock made up of halite
- Forms in arid climates when the ocean evaporates
- Salt domes: formed when a thick layer of salt is covered by lots of sediment and the salt then “erupts” upwards. They often contain sulfur
    - Caused by the pressure on the salt layer forcing part of it upward (similar to how a mercury thermometer works)
    - Often cause rocks to deform, leaving pockets that fill with oil



Fluorite

- Called “fluorspar” in mining industry
- Only common mineral with 4 directions of perfect cleavage, often breaks into an octahedron
- Produces blue glow under UV light. This property was discovered by George Gabriel Stokes, who named fluorescence after the mineral
    - Thought to be fluorescent only when small amounts of yttrium, europium, samarium, or other elements substitute for calcium
- Generally found as vein fillings in rocks subject to hydrothermal activity
- The veins often contain useful metal ores
- Also found in fractures and vugs (small cavity inside a rock) of limestones and dolomites (rock)
- Can be massive, granular, or euhedral (bound as a crystal by itself) as octahedral or cubic crystals
- Fluorspar is sold in three grades:
    - Acid Grade: high purity (+97%). This is the most commonly used grade in the US. Used to make hydrochloric acid
    - Ceramic Grade: medium purity (85-96%). Used in making glass, ceramics, and enamelware. It makes glazes and nonstick coatings such as teflon and is used in many products to strengthen glass
    - Metallurgical Grade: 60-85%. Used in the production of steel, iron, and other metals. It is used as a flux that removes impurities such as sulfur from the metal. 20-60 pounds per ton of metal.
- Other grades:
    - Optical Grade: high quality fluorite with optical clarity is often used as a lens due to its low refractive index and dispersion. Generally mixed with other materials to produce a synthetic lens
    - Lapidary Grade: fluorite with exceptional color and clarity, used to make gemstones. Often treated with a coating, as fluorite is very weak



Hydroxides/Oxides

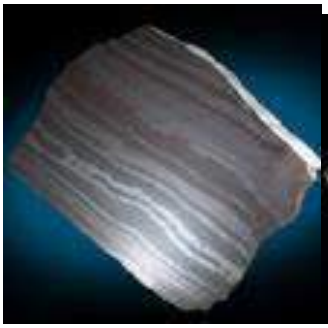
Magnetite

- Strong attraction to magnets
- Lodestone: magnetic form of magnetite (only naturally magnetic mineral). Often found with small iron particles clinging to it
- Oxidizes in wet environments
- Hematite is a pseudomorph of magnetite and is called martite. However, it is only weakly attracted to magnets and has a reddish-brown streak
- Often found in igneous rock or contact metamorphic rocks
- Often found in hydrothermal replacement deposits
- Rarely in sedimentary rocks
- Titano-magnetite: titanium-rich magnetite
- Chrome-magnetite: chromium rich magnetite
- Taconite: banded rock made up of layers of magnetite and red chert
- Important ore of iron

Octahedral form

cubic form

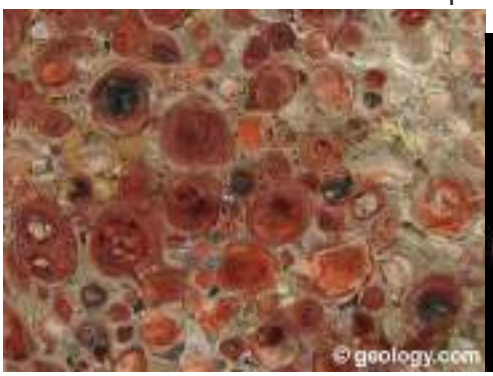
lots of octahedral form

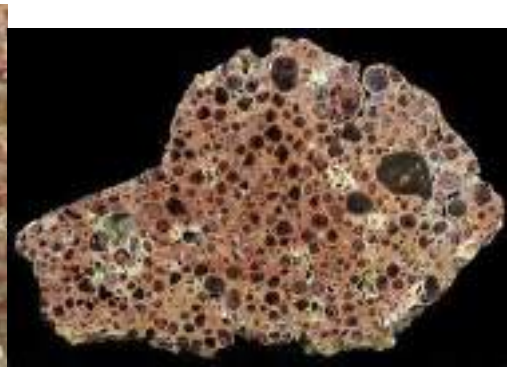


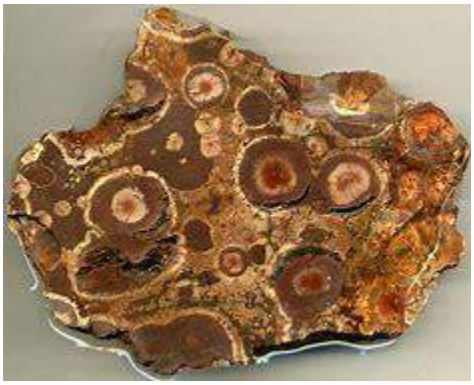
Taconite

Bauxite

- Not actually a mineral, instead a mix of aluminum oxides
- Important source of aluminum ore
- Named after French village Les Baux, where it was first used as an Al ore
- Often formed from (but not necessary): boehmite, diaspore, gibbsite, goethite, hematite, kaolinite, limonite. More or less in order of importance
- Formed when laterite soil (soil rich in Aluminum and iron) loose their silica and other soluble materials. Forms in tropical/subtropical climates
- Purification using bayer process
    - Crush bauxite and wash in hot sodium hydroxide solution (leeches Al from bauxite)
    - Precipitate out aluminum in form of aluminum hydroxide ($Al(OH)3$)
    - Aluminum hydroxide is calcined to form alumina ($Al2O3$)
    - Dissolve alumina in molten cryolite ($Na3AlF6$) and remove the aluminum using electrolysis (This step is called the Hall-Heroult Process)
- Calcined alumina is very hard (9 on mohs) so it is often used as an abrasive in sandpaper and for sand-blasting
- Also used as a proppant (fills gaps in rocks) in oil fields
- Is a pisolite: a sedimentary rock made of pisoids, or grains of calcium carbonate that are 2+ mm in diameter. These pisoids are generally layered and create rings in the rock







Corundum

- Extremely hard and used as an abrasive
- When taking the form of transparent crystals, it is used as a gemstone
- Chemically stable, which gives it even more uses as windows and wafers for circuit boards
- Ruby: red, crystal corundum
- Sapphire: blue crystal corundum
- White sapphire: colorless corundum
- Fancy sapphire: any other color corundum
- Often in igneous syenite, nepheline, and pegmatite
- Can be found in contact metamorphic rocks, including schist, gneiss, and marble
- Often concentrated in alluvial (loose soil) deposits due to its hardness
- Emery stone: granular metamorphic or igneous rocks with lots of corundum. Generally includes other oxide materials too, including magnetite, spinel, and hematite
- Used in lasers

Crystal corundum

Hematite

- Most important iron ore and a key component in many rocks of all types
- Mined in: China, Russia, Australia, Brazil, India, Ukraine, South Africa, Venezuela, Canada, and the US
- Also used for pigments, radiation shielding, and ballast
- Red streak is the key identifier, as it varies greatly in shape, luster, and color
- Not magnetic unless it contains amounts of magnetite (sometimes leads to confusion with it being magnetite or pyrrhotite)
- Specular hematite (or micaceous hematite): shiny luster and appears to be made of layers of mica flakes. Is actually made of many hematite crystals. Crumbles easily
- Made of about 70% iron and 30% oxygen by weight
- Banded iron formations (sometimes called tacomite): alternating layers of hematite and shale. Formed when iron in the oceans mixed with oxygen in the air and fell in layers to the seafloor
- Can crystalize during magma differentiation or precipitate from hydrothermal liquid moving through rocks. Also forms from contact metamorphism
- Generally a sign of lots of oxygen in the air
- Abundant on Mars
- Name comes from greek for “blood red” (haimatitis) due to its powdered form’s color






Specular magnetite

banded iron formation

Goethite/Limonite

- Goethite
    - Named by Johann Georg Lenz in honor of German poet, politician, and geoscientist Johann Wolfgang von Goethe
    - Often forms as a pseudomorph of other minerals, including marcasite, pyrite, sidersite, and gypsum
    - Generally a dark, dull mineral, but some form botryoidal (grape cluster) crystal structures (this is common in Colorado)
    - Sometimes forms crystal sprays on dusty quartz
    - Will become attracted to magnetic fields when heated
    - Often forms as a secondary mineral in hydrothermal replacement deposites, in igneous pegmatite (large grains of the mineral) or basalt, and in limestones, sandstones, and clay
    - Rarely in metamorphic rock
    - Sometimes called bog iron, bog iron ore, brown iron ore, and wood iron
    - Turgite: goethite mixed with hematite
    - Used as iron ore




Botryoidal acicular spray after selenite

- Limonite
    - No defined chemical structure, making it not a true mineral
    - Considered a gossan, or a rock that has oxidized and decomposed. Other rocks often fill it
    - Forms coloring in many soils
    - Fibrous limonite is generally goethite or goethite that has absorbed water
    - Often a pseudomorph of the same minerals as goethite
    - Never forms crystals
    - Sometimes called bog iron, bog iron ore, brown iron ore, and wood iron




Pseudomorph: pyrite stalactite calcite marcasite

Native Elements

Diamond

- Composed of carbon atoms that are each surrounded by exactly 4 other carbon atoms with strong covalent bonds
- Chemically resistant and has highest natural thermal conductivity
- High index of refraction and high dispersion, making it a good gemstone and used in lenses
- Forms from high pressure and heat about 100 miles deep in the earth's surface (in the mantle)
- Delivered to the surface by xenoliths, or chunks of rock that are carried upward by volcanic eruptions without melting
- Also form in subduction zones (when one tectonic plate is forced downward by another) or are delivered in meteorites (however both of these are rare)
- Gemstone diamonds have a specific gravity of about 3.52, while most have between 3.4-3.6 due to impurities
- Diamonds not suitable for gemstones are generally used in industry to cut things or as abrasive
- Diamond's high dispercion on light can create rainbows
- Birthstone of April
- Diamond quality factors:
    - Color: based on intensity, purity, and quality of color. 1/10,000 diamonds is considered a "fancy" in color
    - Clarity: no fractures or impurities
    - Cut: how well the stone is cut by the craftsman
    - Carat: size of the diamond (⅕ of gram and 1/142 of an ounce)
- Sometimes also used as heat sink and as water-resistant parts
- Diamond stimulants: gems that look like diamonds but are chemically different (ie zircon or sapphire)
- Synthetic diamonds are created using high pressure and temperature (HTHP) or a chemical vapor deposition process (CVD)



Diamond "fire" (color dispersion)


Copper

- Found in oxidized zones of copper deposits, hydrothermal vents, in the cavities of basalt that came in contact with hydrothermal liquid, and as pore fillings in conglomerates that came in contact with hydrothermal liquid
- Usually very small deposits and is instead extracted from sulfide deposits
- Most used in electrical wiring and cooking utensils (highly conductive)
- Also used in brass (zinc) and bronze (tin)
- Pure copper is commonly found in Keweenaw, Michigan
    - Halfbreeds: interlocking copper and silver that are commonly found in Keweenaw
- Very ductile, letting it be manufactured into various items
- Nickle silver/German silver: copper, nickel, and zinc alloy that looks like silver (60% copper, 20% nickel, 20% zinc)
- Money metal: copper and nickel alloy

Oxidized copper dendritic copper formation

Silver

- Precious metal: is rare and is extremely valuable
- Has the highest electrical and thermal conductance of all minerals
- Rarely found as a native element
- When found as NE, it is generally found with quartz, gold, copper, sulfides, arsenides, or other silver minerals
- Rarely found in large amounts
- Found in oxidized zones above ores due to its lack of ration with oxygen and water
- Acanthite coating: caused by a reaction with hydrogen sulfide (in the atmosphere or hydrothermal liquid) that tarnishes the silver
- Found in hydrothermal veins and cavities
- Generally forms flakes, plates or dendritic crystal patterns. Sometimes forms filiform (tentacle-like) or wirey crystals
- Acanthite, proustite, and pyrargyrite are the only ores that are found in large enough amounts to warrant mining
- Electrum: alloy of gold and silver, forms naturally if gold mixes with 20% silver. A lot of silver comes from refining this alloy
- Forms a natural alloy with mercury, which is commonly found in silver deposit oxidation zones near cinnabar
- Often obtained from copper, lead, or zinc mining where it appears as an intrusion or part of the mineral

2013 Silver Production

Country	Metric Tons
Mexico	5,360
China	3,900
Peru	3,480
Australia	1,730
Russia	1,500
Bolivia	1,210
Chile	1,190
Poland	1,150

copper with silver

silver wire

crystals of silver

United States	1,060
Canada	663
Other Countries	4,230

Gold

- Resistant to tarnish
- Most gold found in nature is in NE form (not ores)
- Found in hydrothermal veins deposited by ascending solutions, as disseminated (scattered) particles in sulfide deposits, and in placer deposits
- Does not oxidize
- Mostly used in jewelry, about 10% is used for coins and 12% for other things, like machinery and pigments
- Vein gold: gold found in the veins of quartz
- Almost always has traces of silver, and often traces of copper and iron (gold nuggets are normally 70-95% gold, with the rest being silver)
- Gold ore is generally brown, iron stained rock or white quartz, and neither contains much gold
- Gold nuggets form when a chunk of gold gets broken off its mother rock before it gets carried downstream by a river which rolls it into its distinctive shape
- Most ductile and malleable mineral (can be flattened to .00001 of an inch/.000065 cm and 1 ounce can stretch 50 miles)
- Roasted gold: gold that merged with dissolved sulfides due to heating
- Electrum: alloy of gold and silver (75% gold)
- Picture rock: gold veins in quartz

Dendritic crystals

gold leaf

nugget

Picture rock

Sulfur

- Impurities of clay and selenium can cause it to be red, green, brown, or grey
- Often found in petroleum deposits
- When made wet or kept in moist conditions, it combines with hydrogen to form hydrogen sulfide (H2S) and it deteriorates
- Cracks when exposed to mild heat, even body heat
- Should be kept out of sunlight (even that can cause cracking)
- Earthy and massive specimens from volcanic sulfur springs have small bubbles throughout and have a strong rotten-egg smell
- Sulfur mining destroys the crystals by pumping hot water into the sulfur, melting it into a brine which is then brought to the surfaces and evaporated, only leaving the sulfur behind
- Rosickyite: monoclinic form of sulfur (very rare). Sometimes classified as its own mineral
- Sometimes found in salt domes where sulfates are broken down by bacteria
- Also found in volcanic deposits and hot springs as a result of sublimation
- Aka brimstone

Foamy sulfur

Rosickyite

Graphite

- Extremely soft and cleaves with almost no pressure
- Extremely heat resistant and used as a heat sink
- Needs 75,000 pounds/square inch of pressure and 750 degrees C to form under the earth's crust
- Flake graphite: made from regional metamorphism from shales and limestones, which turn into marble, schist, and gneiss. These are then crushed into graphite
- Amorphous graphite: made from coal seam metamorphism. The coal is subject to high heats, which destroys the other organic molecules in the coal, only leaving the carbon which forms crystals
- Also forms from hydrothermal metamorphism, which forms crystals
- Generally formed above diamond (D in mantle, G in crust)
- Atoms linked in hexagons that form thin sheets that are 1 atom thick

Crystal graphite

layers

Rounded graphite

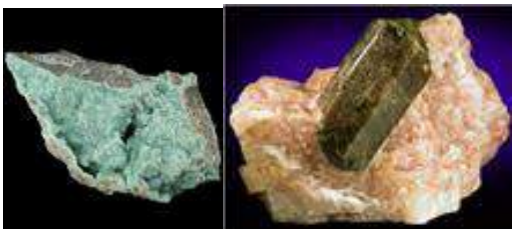
flake graphite

Phosphates

Apatite

- Named after deceit in Greek (apate), as it looks like other minerals
- Describes a group of similar hexagonal phosphate minerals
- Main source of phosphorus required by plants
- Generally green but can be a wide variety of colors
- Good quality apatite is often cut into gemstones
- Fluorapatite: apatite with fluorine in its chemical structure. Most common type of apatite and forms nice crystals
- Chlorapatite: apatite with chlorine.
- Hydroxylapatite: apatite with hydroxyl in its structure (OH). Forms the bones and teeth of most animals
- Often forms as pegamites or ore veins
- Carbonate apatite: CO_3 partially replaces the PO_3 in the structure. Called carbonate-rich apatite
- Maganapatite: magnesium-rich apatite
- Sammite: strontium-rich apatite that contains some rare earth minerals
- Staffelite: botryoidal apatite
- Strontian-Apatite: Ca in apatite is partially replaced by strontium
- Main source of phosphorus

Hydroxylapatite chlorapatite



Botryoidal fluorapatite

Silicates

Sodalite

- Bright blue color with white veins
- Named for its sodium content
- Hackmanite: sulfur-rich sodalite
    - Pink or purple color
    - Strong fluorescence but rare crystallization
    - tenebrescence/photochromism: color becomes more saturated after UV light exposure before eventually fading
    - Often found in Afghanistan
- Used only as a gemstone
- Generally found in sodium-rich igneous rock
- Found in nepheline syenite, trachyte, and phontolite, all of which are extremely rare
- Considered a feldspathoid, or an aluminosilicate mineral containing a lot of calcium, potassium, or sodium. Feldspathoids are generally found in igneous veins and fractures
- Rarely forms crystals
- Often used as a substitute for lapis lazuli, as it is cheaper and looks about the same (have different streaks though)

Hackmanite crystal

Talc

- Crushed into talcum powder that can absorb water, oil, odor, and serve as a lubricant
- Soapstone/Dimension stone: a form of talc that is commonly carved for decorative purposes. Contains amounts of other materials such as micas, chlorite, amphiboles, and pyroxenes
- Similar sheet structure as mica's, with its sheets only being held together by van der Waals bonds
- Minnesotaite: when large amounts of iron substitutes for the magnesium
- Pyrophyllite: when large amounts of aluminum substitutes for the magnesium
- Used in rubber production
- Commonly found in metamorphic rocks in convergent plate boundaries
- Created by:
    - Heated waters carrying magnesium and silica react with dolomitic marbles
    - When rocks such as dunite and serpentine are altered by heat and fluids
- Used as a filler in plastics

Foliated talc

soapstone

Epidote

- No practical uses, just a display mineral
- Elongated crystals are the most desirable form
- Generally refers to a group of minerals, containing epidote (most common), Epidote-(Pb) (aka hancockite), and Epidote-(Sr)
    - Sr and Pb both replace the calcium
    - Hancockite is named for Elwood P Hancock
- Found in contact metamorphism zones such as slate, and in limestones and schists of regional metamorphic rock. Sometimes found in igneous basalt, diabase, and granite pegmatites
- Part of a solid solution chain that ends in clinzosite (epidote is second to last). The iron of epidote is replaced by aluminum, making it brighter
- Epidosite and unakite contain significant amounts of epidote

Hancockite epidote in marble

Olivine

- One of the most common minerals, but large crystals are rare
- Sometimes found in meteorites
- Represents the mineral group of forsterite and fayalite, which are both end members of their solid solution series. Both are very uncommon, so olivine is considered a mineral in this chain close to either of them
- Chrysolite: yellow to yellowish green olivine. Sometimes considered a synonym for olivine
- Soluble in HCl
- Often found in mafic (high magnesium or iron content) igneous rocks, as a primary mineral in metamorphic rocks and serpentine
- Dunite: a rock made of grainy masses of olivine
- Olivinoid: olivine from meteors
- Peridot: transparent olivine, used as a gemstone (August birthstone)
- Used as flux for steel production and as an ore for magnesium

Topaz

- Birthstone for November
- Yellow, orange, red, purple, or blue
- Blue topaz is cheapest and generally gets colored by humans
- Normally colorless, pale yellow, or brown naturally
- Naturally forms orthorhombic crystals with striations parallel to its axis
- Chromium causes red and purple coloring
- Imperial topaz: reddish orange topaz that is very valuable and often found in Brazil
- Originally considered to by any yellowish gemstone, now is based on chemical structure
- Treated topaz is colorless topaz that has been heated, irradiated, and coated with thin layers of metallic oxides to alter color
- Mystic topaz: topaz coated in an iridescent luster that can eventually wear off. Causes the gem to appear to change colors when moved
- Mostly grows in the veins of igneous rock
- Some also comes as pegmatites or in the holes of rhyolite

Staurolite

- Most known for cross shaped penetration twins (2 rectangular crystals intersect to form a perfect cross)
- Most commonly found as 2 bisecting crystals at 60 degree angles to each other (forming an X)
- Can form non-twinning crystals, but this is less common
- Name from Greek for cross (stauros)
- Generally forms in metamorphic schists and and gneiss
- Fairy stone/fairy cross: twinned stones with the cross shape
- Magnesiostaurolite: staurolite with lots of magnesium. Technically another mineral
- Zincostaurolite: zinc-rich staurolite (another mineral)
- No uses other than as a collectors stone
- Forms when shale is altered by regional metamorphism
- State mineral of GA
- “Fairy stone state park” in Virginia




Single crystal

Kaolinite

- Clay mineral that can easily be molded and shaped, especially when wet
- Sometimes forms pseudomorphs of feldspar
- Describes a group of clay minerals
    - Dickite: monoclinic structure. Named after Allan Brugh Dick who discovered it. Secondary mineral found in hydrothermal veins
    - Nacrite: hydrothermal origin. Name comes from French for mother of pearl (Nacre). Monoclinic structure
    - Halloysite: rare form of kaolinite. Used in tableware manufacturing for its high-whiteness and translucent. Tabular crystal structure
    - Odinite: only one with a different chemical formula $(Fe,Mg,Al,Fe,Ti,Mn)_{2.4}((Si,Al)_2O_5)(OH)_4$ and is named for Gilles Serge Odin. monoclinic structure
- Has very similar chemical structure to serpentine, and is sometimes considered a member of the serpentine group
- Very common in clay deposits
- Named after kao-ling, the mountain in China where this mineral was used in ancient times
- Often found near oxidized surfaces where it changed from aluminum silicates like feldspar
- Used in pottery and ceramics, as a stomach smoother, and in paper


Pseudomorph of orthoclase


Halloysite

Halloysite


Nacrite

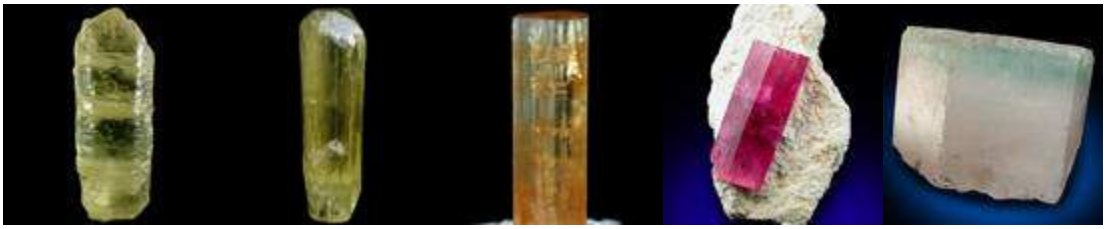

dickite


dickite


Odinite

Beryl

- Emerald: deep green beryl (light green is just green beryl). Caused by chromium
- Heliodor: yellowish beryl
- Aquamarine: blue-blueish green beryl. Green beryl can be heat treated to become blue. Caused by iron
- Morganite: pink beryl
- Golden beryl: yellow beryl
- Red beryl/bixbite: red beryl that is extremely rare and only comes from two places in Utah
- Naturally colorless and transparent
- Forms some of the largest natural crystals
- Often crystalizes in perfect, individual, 6-sided hexagons. Some of these have been 30 ft (8 m)
- Generally have flat bases and sometimes have lengthwise striations
- Sometimes fluorescent
- Insoluble in acids
- Often found in granite pegmatites, mica schists, or in igneous rhyolite deposits
- Precious beryl: used for any transparent beryl
- Goshenite: white-colorless beryl
- Main ore of beryllium



Tourmaline Group

- Most multicolored mineral
- Color can be enhanced by heat treatment
- Many blue and green ones are pleochroic (displaying different colors depending on the angle viewed from). They often appear darker when viewed through their vertical axis
- Some display the cat's eye effect (having a line of light going through the gemstone) when polished into a cabochon (smooth, rounded edges)
- Pyroelectric: generates an electric charge during a temp change
- Piezoelectric: generates an electric charge when under stress
- Deep vertical striations
- Elbaite:
    - $Na(Li,Al)_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$
    - Most well known and valuable tourmaline
    - Multicolored and generally forms tourmaline gemstones
    - Pleochroic (see above) and has cats eye affect (see above)
    - Almost exclusively forms in granite pegmatites
- Schorl:
    - "Black tourmaline"
    - Never transparent or translucent
    - Most common form of tourmaline
    - Tourmaline quartz: dense schorl needles within a quartz crystal
    - $NaFe^{2+}_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$
    - Often forms in granite pegmatites, sometimes in skarns
- Dravite:
    - "Brown tourmaline"
    - Not particularly valuable, but fairly common
    - Named after Davograd, Scandinavia, where it was first described
    - Often forms in marble deposits of metamorphosed limestone or schists, or in mafic igneous rock and pegmatites
    - $NaMg_3Al_6(BO_3)_3Si_6O_{18}(OH)_3F$
- Uvite: green and reddish brown tourmaline
    - Named from Uva Province of Sri Lanka, where it was first described
    - $Ca(Mg,Fe^{2+})_3Al_5Mg(BO_3)_3Si_6O_{18}(OH)_4$
    - Similar to dravite
- Liddicoatite:
    - Named for Richard T Liddicoat
    - Similar to elbaite, and sometimes contains large amounts of fluorine
    - $Ca(Li,Al)_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$
- Buergerite:
    - Extremely rare
    - Named for Martin J Buerger
    - $NaFe^{2+}_3Al_6(BO_3)_3Si_6O_{18}O_3F$

Buergerite Liddicoatite Uvite Dravite Schorl Elbate

Quartz Varieties

- Most common mineral (feldspar is considered a group of minerals)
- Triboluminescent (gives off yellow or orange “flashes” when struck by a hard substance)
- Piezoelectric: generates electric charge when under stress
- Agate/Onyx
    - Banded form of chalcedony
    - Microcrystalline structure
    - Often named for where it comes from, as different places produce different styles
    - Usually forms rounded nodules or knobs that has to be cut open to see the bands
    - Forms from the deposition of silica filling voids in volcanic cavities
    - Often fills entire cavities, but sometimes leaves hollow centers that become geodes (agate often forms the shell of geodes)
    - Often dyed bright blue or red to enhance the color
    - Named for the Achates River (now Drillo River) in Sicily, where it was found in large amounts in ancient times
    - Onyx describes black or black and white banded agate
- Amethyst
    - Gets name from Greek for “not drunken” (amethystos), as it was thought to ward off drunkeness
    - Color sometimes fades with prolonged exposure to light
    - Often heat treated to deepen the color or turn it into citrine. Sometimes also is given a green color, which is called prasiolite or green amethyst
    - Mostly forms stubby pyramid crystals, but can form tall prismatic crystals (called Veracruz Amethyst)
    - Often lines geodes
    - Iron or manganese discoloration
    - Canadian Amethyst: amethyst with an internal coating of red hematite, found in Thunder Bay, Ontario
    - Ametrine: mix of amethyst and citrine
    - Most popular quartz gem
- Chalcedony
    - White or blue microcrystalline form of quartz (crystals are not visible)
    - Often lines geodes
    - Often forms pseudomorphs of organic material (ie petrified wood and coal)
    - Tiger’s eye: pseudomorph of crocidolite that has a bronze sheen and chatoyancy (a band or reflected light across its center)
    - Dendritic Agate: magnesium oxide impurities that resemble trees
- Citrine
    - 2nd most popular quartz gem
    - Mostly formed by heat treating amethyst
    - Can also be made by heat treating smokey quartz
    - Rare in nature, but unlike heat treated ones natural citrine doesn’t have a reddish tint
    - Lemon quartz: light yellow citrine (typically natural)
    - Cactus quartz: citrine or amethyst quartz where one large crystal becomes covered in tiny other crystals
- Crystal
    - Transparent and in crystal form. No impurities

    - Sometimes called “rock crystal”
- Jasper
    - Opaque form of chalcedony (no matter the color)
    - Generally has so many impurities that it is classified as a rock, not a mineral
    - Banded jasper differs from agate, as it is opaque
    - Associated with red, orange, and yellow, but can be green
    - When dull and lacking interesting patterns, jasper is considered chert
    - Impurities are generally iron oxides or organic substances
- Milky Quartz
    - White quartz
    - Most common variety
    - Color caused by tiny bubbles of CO_2 in the quartz or water trapped inside of it
    - Sometimes called greasy quartz
- Opal
    - Amorphous (has no defined shape), making it a mineraloid (generally still classified as if it were a mineral though)
    - Composed of many tiny silica spheres, which diffracts the light hitting it into different colors
    - Some are affected by crazing, where it forms random internal and external cracks (similar to amber). It can often happen due sudden light exposure or it dries too fast
    - Has to be gradually dried, cut, and polished over months or years to avoid cracking
    - More stable in water
- Rose Quartz
    - Color likely caused by manganese or titanium
    - Has refractive index of 1.55
    - Sometimes displays asterism (stars of light appear on polished surface). This is rare, though
    - Rarely treated for color and fairly common


Agate


onyx


chalcedony


chalcedony


Jasper


opal

Garnet Group

Almandine

- Most common garnet and the most commonly used garnet gemstone
- Very few are transparent and useful as gemstones
- Star garnets: almandines that display asterism (star of reflected light) when polished to cabochons
- Often embedded in mica schists
- Paramagnetic: becomes magnetic when heated
- Syrian garnet: slightly purple almandine
- Often used as an abrasive. When made into sandpaper it is called garnet paper
- Named in 1546 by Georgius Agricola, who named it after Alabanda, Turkey where almandine was fashioned into gemstones
- Forms series with pyrope and spessartine (separate series)



Feldspar-Potassium

Amazonite

- Named for the Amazon River (originally called “amazon stone”), despite there being no deposits of it there. Most likely named for the color
- Green variety of microcline
- Gets its green color from trace amounts of lead
- Sometimes referred to as “amazon jade” “yellow emerald” or “green amethyst,” all of which are illegal to sell it by (misnomers)
- Has been used as a gemstone sense ancient Egypt and Mesopotomia
- Rarely used for modern jewelry due to a lack of large deposits and not much public recognition
- Has 2 directions of perfect cleavage, making it easily breakable
- Some crystals have been found among large smokey quartz crystals in Teller County, Colorado
- Usually found in pegmatites, veins, and other cavities



Orthoclase

- One of the most common minerals, is found everywhere
- Polymorph (same chem composition) as microcline and sanidine (the 3 potassium feldspars)
- Microcline is triclinic (see Amazonite) and sanidine and orthoclase are both monoclinic. Sanidine forms at high temperatures and has disordered symmetry, while orthoclase starts at lower temperatures and cools slowly, making it more ordered
- NOTE: orthoclase describes all 3 of these for this binder. Amazonite (microcline) is distinguished by its color only.
- Major part of low temperature metamorphic rocks
- Adularia: white or colorless transparent or translucent orthoclase or sanidine
- Moonstone: either orthoclase adularia or the plagioclase mineral oligoclase. Must display adularescence (a billowy reflection with a blue-white color emanating from the surface)
- Noble Orthoclase: transparent, yellow orthoclase from Madagascar
- Valencianita: bladed (elongated knifelike crystals) or platy (flaky) adularia from Guanajuato, Mexico (named after the mine its found in)
- Used in the manufacturing of glass and ceramics

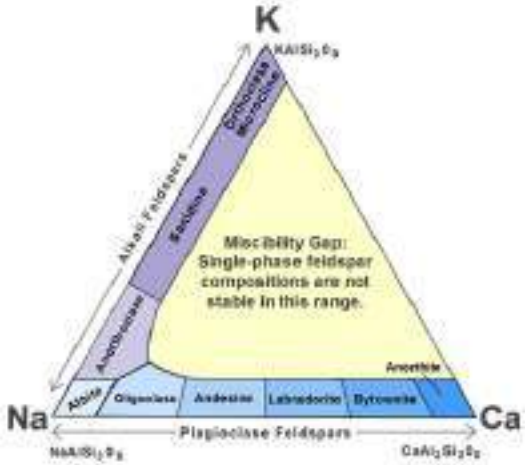
Adularia moonstone

Feldspar-Plagioclase

Albite

- One of the end members of the plagioclase isomorphous (same crystal structure, different elements) solid solution series
- Series (from most calcium to most sodium)
    - Anorthite, bytownite, labradorite, andesine, oligoclase
    - Oligoclase and andesine are sometimes considered variations of albite, not separate minerals
- Also part of a potassium-sodium series (most sodium to most potassium)
    - Albite, anorthoclase, sanidine, orthoclase
    - Albite can contain up to 10% potassium until it is considered anorthoclase
- Very common and important rock forming mineral
- Takes longer to form than other feldspars, letting it have large crystallized forms
- Soluble in HCl
- Often found in granite pegmatites
- Analbite: albite with some potassium replacing the sodium (but not more than 10%)
- Cleavelandite: thin, bladed crystals of albite (usually white)
- Pericline: elongated, white crystals
- Peristerite: iridescent variety of albite

Cleavelandite pericline peristerite



Pyroxene Group

- Prismatic cleavage angles of 87 and 93 degrees

Augite

- Forms a series with diopside and hedenbergite (in between the two)
- Technically a group of minerals due to its variable chemical structure, but is always classified as one mineral
- Important rock forming mineral and forms common crystals
- Most widespread member of the pyroxene group
- Frequently alters into hornblende, chlorite, epidote, and actinolite (called uralite in this form)
- Name comes from Greek for “brightness” (augites), referring to the bright luster that it sometimes exhibits (most of the crystals are dull though)
- Fassaite: low iron color that causes a lighter green color and increased transparency. Found in the Val D’Fassa region of Italy
- Jeffersonite: rich in manganese and zinc. Found in the Franklin District of New Jersey

Fassaite

Jeffersonite

Rhodonite

- Often has black manganese oxide veins
- Some tarnish black or brown when exposed to air
- Sometimes called “manganese spar” or “manganolite”
- Usually found in metamorphic rock and associated with other manganese minerals
- Fairly uncommon (found in Argentina, Australia, Brazil, Canada, England, India, Peru, Russia, and Sweden. Also NC, NJ, and Colorado)
- State gem of Massachusetts
- Similar to rhodochrosite, but rhodochrosite is effervescent in HCl
- Once used as an ore of magnesium in India, now only a display mineral
- Bustamite: calcium-rich variety, separately classified (up to 20% calcium)
- Fowlerite: up to 7% zinc oxide
- Has a polymorph that forms at high temperatures and low pressures called pyroxmangite

Amphibole Group

- Contains iron, magnesium, silicon, oxygen, and hydroxyl
- Has prismatic cleavage at 56 and 124 degrees
- Similar to pyroxenes, but generally forms longer, thinner crystals
- Contains hydroxyl, unlike pyroxenes

Tremolite

- Forms a series with actinolite, which it shares a chemical formula with. Tremolite has more magnesium than iron, while actinolite has the reverse
- Mountain leather: tremolite or actinolite that has silky, elastic, soft fibers that forms a leathery material
- Nephrite: tremolite or actinolite is made of tough, interlocking fibers that is so dense that you cannot see the fibers. Sometimes used as jade
- It contains asbestos that is made of moveable and elastic fibers. Most forms of asbestos are tremolite, not actinolite. Useful for heat protection
- Asbestos form is hazardous to health (can cause asbestosis, which leads to various cancers and does not show symptoms until about 20 years later)
- Occurs in contact metamorphic hornfels and skarns, or marble made of calcite or dolomite
- Byssolite: tremolite or actinolite made of tiny fibrous crystals interwoven into a tough, hairlike mass
- Chrome-tremolite: chromium rich tremolite. Green.
- Hexagonite: tremolite that is pink or purple. Found in St. Lawrence, NY
- Tirodite: tremolite with inclusions of manganese oxide dendrites

Mountain leather asbestos

Hexagonite chrome-tremolite nephrite

Hornblende

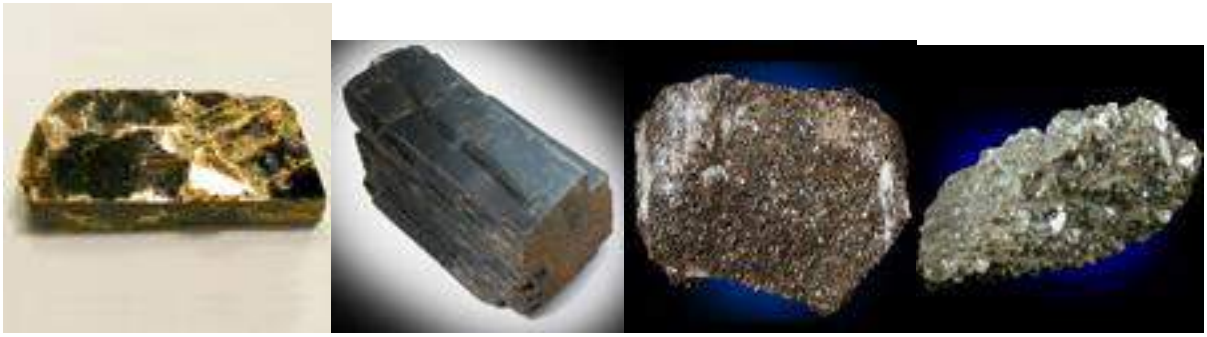
- Describes any calcium aluminum amphibole (or just any dark, opaque amphibole)
- More specifically describes ferro-hornblende and magnesio-hornblende (the two end members of the hornblende solid solution series)
- Extremely common and forms many rocks in many different environments
- Named for its color (horn) and deceiver (blende) German. Deceiver refers to the fact that it looks similar to many ore metals
- Its dark color and opaqueness is caused by the iron
- Edenite: member of the extended hornblende group. Is a group of minerals with similar structure. Named for Edenville, NY where it was first discovered. Forms in marble. $NaCa_2Mg_5Si_7O_{22}(OH)_2$
- Pargasite: another member of the extended hornblende group that describes a group of similar minerals. Lighter in color and sometimes transparent. Named after Pargas, Finland. Often forms in marble made from limestone. $NaCa_2(Mg,Fe)_4,Al(Si,Al)_8O_{22}(OH)_2$
- Gangue material: a mineral in which valuable gems occur but is worthless on its own
- Major constituent of granite (creates the black streaks)

Mica Group

- Soft aluminum silicates with perfect basal cleavage
- Can be peeled
- Subset of phyllosilicates

Biotite

- Very common form of mica
- Named in honor of Jean Baptiste Biot who researched micas for their optical properties
- Common accessory mineral (mineral that is found with other ones)
- Can weigh hundreds of pounds
- Technically a group of the minerals phlogopite, annite, siderophyllite, and eastonite
    - Phlogopite (the only one that is distinguished) is brownish-red and is magnesium rich, as compared to the rest that are iron-rich.
- Absorbs water, which causes it to break apart
- Often found in schists and gneiss or granites and rhyolites
- Primary mica in rare earth pegmatites
- Manganophyllite: manganese-rich biotite
- Poor conductor of heat and electricity, so it is used as an insulator for electrical products
- Sometimes also used as a filler and extender in paints or as a non-stick surface coating on shingles (when ground)
- The bronze colored reflections it produces can sometimes make people confuse it for gold



Eastonite

Lepidolite

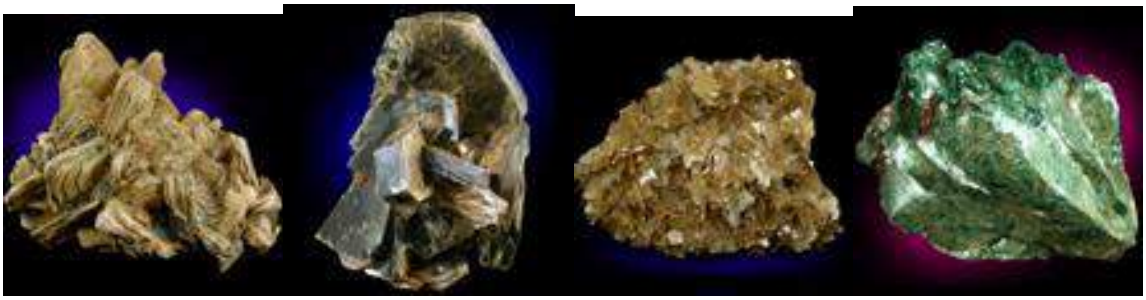
- lithium -rich mica that is pink or purple
- Common matrix mineral (a mineral in which others are embedded) to tourmaline and quartz
- Hard to tell apart from the pink variety of muscovite
- Almost always forms in lithium-rich granite pegmatites, as it requires high levels of lithium to form
- Lithium is normally one of the last ions to form into minerals during crystallization
- Sometimes forms pseudohexagons, but this is extremely rare
- Used as a gemstone (when impregnated with quartz for hardness) and as a lithium ore, with rubidium and cesium being occasional byproducts
- Pink and purple color caused by the manganese, and it is sometimes yellow or colorless
- In between the two minerals polylithionite and trilithonite in a solid solution series
- Is part of pink and purple aventurine (a quartz gem)

Pseudohexagon

aventurite

Muscovite

- Most common mica
- Named for “muscovy glass” which was thick sheets of transparent mica used in Russia
- Often an accessory mineral (found with them)
- Sometimes forms botryoidal flaky clusters
- Often found in granite pegmatites, contact metamorphic rock, schists, and in hydrothermal veins
- Isinglass: old name for muscovite
- Alurgite: manganese-rich, pink or purple form
- Fuchsite: chromium-rich, dark green variety. Named in honor or Johann Nepomuk von Fuchs
- Star Muscovite: twinned muscovite crystals in star-shaped sections
- Sericite: fine grained muscovite, silky looking
- Schernikite: light pink muscovite
- Mariposite: green muscovite in small, dense flake groups. Found in Mariposa Country, CA. Forms in metamorphosed dolomite and quartz as veins or a base material
- Poor conductor of heat and electricity, is used for insulation
- Used in tires and cosmetics (when ground)
- Sometimes is a pseudomorph



Star muscovite fuchsite

Pseudomorph pink muscovite

Sulfates

Celestite/Celestine

- Pure celestite is colorless, barium impurities gives it its blue color
- Isomorphous (same structure) as barite, and sometimes partially replaces barite. May be a solid solution series
    - However, most specimens are at most 15% the other mineral, meaning they cannot fully change between the two. Another explanation is that the environments do not have enough of the other element to fully replace the other
- Named for latin for “godlike (of the sky),” (caelestis) referring to the sky blue color
- Generally forms prismatic or tabular crystals
- Sometimes fluorescent in shortwave UV
- Generally found in sedimentary rock like limestone
- Sometimes thermoluminescent (emitting light when heated)
- Sand celestite: celestite with inclusions of sand, making it brown or greyish and opaque
- Most common mineral containing strontium, and its primary ore. Strontium is used in red fireworks and glow in the dark objects

Sand celestite

Barite

- Has a large variety of colors and crystal habits, but is recognizable for its heavy weight
- US spelling is barite, UK spelling is baryte (IMA currently calls it baryte after years of calling it barite)
- Desert roses: barite that is brown from sand inclusions and occurs in rosette aggregates
    - Gypsum also forms desert roses, which can be told apart from barite ones by their weight
- Often replaces other minerals, and even wood, shells, and fossils
- Also forms mounds in hot, barium-rich springs
- Isomorphous with celestite (see Celestite above for more details)
- Name from Greek for heavy (barys)
- Often fluorescent (but not always; is not an ID factor)
- Sometimes phosphorescent (glows long after the UV light has been removed)
- Generally found in sedimentary layers or hydrothermal and mesothermal metal ore veins
- Bologna stone: nodular, radiating, or massive barite from Bologna, Italy that is phosphorescent
- Main ore of barium
- Important for manufacturing of paper and rubber
- Used in radiology of the digestive system
- Crushed into barium mud and poured into oil wells when drilling
- Once used as a white pigment

Desert rose

Gypsum Varieties

- Often found perfectly intact without any distortions as floater crystals (crystals that are not attached to another rock or matrix)
- Somewhat flexible, especially in thin crystals
- Same chemical structure as anhydrite, but gypsum contains water (anhydrite can absorb water and then become gypsum)
- Growths of clumping layers support the theory that anhydrite can absorb water to become gypsum
- Enhydros: very desirable form of gypsum where a drop of water gets stuck in a hollow channel inside the crystal while it is forming and can then move around in the hollow later
- Sometimes forms in sandy areas, where it traps sand and can become brown or grey and opaque
    - Sometimes makes hourglass shapes in the crystal
    - Desert Rose: rosette of opaque gypsum or barite
- Should never be cleaned with soap, as they can enter the crystal and ruin the luster
- Often found in limestone and clay sedimentary rocks
- Ram's horn: curved gypsum
- Primary ingredient of plaster of paris (finely ground gypsum) used in cement
- Used as a flux and fertilizer

Alabaster

- Massive, fine grained form of gypsum
- Occasionally refers to translucent, banded aragonite
- Name from Alabaston, Egypt where it was mined

Satin Spar

- Fibrous variety of gypsum
- Sometimes describes fibrous calcite or aragonite
- Name alludes to its satiny luster and its original identity as a spar mineral

Selenite

- Transparent and colorless gypsum that forms nice crystals
- Name comes from Greek for "moon" referring to its pale blue reflections
- Often used to describe all varieties of gypsum but technically only refers to transparent varieties

Selenite desert rose ram's horn satin spar alabaster

Sulfides

Sphalerite

- Common mineral but has many different colors and forms
- Very common iron impurities cause it to become black/dark grey and opaque
- One of the few minerals that can be transparent and gemmy or opaque and metallic
- Schalenblende: banded sphalerite associated with wurtzite, pyrite, and galena. Forms concentric rings
- Often forms dodecahedrons
- Some transparent or translucent varieties fluoresce orange in shortwave UV
- Often triboluminescent (gives off orange or yellow flashes when struck)
- Dissolves in HCl
- Often found in limestone, hydrothermal and mesothermal veins
- Cleiophane: transparent, lightly colored sphalerite
- Marmatite: opaque, iron-rich sphalerite
- Ruby jack: red sphalerite that is transparent or translucent
- Main ore of zinc. Also sometimes occurs with cadmium, gallium, and iridium, and is all of their main ore too

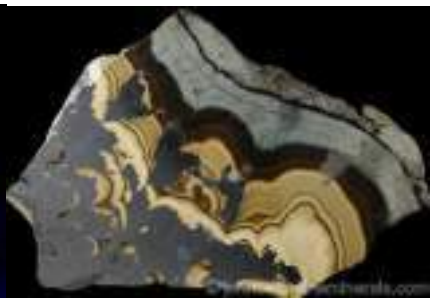
Marmatite

marmatite

ruby jack

marmatite

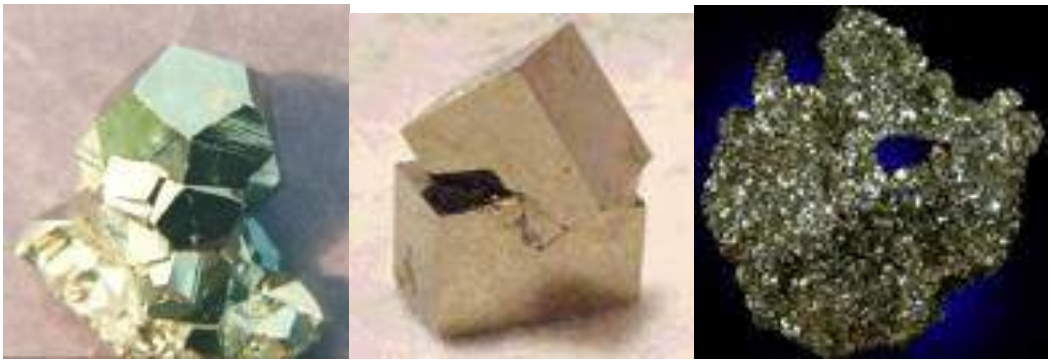
Cleiophane



schalenblende (polished)

Pyrite

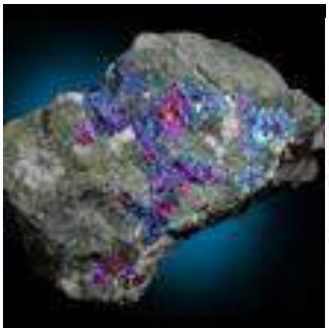
- Frequently occurs with gold
- Often forms aggregates (lots of crystals together), cubes, or penetration twins (2+ crystals formed together)
- Same chemical formula as marcasite, but crystalizes differently (polymorphs)
- Sometimes oxidizes to form a brownish iridescent film
- Often has striated crystals
- Forms in all environments
- Cathedral pyrite: pyrite with etched markings
- Dollar/pyrite sun: flat discs of radiating pyrite or marcasite
- Pyritohedron: pyrite with a pyritohedral shape (12 equal pentagon sides)
- Rainbow pyrite: has iridescence caused by oxidation. Found in the Volga river in Russia
- Minor ore of sulfur and iron, sometimes as a gold ore
- Polished and used as mirrors by Native Americans
- Sometimes forms pseudomorphs of fossils



Pyritohedron

Bornite

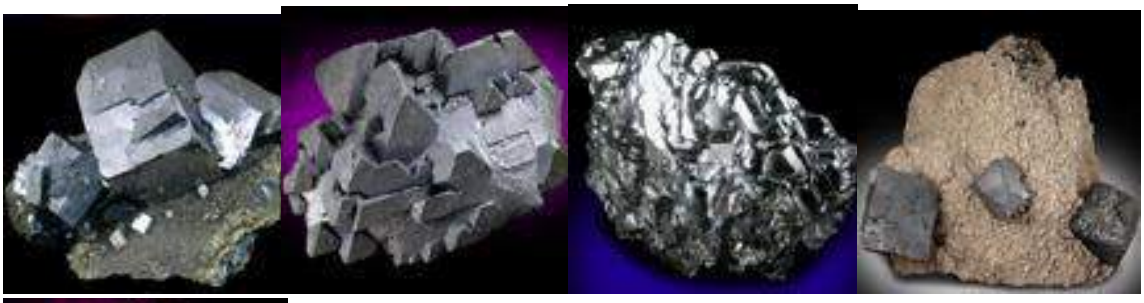
- Ore mineral of copper
- Has an iridescent tarnish, giving it the name “peacock ore”
    - However, peacock ore is often actually chalcopyrite that has been treated with acid to give it a tarnish
- Named for Ignatius von Born, a mineralogist
- Forms isometric crystals at high temperature but recrystallizes at low temperatures into orthorhombic system, retaining the isometric crystals
- Crystals are rare and generally form cubic or dodecahedral shapes
- Mostly occurs in massive or globular forms
- Forms as a primary or secondary mineral in copper ore veins
- Found in hydrothermal or mesothermal metamorphic veins, contact metamorphic zones, or igneous intrusions or dikes




[white crystals are quartz]

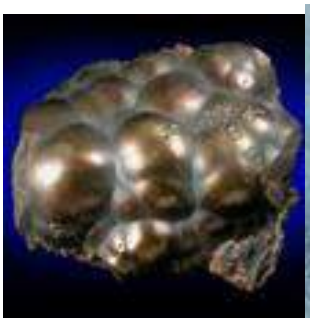
Galena

- Most common mineral containing lead and has been used for its lead for ages
    - Can easily be smelted, which separates the lead from the sulfur
    - Probably the first metal used as an ore
- Ore of silver
- Often forms crystals halfway between cubic and octahedral shapes and sometimes even contains dodecahedral shapes
- Primary mineral that forms into most of the other lead minerals (including cerussite, anglesite)
- Bismuth impurities results in octahedral cleavage, while silver results in flaky, slightly bent formations
- Tarnishes when exposed to air, turning its metallic luster dull (can be removed with soap and water)
- Very fragile crystals that can break under slight pressure
- Generally found in limestone, hydrothermal and mesothermal veins, hydrothermal replacement deposits, and placer deposits
- Acerila: granular galena. Term only used in a few South American countries
- Argentiferous Galena: silver-rich galena (can contain up to 20% silver)
- It may “snow” galena on Venus due to the high concentration of lead and sulfur in its atmosphere
- Used as a semiconductor in early radios to convert AC to DC



Chalcopyrite

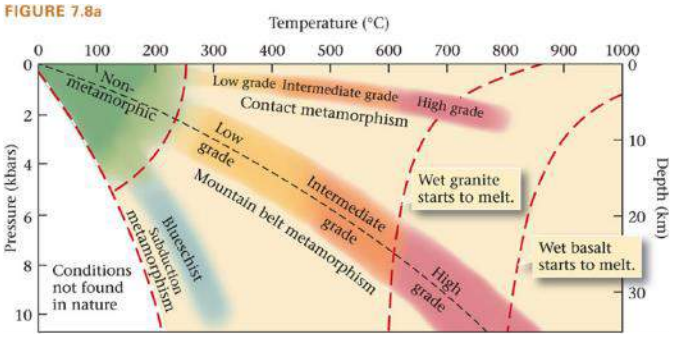
- Often forms peacock ore, which is supposed to be naturally tarnished bornite but is often made cheaply by staining chalcopyrite with acid
- Sometimes naturally tarnishes to a dull, green-grey shade but needs treating to turn red or blue
- Generally forms tetrahedrons and octahedrons, but they are slightly asymmetrical, so they are categorized as tetragonal
- Soluble in nitric acid and turns the solution blue
- Often found in copper deposits, hydrothermal and mesothermal veins, hydrothermal replacement deposits, schists, and igneous intrusions and dikes
- Blister copper: chalcopyrite in globular or botryoidal form
- Main ore of copper, sometimes used in cheap jewelry
- Sometimes also considered “fools gold” but is less common than pyrite




Acid treated

Natural tarnish

Metamorphic



Gneiss

- Defined by its bands of granular, palty, or elongated minerals
- Mineral crystals generally parallel the bands
- No defined composition
- Generally forms by regional metamorphism at convergent plate boundaries
- High-grade metamorphic rock. Recrystallizes into larger crystals and becomes banded
- Most common formation path goes: shale, slate, phyllite, schist, gneiss
    - Clay in shale turns to micas, which increase in size until becoming granular (when it becomes gneiss)
- Granite gneiss: granite that gets metamorphosed into banded gneiss. Only a structural change, doesn't affect the composition much
- Usually has light bands of quartz or feldspar alternating with dark palty or elongate minerals
- Sometimes gets a name (ie "garnet gneiss") when it contains distinctive minerals from its environment
- Has no planes of weakness, making it useful in construction and landscaping
- Often called granite when sold, as all rocks with visible interlocking feldspar grains is called granite in that business




Marble

- Forms from limestone and is mainly composed of calcite
- Often contains other clay minerals, like mica, quartz, pyrite, iron oxides, or graphite
- When metamorphosed, the calcite in the limestone recrystallizes to form a mass of interlocking calcite crystals
    - Dolomitic marble forms when dolostone undergoes the same process
- Usually forms in regional metamorphic zones at convergent plate boundaries
- Sometimes also forms in contact metamorphic zones
- The calcite crystals slowly grow during the changing process (recrystallization is what marks the difference between marble and limestone)
- Forms massive deposits and can be mined easily for lots of money
- Uses as either crushed stone or dimension stone
    - Crushed stone: used as an aggregate in construction
    - Dimension stone: sawed marble used in various decorative ways
- Naturally white, but can turn various other colors with impurities
- High purity marble can be crushed and processed to remove any remaining impurities. This powder (called whiting) is then used as filler in paint, paper, plastic and various other things
- Often used for acid neutralization (similar to calcite, but is often cheaper)
- Can accept a polish once sanded (any soft rock that can be polished is often incorrectly called marble)
- Granoblastic: grains are intergrown, interlocking, and equidimensional




Phyllite

- Made of mica flakes in parallel alignment
- Can be easily split into sheets and slabs
- Has a reflective sheen due to its alignment that differentiates it from slate
- Almost always forms in convergent plate boundaries involving continents
- Doesn’t need a ton of pressure or heat
- Crystals form from the transformation of clay
- Porphyroblasts: crystals of other minerals that are large enough to be seen within the phyllite
- Reveals the upper limits of heat and pressure that nearby rocks were exposed to
- Has few uses, sometimes used in landscaping


Quartzite

- Almost 100% quartz
- Forms from quartz-rich sandstone that gets recrystallized and is bound together by silica cement
- Separated from sandstone by the fact that quartzite breaks through the quartz crystals instead of the boundaries between them
- Has a hardness of about 7
- Used as an impact tool by early humans
- Forms at convergent plate boundaries with continents involved
- Very common in mountains and, due to its lack of weathering, often forms exposed ridges on the mountain
- As it is mostly quartz, it is useless as a soil former
- Quartz arenite: new term used to describe sedimentary rocks made of mostly quartz. These rocks were once also classified as quartzite
- Often used in countertops instead of granite or marble, as it is more durable. Can also be man-made, which is cheaper
- Used as a crushed stone in construction, but due to its hardness it can wear down machines easily
- Aventurine: quartzite with fuchsite (green muscovite), iron (makes it pink/red), dumortierite (blue) or any other color that has a glittery luster called aventurescence and is semi-transparent to translucent. Used in ornaments.
- Granoblastic: grains are intergrown, interlocking, and equidimensional

Schist (Both in one)

- Set apart from slate by having grains that can be seen with eyes
- One of the most widespread continental rocks
- Made up of palty or elongated minerals (mica, talc, chlorite, graphite, amphiboles)
- Displays schistosity foliation, which is palty or elongated minerals arranged perpendicular to the force that metamorphosed them
- Schist is generally considered to contain +50% elongated minerals to keep it apart from gneiss, but differentiation is generally up to the geologist
- Fissile: has the tendency to split along sub-parallel surfaces (s-surfaces)
- Name comes from Greek for split (skhistos)
- Often forms at convergent plate boundaries from phyllite
- Generally is named based on the visible crystals within it
- Mostly useless in construction and other uses
- Hosts many gem minerals

Garnet schists

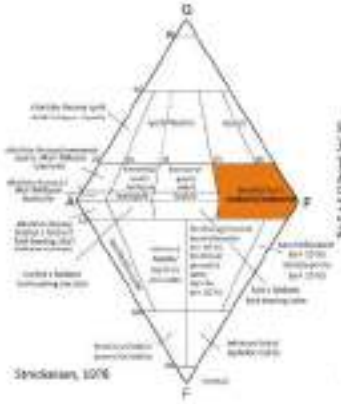
Mica schists

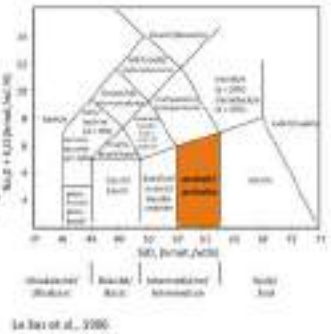
Slate

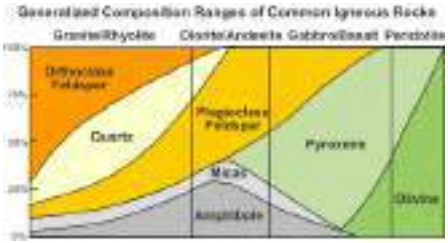
- Made up of clay minerals or micas (micas show a more developed slate, while clay shows that it hasn't been metamorphosing for long)
- Can also contain a lot of quartz and some feldspar, pyrite, calcite or hematite
- Normally grey but can be green, red, black, purple, or brown depending on the concentration of iron and organic compounds
- Forms from sedimentary rocks (normally shale or mudstone) at convergent plate boundaries
- Slate once referred to both shale and slate (partially due to the partial metamorphosis of shale into slate)
- Has parallel formations of palty minerals that allows it to easily break apart
- Used in roofing for its ability to withstand frozen water and not absorb much liquid
- Good electrical insulator and used in early electrical panels



Igneous







Andesite

- Named for the Andes Mountains
- Either aphanitic (fine-grained) or porphyritic (has one set of crystals that is distinctly larger than another)
- Volcanic equivalent to diorite
- Contains plagioclase feldspars and at least one ferromagnesian mineral (ie biotite or pyroxene)
- Amygdaloidal andesite: forms when bubbles left in the magma are later filled in, often by zeolite (microporous, aluminosilicate) minerals
- Can be used to map ancient subduction zones, as volcanoes that produce andesite form on the crust above these zones
- Generally blue-gray or grey color
- Resistant to slipping, so it is used in tiles
- Used in construction, filling, and landscaping
- Forms very close to the surface but not on it

Basalt

- Most common rock on earth's surface
- Start off as black and weather to green or brown
- Rich in iron and magnesium and made of olivine, pyroxene, and plagioclase
- Generally fine grained and glassy, but can sometimes by porphyritic with phenocrysts (large grains) of olivine, augite, or plagioclase
- Occasionally has a porous texture due to bubbles in the lava
- Makes up a huge part of the seafloor and can even form into volcanic islands
- Dark plains on the moon (maria) and volcanoes on Mars and Venus are all likely made of basalt
- Tholeiitic basalt: rich is silica and low in sodium. Makes up most of the ocean floor
    - Mid ocean ridge basalt (MORB): only forms at ocean ridges and is low in incompatible elements
- High alumina basalt: midway between tholeiitic basalt and alkali basalt. Over 17% alumina and over or under saturated with silica
- Alkali basalt: poor in silica and rick in sodium
- Boninite: high magnesium basalt that normally erupts in back-arc basins. Has low titanium content
- Sometimes forms 6-sided columns
- Basalt that erupts underwater often forms pillow shapes
- Often used in construction and the creation of steel wool
- Underwater basalt creates a barrier for the re-release of CO_2 into the atmosphere





Diorite

- Contains plagioclase feldspar and dark colored minerals like hornblende or biotite
- Generally found in dikes, sills, and intrusions in the earth's crust
- Normally grey or dark grey, but can be black, blue-grey, or greenish
- Used in construction and the dimension stone industry (carved stones)
- Forms when basaltic magma from oceanic crust rises up and intrudes into continental, granite filled crust and melts part of the granite, mixing the two rocks
- Phaneritic (coarse grained)
- Found in a convergent boundary where an oceanic plate subducts under a continental one
- Often sold as granite due to its interlocking grains of feldspar
- Sometimes cut and polished, as it accepts polish well

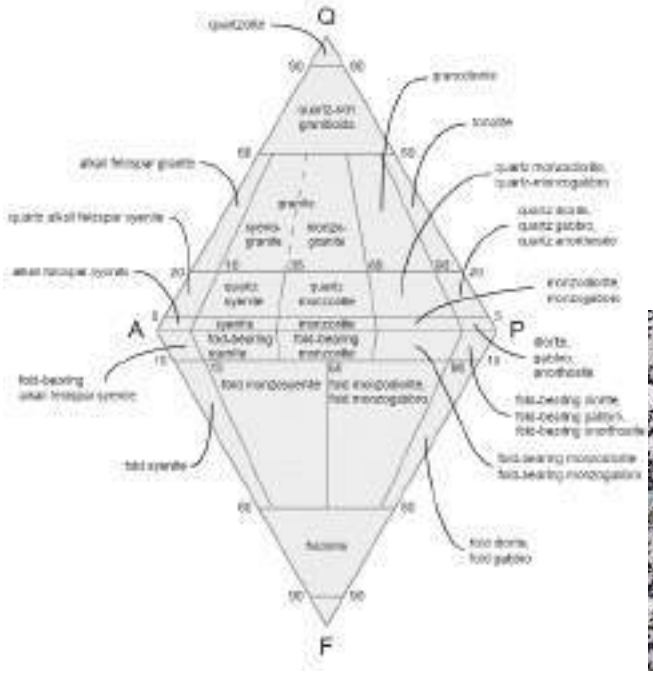
Gabbro

- Black to green color
- Made of plagioclase and augite
- Most common rock in deep oceanic crust
- The intrusive equivalent to basalt
- Generally found under a layer of faster forming basalt in the oceanic crust (magma cools quickly above it to form basalt, which a layer under it forms slowly into gabbro)
- Can form in thick lava flows that allow rocks towards the bottom of the flow to form slowly
- Used in construction as a crushed stone or aggregate
- Can be highly polished and is used in countertops and other things
- Called “black granite” in the dimension stone industry
- Used as an ore of titanium when it contains ilmenite, a rare mineral
- Also sometimes mined for nickel, chromium, or platinum




Granite

- Most common intrusive rock in the continental crust
- Mainly made of feldspar, quartz, and mica, with it being mostly feldspar and about 10% quartz
- Gets its color from whatever type of feldspar it is made of (ie alkali feldspar makes it pink)
- Crystalizes from silica-rich magma and often releases hydrothermal solutions, which then go to form mineral deposits
- Name first appeared in a book by Caeslpinus in the 16th century
- Found in stocks (less than 100 m^2) or batholiths (more than 100 m^2)
- Used in architecture for ages
- China, Brazil, and India are the current leading manufacturers of granite



Obsidian

- Naturally occurring glass
- Has conchoidal fracture and a vitreous luster
- Color is controlled by the inclusions (normally black, but can be red, green yellow, or even transparent)
- Cools so rapidly that the atoms are unable to rearrange into a crystalline structure
- Due to its amorphous (no pattern) structure, it is considered a mineraloid
- Can be intrusive when forming around the edges of a sill or dike
- Mahogany obsidian: obsidian where black and brown is swirled together
- Unstable, and will randomly crystallize into white or grey cristobalite spots. Snowflake obsidian is when this happens throughout the rock
- Rainbow/golden/silver obsidian: obsidian with an iridescent or metallic luster
- Generally made from the same stuff rhyolite and granite
- Tachylyte: obsidian formed from the same minerals basalt and gabbro
- Conchoidal fracture can leave it having very sharp edges, making it useful for sharp edges by early humans (very valuable in the stone age)
- Still used today in surgeries, as obsidian blades can be much thinner and sharper than steel ones
- Hardness of about 5.5

Snowflake obsidian

mahogany obsidian

various patterns of obsidian

Clear conchoidal fracture in the center

Pegmatite

- Extreme: they contain exceptionally large crystals and sometimes have rare crystals in them
- The only qualification is that each crystal must be at least 1 cm in diameter
- Generally has a composition similar to granite
- Pegmatite, when it has a similar composition to another rock, is given that rock's name as an indicator (ie granite pegmatite)
- Sometimes contain valuable minerals like spodumene (ore of lithium) or beryl (ore of beryllium). Also contains beautiful gemstones
- Large crystals are caused by low-viscosity fluids (ie water).
    - As other rocks crystalize, the water in the magma remains until it eventually has such a high concentration that it separates out. This water contains many ions that are highly mobile, allowing them to form crystals freely
    - Generally forms in late stages of crystallization
    - Forms on the edges of a batholith in pockets or in fractures (fractures make pegmatite dikes)


Pegmatite dike

Pumice

- Light coloring
- Extremely porous and only forms in explosive volcanic eruptions
- Technically a form of glass, similar to obsidian. Also a mineraloid like obsidian due to its lack of crystals
- Vesicles are the pores
- Cools too quickly to form crystals
- Forms when magma with a % of gas by weight breaks through the surface. The sudden pressure drop causes a rush of gas that shreds the magma
- Generally forms from rhyolite composition, rarely from basalt
- Has specific gravity of <1
- Pumice rafts: large amounts of pumice floating through the sea. A hazard for ships and can be tracked by satellites
- Used in lightweight concrete manufacturing
- Pumicite: mineral-esque pumice with grains less than 4 mm. Synonymous with volcanic ash, and can be produced by crushing pumice
- Pumice reticulite: pumice where all the bubbles have burst, leaving a honeycomb structure

Pumice reticulite

Rhyolite

- Extrusive equivalent to granite
- Contains mainly plagioclase, quartz, and sanidine with some hornblende and biotite
- Trapped gasses form vugs which are often filled with crystals, opal, or glass
- Often partially cools before erupting to the surface, forming phenocrysts (larger grains) and groundmass (the small grains)
- Rarely produced in oceanic eruptions
- Forms from effusive (poured) eruptions with obsidian
- Often forms lava domes, or a mound around the vent the lava is coming from
- Has no practical uses, as it is easily fractured and has a variable composition

Scoria

- Vesicular and dark colored
- Has a similar composition to andesite or basalt
- Forms from the top of the lava flow where there are many air bubbles
- Has larger vesicles and thicker walls than pumice and generally forms from less viscous lava
- Often used as a high-temperature insulator and in landscaping
- Name comes from Greek for rust (skoria)
- Made up of glass
- About 50% silica and 10% calcium oxide
- Generally found around the mouth of short erupting volcanoes
- Used to carve the statues on Easter Island



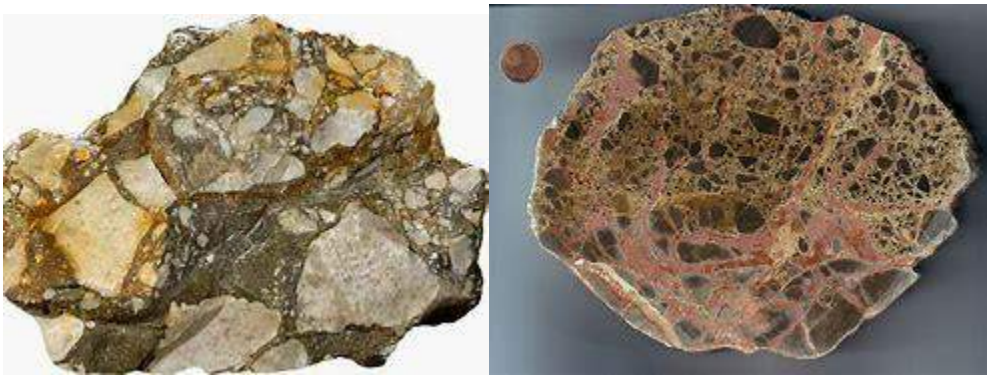

Sedimentary

Arkose

- Made up of mostly quartz, but is classified by its feldspar content (at least 25%)
- Crystals of feldspar must be visible with the unaided eye
- Subarkose: rocks that contain a good amount of feldspar but not enough to be arkose (about 10-20% feldspar)
- Arenite (clean sandstone): a sandstone with very little matrix material (smaller grains binding the thing together). Arkose is generally a clean sandstone.
- Feldspathic graywacke/arkosic wacke: “dirty” arkose that contains more than 15% mud materials
- Generally made of potassium feldspar
- Forms about 15% of all sandstones
- Originally thought to form in areas with little to no erosion (so the feldspar doesn’t weather away before the quartz)
- Now known to form from fast weathering that doesn’t have the time to break up the feldspar
- Name first used by Alexandre Brongniart in 1826 (France)

Breccia

- Clastic sedimentary rock with grains over 2 mm in diameter
- Large grains are usually angular
- Often forms on the base of outcrops where weathered rock accumulates or stream deposit that are a short distance from the weathering site
- Forms from debris flow deposits (deposits where a large amount of debris, some of which is in large chunks fall down in hill or other slope)
- Differs from conglomerate in its particle shape (breccia is angular while conglomerate is rounded)
- Often gets a name (ie granite brecca) from the type of rock it is made of
- Monomict breccia: clasts (large chunks) made of one type of rock
- Polymict breccia: clasts are made of many different types of rock
- Sometimes used in road building
- Sometimes used as a term for limestones with a broken, angular pattern in the dimension stone trade
- Other uses of the word breccia:
    - Collapse breccia: broken rock that comes from a cavern collapse
    - Fault/tectonic breccia: broken rock found in the contact area of two faults
    - Flow breccia: a lava texture formed when the crust of a lava flow is broken
    - Fold breccia: formed from the folding of thin, brittle rock layers
    - Igneous breccia: a rock made of angular fragments of igneous rock
    - Impact breccia: broken rock produced by the impact of a cosmic body
    - Pyroclast breccia: broken rock ejected from a volcanic blast



Chert

- Composed of microcrystalline or cryptocrystalline quartz
- Aka flint
- Variety of chalcedony (see quartz section for more)
- Grows in soft sediments where dissolved silica is transported by groundwater
- If enough crystals form, they can merge together to form a layer of rock
- Can also form from diatoms and radiolarians that die and fall to the bottom of the ocean. Their silica skeletons recrystallize into chert
- Iron oxides produce a red color (commonly called jasper)
- Organic material forms grey or black chert (called flint)
- Strong conchoidal fracture makes it sharp
- Used in the past for weapons and knives
- Has a hardness of about 7
- Produces a spark when struck against steel
- Novaculite: porous, even texture that is used to sharpen things

Conglomerate

- Made up of rounded clasts that are over 2 mm in diameter
- Matrix made of clay and sand particles
- The cement is normally made of calcite or quartz
- Most common clasts are quartzite, sandstone, limestone, granite, basalt, and gneiss
- Almost always forms in water deposit areas (wind is unlikely to weather it enough)
- Clasts are rounded by long downstream trips
- Occasionally used as an aggregate
- Too variable in composition to have many uses
- Can be analysed to find rare minerals. In a conglomerate contains a mineral commonly found with a rare mineral (ie diamond), the conglomerate can be traced back to its origin point to mine for the mineral
- Puddingstone: conglomerate with a sharp contrast between the clasts and the cement. Named in England after plum pudding
- Conglomerate found on Mars points to the existence of there once being water on the planet

puddingstone

Diatomite

- Friable (easily crushed) and is composed of the siliceous skeletons of diatoms
- Porous with a very low specific gravity
- Diatoms: photosynthetic, single celled organisms that float in water bodies. They has a silica-based cell wall (called a frustule) and produce about half of the organic mass in oceans
- Sediment composed of over 30% diatom frustule, then it becomes diatom ooze that then becomes diatomite
- Has small particle size, high porosity and surface area, inert siliceous composition, and a low specific gravity. These make it useful in:
    - Filtration: pores are small enough to trap bacteria and suspended particles
    - Cement additive: used as a filler in cement for its high silica content
    - Used as a filler in various things (like paint, plastic, and rubber)
    - Absorbent: dry diatomaceous earth absorbs lots of water
- US produces the most diatomite
- Saltwater diatomite can contain salt that makes it toxic for some uses
- 7-400$ per ton



Diatomaceous earth

Dolostone

- Composed mostly of dolomite
- Forms from the alteration of lime mud and limestone by magnesium-rich groundwater
    - The calcite in the limestone reacts with the magnesium
    - Called dolomitization
    - Sometimes only alters part of the limestone, forming dolomitic limestone
- Very similar to limestone and has the same uses
- Slightly harder than limestone and diffuses less in HCl
- When metamorphosed, the dolomite crystals grow and it becomes dolomitic marble
- Many uses:
    - Crushed into an aggregate
    - Fired in the making of cement
    - Used as dimension stone
    - Calcined to produce lime
    - Due to shrinkage during dolomitization, there are pores that often fill with oil or natural gas, or lead, copper, or zinc
    - Used as a source of magnesia (MgO)


Sandstone

- Made of sand-sized grains of rocks, minerals, or organic compounds
- Cemented together using clay or silt particles
- One of the most common sedimentary rocks
- Forms in basins where sand is delivered by gravity, wind, and rivers
- Sometimes used for crushed stone and, if it has enough quartz, glassmaking
- Sometimes serves as a reservoir for oil, natural gas, and groundwater
- Sand grains are 1/16 mm to 2 mm
- Mostly quartz or feldspar due to their lack of weathering
- Arenites: sandstones with very little matrix (“clean sandstone”)
- Wackes: have a lot of matrix (“dirty”)
- Cement is generally quartz (silica) or calcite (carbonate)
- Soft enough to be carved fairly easily
- Used in construction and sculptures




Shale

- Made up of compressed silt and clay particles
- Type of mudstone that is differentiated by its lamination and fissileness (breaks along layers easily)
- Conventional oil and natural gas
    - Black organic shales are the main source rock for oil and natural gas
    - Oil and natural gas trapped in the shale begin to climb upwards and eventually form a pool in a porous rock above the shale (ie sandstone). This is a conventional reservoir from which the oil can easily be extracted
- Unconventional oil and natural gas
    - Way of getting the oil and natural gas out of the shale directly
    - Used hydrofracking, where water was pumped down into the shale to break it open
    - Also did horizontal drilling, where they drill a well through the rock layer, parallel to the surface
- Mixing ground shale with water produces the most commonly used clay
- Crushed with limestone and heated to produce cement (calcium oxide in the limestone combines with the shale)
- Oil shale: shale with up to ⅓ made of kerogen (a form of organic material). Can be treated to produce oil, but it is not very efficient and has large environmental impacts
- Mostly made of clay minerals
- Black shales contain 1-2% organic matter and form in anoxic areas alongside pyrite
- Red color made by hematite, yellow or brown by limonite or goethite
- Can hold large quantities of liquid but does not release it easily
- Has been found on Mars





Coal Varieties

- Formation:
    - Plants die in a swamp and fall into the water, which is normally anoxic, which prevents decay
    - If the plants die faster than they decay, a thick layer forms and is eventually covered by sediment
    - Water height must be maintained the whole time or else it will decay (too low) or the plants will drown (too high)
    - This height can be maintained by the landscape subsidizing at the rate the plants die (more common) or the water rising in sync to their death (less common)
- Coal rank is the measurement of how much change has occurred to the organic matter (sometimes called organic metamorphism)
- Turned into coke by heating coal with no air around, which concentrated the carbon. Coke is then used as a high-carbon fuel
- Ranks (in order from lowest to highest)
    - Peat: less than 60% carbon, organic sediment (not really coal)
    - **Lignite**:
        - 60-70% carbon.
        - Sometimes contains recognizable plant structures.
        - Made from peat.
        - Brown-black color, sometimes called “brown coal.”
        - Has a heating value of less than 8300 british thermal units per pound
    - Sub bituminous: 71-77% carbon. 8300-13000 british thermal units per pound
    - **Bituminous**:
        - Most abundant coal (50% of the coal produced in the US)
        - 77-87% carbon
        - Has a heating value higher than sub bituminous
        - Often called “soft coal”
        - Divided into 3 categories (high, medium, low) based on volatile content
    - **Anthracite**:
        - Technically a metamorphic rock
        - Over 87% carbon content
        - “Hard coal”
        - Divided into semi-anthracite, anthracite, and meta-anthracite based on carbon content
        - Has a semi-conchoidal fracture

Anthracite

bituminous

lignite

Limestone Varieties

- Composed of calcite
- Forms mostly in clear, warm, shallow marine waters
- Forms either from the accumulation of organic debris or the precipitation of calcium carbonate from water (less abundant than organic)
- Biological limestone often contains fossils
- Most biologic limestone still contains lots of precipitated calcium carbonate (up to 50%) as a cement
- Generally forms between 30 degree latitudes
- Forms speleotherms: cave formations that form when water dripping from the ceiling evaporates, leaving behind the calcium carbonate (travertine)
- Must contain at least 50% calcium carbonate by weight
- Effervesces in 5% HCl
- Types:
    - Chalk:
        - Forms from the accumulation of the shells of microscopic marine organisms (ie foraminifera) and algae
        - Easily broken and crushed
        - Used to write on blackboards, commonly man-made
    - Coquina:
        - Composed almost entirely of sand-sized shell bits and coral debris
        - Poorly cemented
        - Forms where waves deposit lots of biologic grains without many rock or mineral deposition
    - Fossiliferous:
        - Contains obvious and abundant fossils
        - Can easily be examined to determine its geologic age
    - Oolite
        - Made up of ooliths, small, sand-sized clasts of calcium carbonate
        - Ooliths form by the precipitation of calcium carbonate around a particule nucleus, forming concentric rings
        - Forms in wavy waters or when rolling across sediment
        - Calcium carbonate cement binds it together
        - Common in the Great Salt Lake, Utah, and the Bahamas Platform
    - Travertine
        - Forms when geothermal heated water, supercharged with dissolved gas and minerals, rises to the surface and evaporates and the calcium carbonate precipitates out
        - Also forms in subsurface caverns, where it forms cave structures
        - Naturally pure white, but is often stained colors
        - Often forms banded patterns as a crust on top of other rocks
        - Used in architecture in ancient Rome and Egypt
        - High-quality travertine can accept a polish


Oolitic


fossiliferous


chert


chalk


travertine

Name	Hardness	SG	Streak	Fracture	Tenacity	Luster	Chemical Structure	Color	Crystal System
Borates									
Ulexite	2.5	1.96	White	Uneven	Brittle	Viterous, silkey	$NaCa[B_5O_6(OH)_6] \cdot 5H_2O$	Colorless, white/grey	Triclinic
Carbonates									
Azurite	3.5-4	3.77-3.78	Pale blue	2 direction, one perfect, one poor	soft	viterous, earthy	$Cu_3(CO_3)_2(OH)_2$	Deep blue	Monoclinic
Malachite	3.5-4	4	Pale green	1 perfect, one fair	soft	many	$Cu_2(CO_3)(OH)_2$	Deep green	Monoclinic
Aragonite	3.5-4	2.94-2.95	White	subconchoidal	brittle	viterous, dull	$CaCO_3$	Many	Orthorhombic
Calcite	3	2.71	White grayish	perfect,3direction	brittle	viterous	$CaCO_3$	Light medium	Trigonal/ Hex
Dolomite	3.5-4	2.85	White	perfect,3direction	brittle	viterous, pearly	$CaMg(CO_3)_2$	Light	Trigonal/ Hex
Halides									
Halite	2-2.5	2.1-2.2	White	perfect	soft	viterous	NaCl	Numerous	Cubic
Fluorite	4	3.1-3.3	White	4direction,perfect	soft	viterous	CaF_2	Numerous	Cubic
Hydroxides/Oxides									
Magnetite	5.5-6.5	5.2	Black	uneven	brittle	metallic	$Fe^{2+}Fe^{3+}{}_2O_4$	Black	Cubic
Bauxite	1.0-2	2.3-2.7	White	none	brittle	dull/earthy	$Al(OH)_3$ ± extra Al or OH	Yellow, brown	N/A
Corundum	9	4-4.1	White	none	none	viterous	Al_2O_3	Numerous	Trigonal/ Hex
Hematite	5.0-6	5.26	Brown-red	none	soft	earth to metallic	Fe_2O_3	Brown red, black	Trigonal/ Hex
Goethite/Limonit	5-5.5	3.3-4.3	Orange brownish	splintery	brittle	silky,metallic,dull	$\alpha\text{-}Fe^{3+}O(OH)$	Black-brown light	Orthorhombic
Native Elements									
Diamond	10	3.52	White	rarely breaks	hard	adamantine	C	Numerous	Cubic
Copper	2.5-3	8.9	Copper-red	none	ductile	metallic	Cu	Copper or green	Cubic
Silver	2.5-3	10.5	Silver-white	none	soft	metallic	Ag	Silver	Cubic
Gold	2.5-3	19.3	Golden-yellow	none	ductile	metallic	Au	Yellow	Cubic
Sulfur	1.5-2.5	2-2.1	White	conchoidal	brittle	adamantine-dull	S	Yellow	Orthorhombic
Graphite	1.0-2	2.1-2.3	Gray	1direction perfect	slippery	metallic-earthy	C	Grey	Trigonal/ Hex
Phosphates									
Apatite	5	3.1-3.2	White	conchoidal	brittle	viterous	$Ca_5(PO_4)_3(F,Cl,OH)$	Many esp. green	Trigonal/ Hex
Silicates									
Sodalite	5.5-6	2.14-2.4	Colorless	uneven	brittle	viterous-greasy	$Na_8Al_6Si_6O_{24}Cl_2$	Many esp. blue	Cubic
Talc	1	2.58-2.83	White	perfect 1direction	soft	pearly	$Mg_3Si_4O_{10}(OH)_2$	Light to gray, green	Monoclinic
Epidote	6.0-7	3.35-3.5	Colorless-grayish	perfect,1direction	Brittle	viterous	$Ca_2(Al,Fe)_2(SiO_4)_3(OH)$	Dark or yellowish	Monoclinic
Olivine	6.5-7	3.27-4.32	Colorless	conchoidal	Brittle	viterous	$(Mg,Fe)_2SiO_4$	Green brown	Orthorhombic
Topaz	8	3.49-3.57	Colorless	perfect basal	Brittle	viterous	$Al_2SiO_4(F,OH)_2$	Numerous	Orthorhombic
Staurolite	7-7.5	3.65-3.83	Colorless-grayish	subconchoidal	brittle	viterous, dull	$Fe_2Al_9Si_4O_{22}(OH)_2$	Dark	Orthorhombic
Kaolinite	2-2.5	2.6-2.63	White	earthy	brittle	dull	$Al_2Si_2O_5(OH)_4$	Light, medium	Monoclinic
Beryl	7.0-8	2.6-2.9	White	conchoidal	brittle	viterous, waxy	$Be_3Al_2Si_6O_{18}$	Numerous	Trigonal/ Hex
Tourmaline	7-7.5	3-3.2	Colorless	conchoidal	Brittle	viterous	see notes	Medium	Trigonal/ Hex
Quartz Varieties									
Agate/Onyx	7	2.6-2.7	white	conchoidal	Brittle	viterous	SiO_2	many (black onyx)	Trigonal/ Hex
Amethyst	7	2.6-2.7	white	conchoidal	Brittle	viterous	SiO_2	Purple	Trigonal/ Hex
Chalcedony	7	2.6-2.7	white	conchoidal	Brittle	viterous	SiO_2	white/blue	Trigonal/ Hex
Citrine	7	2.6-2.7	white	conchoidal	Brittle	viterous	SiO_2	Orange/Yellow	Trigonal/ Hex
Crystal	7	2.6-2.7	white	conchoidal	Brittle	viterous	SiO_2	Clear	Trigonal/ Hex
Jaspar	7	2.6-2.7	white	conchoidal	Brittle	viterous	SiO_2	many (opaque)	Trigonal/ Hex
Milkey Quartz	7	2.6-2.7	white	conchoidal	Brittle	viterous	SiO_2	White	Trigonal/ Hex
Opal	4.5-6.5	1.9-2.3	White	conchoidal	Brittle	viterous	$SiO_2 \cdot nH_2O$	Many esp. dark	N/A
Rose Quartz	7	2.6-2.7	white	conchoidal	Brittle	viterous	SiO_2	Pink	Trigonal/ Hex
Garnet Group									
Almandine	6.5-7.5	4.1-4.3	White	conchoidal	Brittle	viterous	$Fe_3Al_2Si_3O_{12}$	Dark esp. brown	Cubic
Feldspar-Potassium									
Amazonite	6-6.5	2.55-2.63	White	2perfect,perp.	brittle	viterous	$KAlSi_3O_8$	Medium esp. green	Triclinic
Orthoclase	6	2.6	white	conchoidal	Brittle	viterous	$KAlSi_3O_8$	many esp. white	Monoclinic
Feldspar-Plagiocase									
Albite	6-6.5	2.6-2.63	White	subconchoidal	Brittle	viterous	$NaAlSi_3O_8$	Many Esp. Light	Triclinic
Pyroxene Group									
Augite	5.5-6	3.23-3.52	Gray-green	uneven	Brittle	viterous,dull	$(Ca,Na)(Mg,Fe,Al)(Al,Si)_2O_6$	Dark esp. Black	Monoclinic
Rhodonite	5.5-6.5	3.57-3.76	White	hacky	Brittle	viterous	$MnSiO_3$	Red pink	Triclinic
Amphibole Group									
Tremolite	5.0-6	2.9-3.2	White	Uneven	brittle,elastic	viterous,silky	$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$	Many esp. white	Monoclinic
Hornblende	5.0-6	3.28-3.41	White gray	Uneven	brittle	viterous-dull	$Ca_2(Mg,Fe^{2+},Fe^{3+},Al)_5(Si,Al)_8O_{22}(OH)_2$	Dark esp. green	Monoclinic
Mica Group									
Biotite	2.5-4	2.7-3.4	Colorless	Uneven	sectile,elastic	pearly	$K(Mg,Fe^{2+3})(Al,Fe^{3+})Si_3O_{10}(OH,F)$	Dark	Monoclinic
Lepidolite	2.5-3	2.8-3.3	Colorless	Uneven	sectile,elastic	pearly	$K(Li,Al)_3(Si,Al)_4O_{10}(F,OH)_2$	Pink, purple, med.	Monoclinic
Muscovite	2.5-4	2.77-2.88	Colorless	Uneven	sectile,elastic	pearly	$KAl_3Si_3O_{10}(OH)_2$	Light	Monoclinic
Sulfates									
Celestite	3-3.5	3.96-3.98	White	Uneven	brittle	viterous,pearly	$SrSO_4$	Light blue	Orthorhombic
Barite	3-3.5	4.5	White	Uneven	brittle	viterous,pearly	$BaSO_4$	Light medium	Orthorhombic
Gypsum Varieties									
Alabastar	2	2.3-2.4	white	Uneven	sectile, flexible	viterous	$CaSO_4 \cdot 2H_2O$	white	Monoclinic
Satin Spar	2	2.3-2.4	white	fibrous	sectile, flexible	silky	$CaSO_4 \cdot 2H_2O$	white-translucent	Monoclinic
Selenite	2	2.3-2.4	white	Uneven	sectile,flexible	viterous	$CaSO_4 \cdot 2H_2O$	translucent	Monoclinic
Sulfides									
Sphalerite	3.5-4	3.9-4.1	white-brown	conchoidal	brittle	metallic-resinous	(Zn)S	Num. Esp. black	Cubic
Pyrite	6-6.5	5	Green-black	conchoidal	brittle	metallic	FeS_2	Pale yellow	Cubic
Bornite	3	5-5.1	Gray-black	conchoidal	brittle	metallic	Cu_5FeS_4	Dark/ Blue	Cubic
Galena	2.5	7.58	Lead-gray	subconchoidal	brittle	metallic-dull	PbS	Lead gray	Cubic
Chalcopyrite	3.5-4	4.3-4.4	Green-black	Uneven	brittle	metallic	$CuFeS_2$	Brassy yellow	Tetragona