Mineral Hunters Guide: Ruggles Mine Edition

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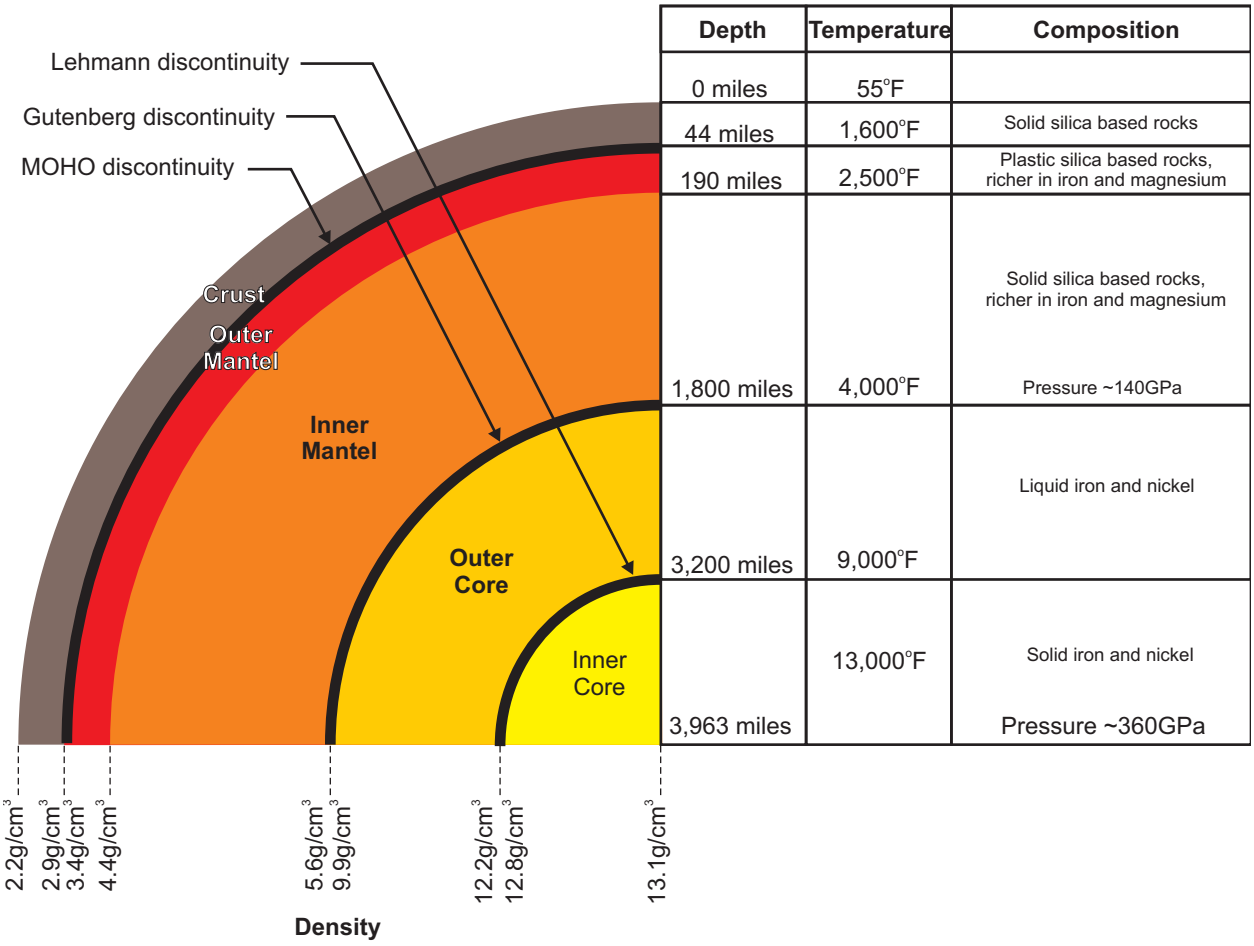
Contents

1. Makeup of the earth

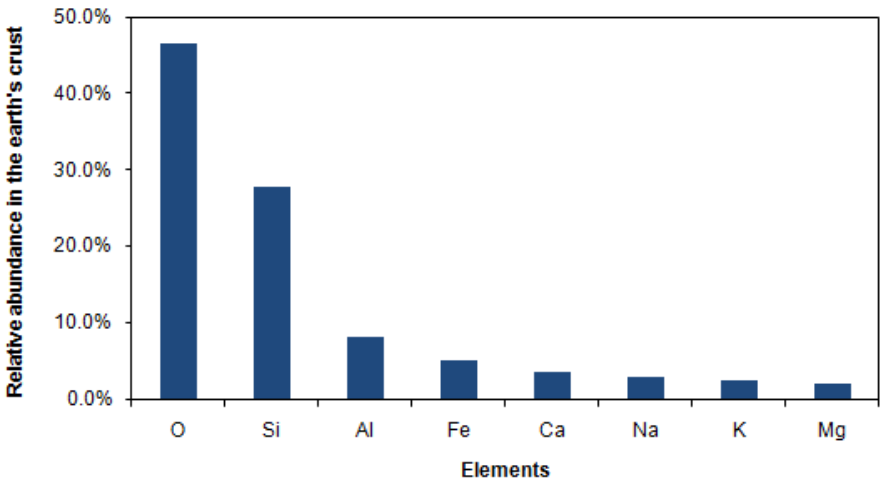
The earth is made up of several layers. Proceedings from the outside in:

- Crust - the cool-solid outer skin of the planet. The crust varies in thickness and composition. Under the continents the crust varies in thickness between 15.5 to 43.5 miles and is mainly made up of rocks such as granite that contain, silicon, oxygen, sodium, potassium and aluminum. The crust under the ocean is thinner than under the continents varying between 4.3 and 6.2 miles thick. The crust under the ocean is made up of denser basalt type rocks that contain iron, magnesium, silicon and oxygen. The average temperature on the surface of the earth is 55^{o}F and at the bottom of the crust may be as high as 1,600^{o}F.
- Mantle - the next layer moving toward the center of the earth is nearly 1,800 miles thick. There is an outer mantel that extends down to 190 miles and is believed to be made up of silicon, oxygen, iron and magnesium. The temperature at the bottom of the outer layer is about 2,500^{o}F and the rock is a liquid. The inner mantel extends down to around 1,800 miles and although the temperature is around 4,000^{o}F there is so much pressure that the rock is still solid. The inner mantel is believed to consist of sulfur, oxygen, silicon and magnesium.
- Core - the core is roughly 2,163 miles thick. There is an outer core that is roughly 1,400 miles thick, and has a temperature at its outer boundary of around 4,000^{o}F and a temperature at its inner boundary of around 9,000^{o}F. The outer core is believed to be made up of liquid iron and nickel and is also believed to be the source of the earth's magnetic field. The inner core is at the center of the earth and is roughly 763 miles thick with a temperature of around 13,000^{o}F. The inner core is under so much pressure that it is a solid ball of iron and nickel.



Depth	Temperature	Composition
0 miles	55°F	
44 miles	1,600°F	Solid silica based rocks
190 miles	2,500°F	Plastic silica based rocks, richer in iron and magnesium
1,800 miles	4,000°F	Solid silica based rocks, richer in iron and magnesium Pressure ~140GPa
3,200 miles	9,000°F	Liquid iron and nickel
3,963 miles	13,000°F	Solid iron and nickel Pressure ~360GPa

Figure 1. Structure of the earth.



Element	Atomic symbol	%
Oxygen	O	46.6%
Silicon	Si	27.7%
Aluminum	Al	8.1%
Iron	Fe	5.0%
Calcium	Ca	3.6%
Sodium	Na	2.8%
Potasium	K	2.6%
Magnesium	Mg	2.1%

All other elements occur at less than one percent.

Figure 2. Relative abundance of elements in the earth's crust.

2. Types of rocks

There are three major types of rocks:

- Igneous rock - crystalline rocks formed from cooling magma. If the igneous rock forms underground it cools slowly, has large grains and is called plutonic igneous rock. Igneous rock formed from lava on the surface cools rapidly, has small grains and is called volcanic igneous rock.
- Sedimentary rock - rocks formed from layers of small particles that are compacted and cemented together. There are clastic, chemical (formed from the material left behind during evaporation) and organic.
- Metamorphic rock - metamorphic means change form. Metamorphic rocks are igneous or sedimentary rocks that have changed form due to temperature and pressure.

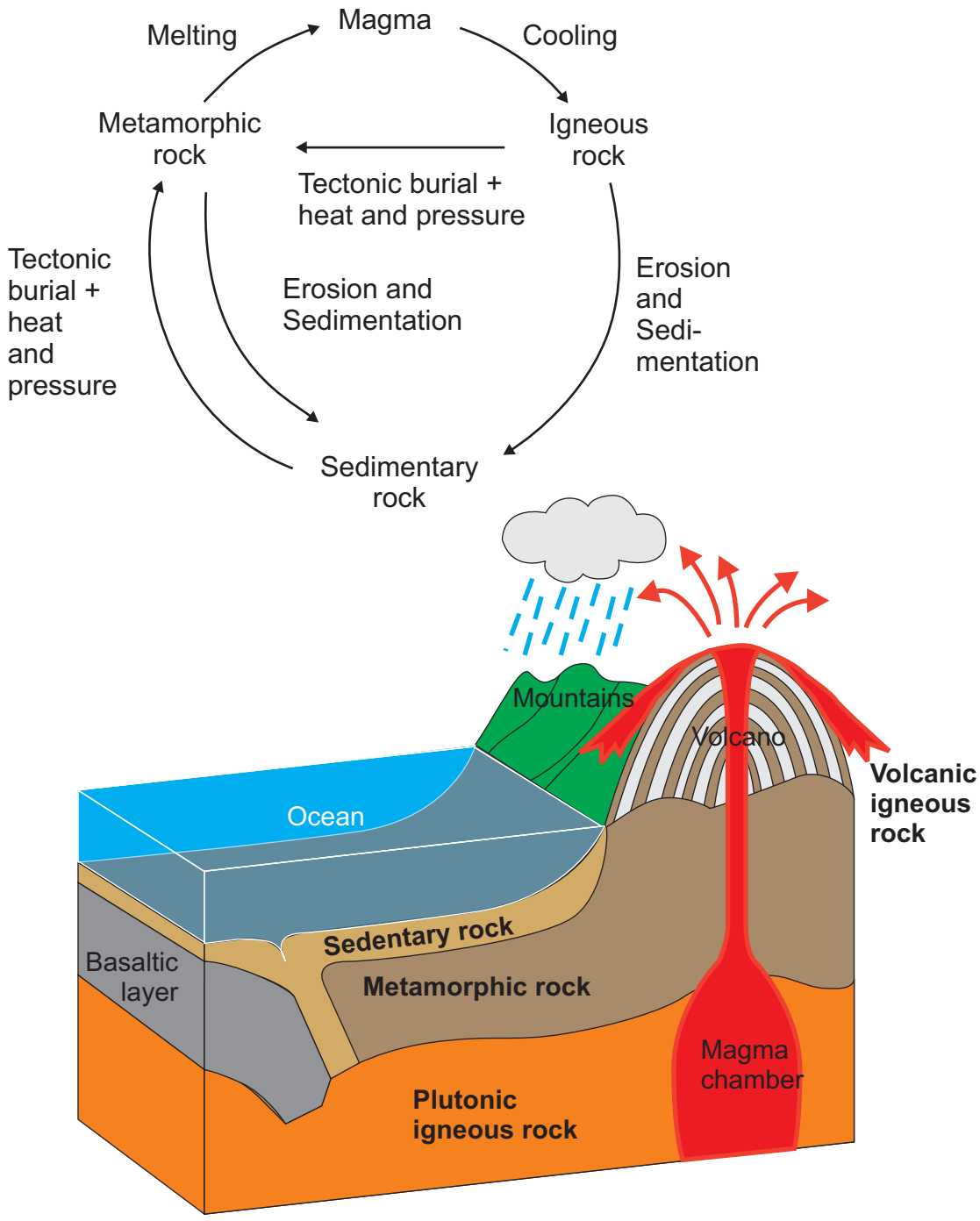


Figure 3. Rock cycle.

3. Definition of a mineral

A mineral is a naturally occurring solid formed through geological processes that has a characteristic chemical composition, a highly ordered atomic structure, and specific physical properties.

To qualify as a mineral a substance has to meet five criteria:

- Naturally occurring
- Solid - not always true
- Definite chemical composition - the elements occur in a specific ratio to each other
- Crystal structure - atoms follow a pattern
- Inorganic - never been alive

The key difference between a mineral and a rock is the definite chemical composition. Minerals are made up of elements and rocks are made up of minerals.

4. Number of minerals and the most common types

There are over 3,200 different minerals that have been identified and more are added every year but only a few dozen are common.

From the discussion on the makeup of the earth it can be seen that the most common elements in the earth's crust are oxygen and silicon. Not surprisingly the most common minerals are a combination of oxygen and silicon called silicates. Silicates are mostly silicon and oxygen but also contain other elements.

Common silicates are:

- Olivine
- Pyroxene group
- Amphibole group
- Micas - very common at Ruggles mine
- Feldspar - very common at Ruggles mine
- Quartz - very common at Ruggles mine

Common non-silicate minerals are:

- Oxides - hematite and magnetite
- Sulfides - pyrite - very common at Ruggles mine
- Sulfates - gypsum
- Halides - halite
- Carbrates - calcite - Ruggles mine mineral
- Sulfur

See the section on chemical properties for information on what makes up these mineral groups.

5. Mineral properties and how to measure them

By measuring the physical properties of minerals and comparing them to tables of mineral properties the type of mineral being examined can be determined.

Common mineral properties are:

- Cleavage and fracture - how the mineral breaks.
- Streak - what color line is left when scrapping the mineral on a porcelain plate.
- Color - what color does the mineral appear? Not as reliable as a streak test because impurities and cause large variations in color. Quartz for example can be white, smoky-grey, rose or amethyst.
- Hardness - measured on a MOH scale by scratching the mineral with different samples.
- Luster - how shiny is the mineral
- Transparency - can you see through or into the mineral or is it opaque.
- Specific gravity - the density of the mineral relative to the density of water.

Other properties or tests:

- Acid test - does the mineral bubble when vinegar or hydrochloric acid is applied.
- Fluorescence - does the mineral glow when exposed to ultraviolet light.
- Magnetism - does the mineral attract a compass needle? Only a few minerals are magnetic so this test really narrows down the search, however not all "magnetic" minerals always show magnetism.

5.1. Cleavage

Cleavage is measured by two factors, quality and number of sides.

Quality of cleavage for each face is defined as:

- Perfect - a smooth plane free of imperfections.
- Excellent - smooth but not perfect plane.
- Distinct - a well defined plane.
- Good - a well defined plane but with rough surfaces.
- Poor - the plane is barely visible and the rough surface is dominant.
- None - the broken surface is jagged and rough

Minerals may cleave on only one side or on several sides. There are six basic forms of cleavage that determine how many directions the mineral cleaves in. Each direction results in two planes or sides.

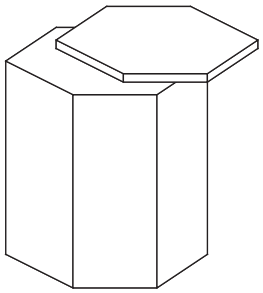
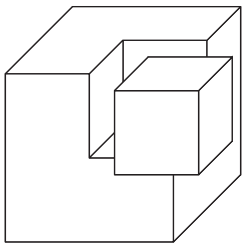
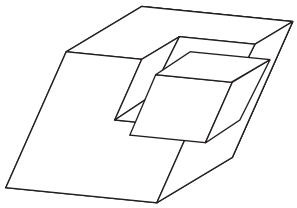
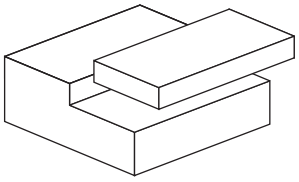
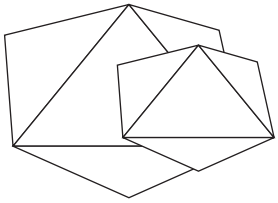
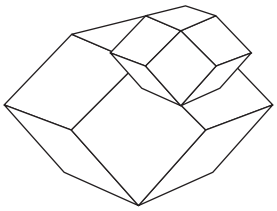
		
Basal cleavage: cleavage on single plane parallel to the base of the crystal.	**Cubic cleavage:** 3 directions with 90 degree angles forming a smaller cube.	**Rhombohedral cleavage:** 3 directions with oblique or obtuse angles.
		
Prismatic cleavage: 2 directions leaving a stair step pattern.	**Octahedral cleavage:** 4 directions in a triangular pattern.	**Dodecahedral cleavage:** 6 directions.

Figure 4. Cleavage.

5.2. Fracture

Fracture is the characteristic mark left when a mineral chips or breaks. Cleavage and fracture differ in that cleavage is the break of a crystal face where a new face (resulting in a smooth plane) is formed, whereas fracture is the "chipping" of a mineral. All minerals exhibit a fracture, even those that exhibit cleavage. If a mineral with cleavage is chipped a certain way, it will fracture rather than cleave.

Terms used to describe fracture:

- Conchoidal - Fracture resembling a semicircular shell, with a smooth, curved surface. An good illustration of a conchoidal fracture is a large chip in a piece of glass. This fracture is also known as "shelly" in some references.
- Uneven - Fracture that leaves a rough or irregular surface.
- Hackly - Fracture that resembles broken metal, with rough, jagged, points. True metals exhibit this fracture. This fracture is also known as "jagged".
- Splintery - Fracture that forms elongated splinters. All fibrous minerals fall into this category.
- Earthy or crumbly - Fracture of minerals that crumble when broken.
- Even or smooth - Fracture that forms a smooth surface.
- Subconchoidal - Fracture that falls somewhere between conchoidal and even; smooth with irregular rounded corners.

5.3. Hardness

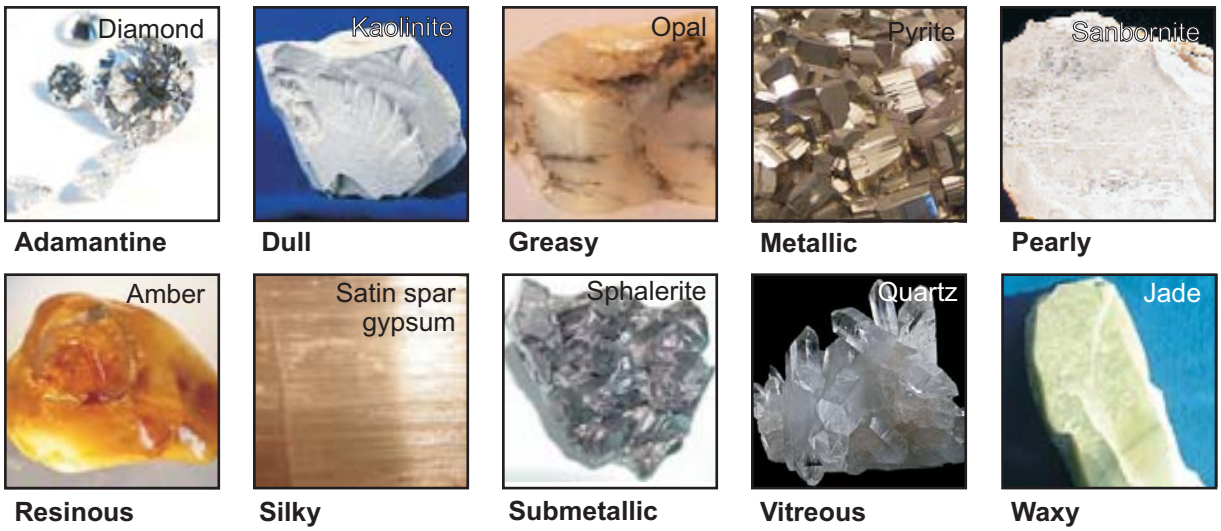
To determine hardness try scratching the sample with progressively harder objects and note whichobject scratches the sample.

Table 1: Hardness Scale.

"Official" MOH hardness scale	"Unofficial" MOH hardness scale	Mineral or object	Absolute hardness
1		Talc ($Mg_3Si_4O_{10}(OH)_2$)	1
	1	**Lead pencil**	
2		Gypsum ($CaSO_4$-$2H_20$)	3
	2.2-2.5	**Fingernail**	
3		Calcite ($CaCO_3$)	9
	3.5	**Copper penny**	
4		Fluorite (CaF_2)	21
	4.5	**Iron nail**	
5		Apatite ($Ca_5(PO_4)_3(OH\text{-},Cl\text{-},F\text{-})$)	48
	5.1	**Inexpensive pocket knife**	
	5.5	**Window glass**	
6		Orthoclase Feldspar ($KAlSi_3O_8$)	72
	6.5	**Good steel file**	
7		Quartz	100
	7	**Porcelin streak plate**	
8		Topaz ($Al_2SiO_4(OH\text{-},F\text{-})_2$)	200
9		Corundum (Al_2O_3)	400
10		Diamond (C)	1,600

5.4. Luster

How light reflects from the sufcae of a mineral.



- Adamantine - transparent to translucent minerals with a high refractive index. They display extraordinary brilliance and shine and are very rare. Examples: diamond, cerussite and zircon.
- Dull - poor reflective qualities, much like unglazed porcelain. Most minerals with a dull luster have a rough or porous surface. Also referred to as earthy. Example: kaolinite.
- Greasy - appears as if it were coated with grease, often also feels greasy. Examples: Opal and cordierite.
- Metallic - opaque and reflective, like metal. Examples: galena, pyrite, magnetite.
- Pearly - similar to the inside of a mollusk shell or shirt button. Examples: muscovite and stilbite.
- Resinous - the luster of many yellow, dark orange, or brown minerals with moderately high refractive indices. Example: amber.
- Silky - optical properties similar to silk cloth also having a fine fibrous structure. Examples: asbestos, ulexite and the satin spar type of gypsum. Fibrous is similar but coarser.
- Submetallic - opaque to nearly opaque and reflects well. Similar to metallic but duller. Thin splinters or sections are translucent. Examples: sphalerite, cinnabar and cuprite.

- Vitreous - reflective properties similar to glass. The most common mineral luster; Examples: calcite, quartz, topaz, beryl, tourmaline and fluorite.
- Waxy - appears as if it were coated with a layer wax. Examples: jade and chalcedony.

5.5. Transparency

The transparency of a mineral refers to how light passes through the mineral and is broken up into three groupings:

1. Transparent - if you can see through the mineral it is transparent.
2. Translucent - if light passes through a mineral but you can't see objects clearly through it they are said to be translucent.
3. Opaque - light does not pass through even thin sections of the mineral.

5.6. Specific gravity

Specific gravity is the density or mass per unit volume of a substance compared to the density of water.

Specific Gravity = density of a substance/density of water

Since the density of water is 1g/ml or 1g/cm^3 if the density of a substance is measured in g/ml or g/cm^3 the density is equal to the specific gravity.

6. Mineral chemical properties

The following are the major mineral classes in order of abundance and their chemical properties.

- Silicates - based on the SiO_4^{-4} anion. Silcates are far and away the most abundant mineral and 95% or more or most rocks are made up of silicates. Composed primarily of silicon and oxygen, silicates also includes ions such as aluminum, magnesium, iron, and calcium. Some important rock-forming silicates include the feldspars, quartz, olivines, pyroxenes, amphiboles, garnets, and micas. There are over 500 silicates.
- Carbonates - minerals containing the anion $(CO_3)^{2-}$ and include calcite and aragonite (both calcium carbonate), dolomite (magnesium/calcium carbonate) and siderite (iron carbonate). Commonly found on sea floors where the shells of dead sea life accumulate, setting where evaporating water leaves them being such as the Great Salt Lake or in Karst regions where dissolution and re-precipitation of carbonates leads to the formation of caves, stalactites and stalagmites. The carbonate class also includes the nitrate and borate minerals. There are approximately 200 carbonates.
- Sulfates - minerals containing the sulfate anion, SO_4^{2-}, all sulfates contain sulfur, oxygen and a metal. Sulfates commonly form in settings where highly saline waters slowly evaporate, allowing the formation of both sulfates and halides at the water-sediment interface. Sulfates also occur in hydrothermal vein systems as gangue minerals along with sulfide ore minerals. Another occurrence is as secondary oxidation products of original sulfide minerals. Common sulfates include anhydrite (calcium sulfate), celestine (strontium sulfate), barite (barium sulfate), and gypsum (hydrated calcium sulfate). The sulfate class also includes the chromate, molybdate, selenate, sulfite, tellurate, and tungstate minerals.
- Halide - minerals that contain halogen anions, fluoride (F^-), chloride (Cl^-), bromide (Br^-), iodide (I^-) and astatide (At^-). Halides include the natural salts and include fluorite (calcium fluoride), halite (sodium chloride), sylvite (potassium chloride), and sal ammoniac (ammo-

nium chloride). Halides, like sulfates, are commonly found in settings such as salt lakes and landlocked seas such as the Dead Sea and Great Salt Lake where water has evaporated and left them behind. The halide class includes the fluoride, chloride, bromide and iodide minerals. There are only about 100 members to this group.

- Oxides and Hydroxide - compounds of one or two metallic elements plus oxygen, with two prominent exceptions: ice and quartz. Ice (H_2O) always gets left out of the mineral books. Quartz (SiO_2) is treated as one of the silicate minerals. They commonly occur as precipitates close to the Earth's surface, oxidation products of other minerals in the near surface weathering zone, and as accessory minerals in igneous rocks of the crust and mantle. Common oxides include hematite (iron oxide), magnetite (iron oxide), chromite (iron chromium oxide), spinel (magnesium aluminium oxide - a common component of the mantle), ilmenite (iron titanium oxide), rutile (titanium dioxide), and ice (hydrogen oxide). The oxide class includes the oxide and the hydroxide minerals and has over 250 members.
- Sulfide - a mineral sulfur and another element (but without oxygen as in Sulfates). Many sulfide minerals are economically important as metal ores. Common sulfides include pyrite (iron sulfide - commonly known as fools' gold), chalcopyrite (copper iron sulfide), pentlandite (nickel iron sulfide), and galena (lead sulfide). The sulfide class also includes the selenides, the tellurides, the arsenides, the antimonides, the bismuthinides, and the sulfosalts (sulfur and a second anion such as arsenic). There are over 300 sulfides.
- Phosphate - minerals containing PO_4 although is also includes any mineral with a tetrahedral unit AO_4 where A can be phosphorus, antimony, arsenic or vanadium. By far the most common phosphate is apatite which is an important biological mineral found in teeth and bones of many animals. The phosphate class includes the phosphate, arsenate, vanadate, and antimonate minerals.
- Native Elements - free uncombined elements. This group is fairly small with about 50 members. Some elements such as gold and silver are rare and valuable.

- Organic - includes biogenic substances in which geological processes have been a part of the genesis or origin of the existing compound. Minerals of the organic class include various oxalates, mellitates, citrates, cyanates, acetates, formates, hydrocarbons and other miscellaneous species. Examples include whewellite, moolooite, mellite, fichtelite, carpathite, evenkite and abelsonite

7. Practicle uses of minerals

Most minerals have some practical use. The following are some of the more common Ruggles mine minerals and their uses:

- Quartz - (silica) - As crystal, quartz is used as a semiprecious gemstone. Crystalline varieties include amethyst, citrine, rose quartz, smoky quartz, etc. Because of its piezoelectric properties, quartz is used for pressure gauges, oscillators, resonators and wave stabilizers. Also used in manufacturing of glass, paints, abrasives, refractories and precision instruments.
- Pyrite - Used in the manufacture of sulfur, sulfuric acid and sulfur dioxide; pellets of pressed pyrite dust are used to recover iron, gold, copper, cobalt, and nickel.
- Mica - Mica commonly occurs as flakes, scales or shreds. Sheet muscovite (white) mica is used in electronic insulators; ground mica in paints, as joint cement, as a dusting agent, in well-drilling mud and lubricants; and in plastics, roofing, rubber and welding rods.
- Feldspar - A rock forming mineral; industrially important in glass and ceramic industries; pottery, porcelain and enamelware; soaps; bond for abrasive wheels; cement and glues; insulating compositions; fertilizer; tarred roofing materials; and as a sizing, or filler, in textiles and paper applications.

8. Physical properties of Ruggles mine minerals

The following table lists the properties of all the minerals found at Ruggles mine.

Table 2: Ruggles mine mineral properties in alphabetical order

Mineral	Color	Streak	Cleavage/fracture	Hardness (MOH)	Luster	Transparency	Specific gravity	Notes
Albite	White or colorless, may be bluish, grey or reddish	White	Distinct/uneven	6.0-6.5	Pearly	Transparent to translucent	2.60-2.63	Fuses with difficulty coloring the flame yellow
Amethyst	Purple	Colorless to white	None/concoidal to uneven	7	Vitreous	Transparent to translucent	2.65	Insoluble except in hydrofluoric acid
Apatite	Colorless, pale yellow or greenish white	White	Poor/subconcoidal	5	Vitreous	Transparent to translucent	3.1-3.2	Soluble in hydrochloric acid
Aquamarine	Blue	White	Indistinct/uneven to concoidal	7-8	Vitreous	Transparent to translucent	2.6-2.9	Fuse with difficulty rounding the edges of small framents
Autunite	Yellow to green	Yellow	Perfect basal/uneven	2-2.5	Vitreous to pearly	Transparent to translucent	3.05-3.2	Radioative
Bertrandite	Colorless, white and pale yellow	White to grey	Good in one direction lengthwise/uneven to concoidal	6-7	Vitreous to pearly	Transparent to translucent	3.3-3.5	Some specimins hve fluoresced green under UV light
Beryl (large - golden, blue, aqua)	Colorless, white and red (other colors are named seperately)	White	Indistinct/uneven concoidal	7-8	Vitreous	Transparent to translucent	2.6-2.9	Fuse with difficulty rounding the edges of small framents
Beta-uranophane	Green and yellow	Pale yellow	Perfect in one direction	2.4-3	Vitreous to silky	Transparent to translucent	3.9	Fluoroscent, weak green
Biotite	Black or dark brown to reddish brown, green and very rarely white	Colorless	Perfect basal/uneven		Splendent to vitreous	Transparent to nearly opaque	2.7-3.4	Soluble in sulfuric acid
Bornite	Coppery red, coppery borwn or bronze, tarnishing to iridescent blue, purple or red	Grayish black	Very poor/uneven to concoidal	3	Metalic	Opaque	5.0-5.1	Soluble in nitric acid
Calcite	White, colorless, grey, red, brown, green and black	White o grayish	Perfect/subconchoidal to uneven	3	Vitroeus to pearly or dull	Transparent to translucent	2.71	Effervecese in cold dilut hydrochorlic acid
Chrysoberyl	Green or yellow to bronwish or grey	White	Disctinct prismatic/concoidal to uneven	8.5	Vitreous	Transparent to translucent	3.7	Insoluble
Clarkite	NA	NA	NA	NA	NA	NA	NA	NA
Clevelandite	NA	NA	NA	NA	NA	NA	NA	NA
Columbite	Gray-black to brownish black	dark red to black	Disticnt/subconcoidal to uneven	6-6.5	Sumetallic to resinous	Translucent to opaque	5.1-8.2	Specific gravity increases with tantalum content
Comptite	NA	NA	NA	NA	NA	NA	NA	NA
Cryolite	Colorless, white, yellowish, brown or reddish	White	None/uneven	2.5	Vitreous to greasy	Transparent to translucent	2.97	Almost invisible in water, fuses easily with a yellowish flame
Cymatolite	White	NA	Irregular/uneven, splintery, fibrous, micaceous	NA	Silky, pearly, dull	NA	NA	NA

Table 2: Ruggles mine mineral properties in alphabetical order

Mineral	Color	Streak	Cleavage/fracture	Hardness (MOH)	Luster	Transparency	Specific gravity	Notes
Feldspar	White, pink, tan, green or gray	White	Two or three/conchoidal or brittle	6-.65	Glassy or pearly	Opaque	2.56	
Fluorapatite	Sea-green, violet, purple, blue, pink, yellow, brown, white, colorless	White	Indistint/brittle to concoidal	5	Vitreous, resinous to dull	Transparent to opaque	3.1-3.2	Fluoresecent and phosphoresceent
Garnet (Pyrope)	Pinkish, purplish red to crimson, nearly black	White	None	6.5-7.5	Vitreous	Transparnet to translucent	3.5-3.8	Fuses fairly easily ad is virtually insoluble in acids
Garnet (Grossular)	Green, yellowish green, yellow, brown, red, orange, reddish brown, white, pink, gray or black	White	None	6.5-7.5	Vitreous or resinous	Transparent to nearly opaque	3.4-3.6	Insoluble in acids.
Garnet (Almandine)	Deep red to reddish brown and brownish black	White	None	6.5-7.5	Vitreous to resinous	Transparent to translucent	4.1-4.3	Insoluble in acids, fuses failry easily
Gratonite	Dark lead gray	Gray	None	2.5	Metallic	Opaque	6.2	
Gummite	Orange, yellow, orange-red, red-brown, brown-black, black	Yellow, brownish, olive-green	Irregular/Uneven, Conchoidal	2.5-5	Vitreous, Waxy, Greasy, Dull	Translucent	3.9-6.4	
Kasolite	Green, Gray green, Yellow, Yellow brown, Reddish orange	light brownish yellow	Uneven - Flat surfaces (not cleavage) fractured in an uneven pattern. Good cleavage	4	Resinous, greasy	Transparent to translucent	5.96 - 6.5	Radioactive
Lepidolie (lemon yellow)	Pink, purple, grayish and white or colorless	Colorless	Pefect basal, uneven fracture	2.5-3	Pearly	Transparent to translucent	2.8-3.3	Colors flame red and is insoluble in acids
Lithiophylite	Brown, Yellowish brown, Salmon, Brownish, Blackish	Gray white	Conchoidal - Uneven - Uneven fracture producing small, conchoidal fragments	4-5	Vitreous, resinous	Transparent to Translucent	3.34	
Manganapatite	Blue to dark blue	White	Poor basal cleavage. Clear along {0001} and {10/10}. Brittle fracture	5			3.12-3.22	Soluble in hydrocloric acid, in sulphur acid and nitrous acid. The nitric acid solution gives with ammonium molybdate an yolk yellow precipitate
Marcasite	Brassy yellow	Greenish black	Distinct cleavage, uneven fracture	6-6.5	Metallic	Opaque	4.92	Decompose redily on exposure to air. Disolves sin ntirc acid with difficulty.
Molybdenite	Gray	Gray	Perfect basal cleavage, uneven fracture	1-1.5	Metallic	Opaque	4.62-5.06	Can fell greasy to teh touch
Montmorillonite	White, Gray white, Yellow, Brownish yellow, Greenish yellow	White	Earthy - Dull, clay-like fractures with no visible crystalline affinities, (e.g. howlite). Perfect cleavage	1.5-2	Earthy (dull)	Translucent to oaque	2-2.7	Non-fluorsecent
Muscovite	Colorless to white or gray, may be tinged with yellow, green, brown, red or violet	Colorless	Prefect basal cleavge, uneven fracture	2.5-4	Vitroeus to pearly	Transparent to tranluscent	2.77-2.88	Insouble in acids

Table 2: Ruggles mine mineral properties in alphabetical order

Mineral	Color	Streak	Cleavage/fracture	Hardness (MOH)	Luster	Transparency	Specific gravity	Notes
Parsonite	Light citron-yellow, honey-brown, green-brown, pale rose (rare); pale yellow in transmitted light		Choncoidal fracture, no cleavage	2.5-3	Sub-Adamantine, Greasy	Transparent to tranluscent	5.72-5.75	
Phosphyanylite	Golden yellow, Dark yellow, Lemon	Light yellow	Fracture {100} Perfect, {010} Indistinct	2.5	Vitreous, pearly	Translucent	4.1	Fluorescent, Short UV=orange-brown, Long UV=Orange-Brown
Psilomelane	Iron black, Dark steel gray.	Bronwish black	Fracture Uneven - Flat surfaces (not cleavage) fractured in an uneven pattern, no cleavage	5-6	Sub metallic	Opaque	4.4-4.7	Non-fluorescent, nonmagnetic
Purpurite	Brownish black, Violet, Dark pink, Dark red, Reddish purple	Red	Fracture Brittle - Uneven - Very brittle fracture producing uneven fragments, cleavage {100} Perfect, {001} Perfect	4-5	Earthy (dull)	Subtranslucent to opaque	3.4	Non-fluorescent, nonmagnetic
Pyrite	Pale yellow	Greenish black	Indistinct cleavage and conchoidal to uneven fracture	6-6.5	Metallic	Opaque	5	Gives off sparks when sturck with a hard obeject. Known as fools gold.
Pyrrhotite	Bronze, Bronze red, Dark brown	Gray black	Fracture Uneven - Flat surfaces (not cleavage) fractured in an uneven pattern, cleavage {0001} Imperfect, {1120} Imperfect	3.5-4	Metallic	Opaque	3.5-4	Non-fluorescent, magnetic
Quartz (Rose, smoky, white)	White, gray, red, purple, pink, yellow, green, brown and black‘‘‘	Colorless to white	No cleavage, conchoidal to uneven fracture	7	Vitreous	Transparnet to translucent	2.65	Insouble unless placed in hydrofluoric acid
Reddingtite	White, Yellowish white, Colorless, Reddish brown, Dark brown	White	Fracture Brittle - Uneven - Very brittle fracture producing uneven fragments, cleavage is indistinct	3.5	Vitreous - resinous	Transparnet to translucent	3.1	Non-fluorescent.
Safflorite	Tin white (darkens upon exposure to air).	Black	Cleavage is indistinct, fracture is conchoidal	4.5-5	Metallic	Opaque	6.9-7.4	
Sillimanite	Bluish, Brownish greenish, Colorless, Gray, Gray green	White	Fracture Splintery - Thin, elongated fractures produced by intersecting good cleavages or partings (e.g. hornblende). Cleavage {010} Perfect	7	Vitreous	Transparnet to translucent	3.24	Non-fluorescent.
Soddylite (pseudo, uranite, dense yellow)	NA	NA	NA	NA	NA	NA	NA	NA
Staurolite	Reddish-brown, brown, and black	White	Cleavage is poor, in one direction, fracture is uneven to conchoidal	7-7.5	Vitreous to resinous to dull	Transluscent to opaque	7-7.5	
Tobernite	Green	Pale green	Cleavage is perfect basal, fracture is uneven	2-2.5	Vitreous to pearly	Transparent to translucent	3.2	Radioactive and chemically unstable, it often become metaborbernite
Topaz crystals	White, colorless gray, yellow, orange, brown, bluish, greenish, purple or pink	Colorless	Cleavage is perfect, fracture is subconchoidral to uneven	8	Vitreous	Transparent to translucent	3.49-3.57	Insoluble in acids, does no fuse

Table 2: Ruggles mine mineral properties in alphabetical order

Mineral	Color	Streak	Cleavage/fracture	Hardness (MOH)	Luster	Transparency	Specific gravity	Notes
Tourmaline (black)	Black	Colorless	Cleavage is very indistinct, fracture is uneven to conchoidal	7-7.5	Vitreous	Transparent to opaque	3.0-3.2	Insouble in acid, draker colors fuse with difficulty
Triphylite	Gray, Bluish gray, Brownish, Blackish	Grayish white	Fracture Uneven - Flat surfaces (not cleavage) fractured in an uneven pattern, cleavage {001} Perfect, {110} Good	4-5	Greasy	Transparent to translucent	3.4-3.6	Non-fluoroscent
Uraninite (specs with gummite)	Brownish black, Gray, Grayish black, Black	Bronwish black	Fracture, Brittle - Conchoidal - Very brittle fracture producing small, conchoidal fragment, cleavage good	5-6	Sub metallic	Nearly opaque	6.5-10.95	Non-fluororsecent, radioactive
Uranium	Silvery-white	NA	NA	NA	NA	NA	19.1	Radiactive, disolve in hydrochloric and nitric acid
Uranophane	Yellow, Yellow brown, Yellow green, Yellow orange, Light yellow	Yellowish white	Fracture, Uneven - Flat surfaces (not cleavage) fractured in an uneven pattern, Cleavage, {100} Perfect	2.5	Vitreous	Translucent to subtranslucent	3.9	Fluorescent, Short UV=weak yellow-green, Long UV=weak yellow-green. Radioactive.
Usanospinite	NA	NA	NA	NA	NA	NA	NA	NA
Vandendriesscheite	Brownish yellow, Yellow orange	NA	Cleavage, {001} Perfect	3	Adamantine	Transparent to translucent	5.45	Radioactive
Vivianite	Colorless, Green, Blue, Dark green, Dark bluish green	Bluish white	Fracture, Sectile - Curved shavings or scrapings produced by a knife blade, (e.g. graphite). Cleavage, {010} Perfect	1.5-2	Vitreous - Pearly	Transparent to translucent to opaque	2.6-2.7	Non-fluorescent
Voelerkenite	NA	NA	NA	NA	NA	NA	NA	NA
Zircon	Brown, Reddish brown, Colorless, Gray, Green	White	Fracture, Uneven - Flat surfaces (not cleavage) fractured in an uneven pattern. Cleavage: {110} Indistinct	7.5	Adamantine	Transparent to translucent to opaque	4.6-4.7	Fluorescent, Short UV=yellow,green orange, Long UV=yellow, green orange. Radioactive

9. Mineral identification worksheets

The mineral identification worksheets can be used to note the physical properties of minerals and help in identifying them.

Mineral Identification Worksheet

Sample ID: _____

Color: _____

Streak: _____

Specific gravity:_____

Magnetic: __ yes, __ no

Fluorescent: __yes, __no

Radioactive: __yes, __no

Cleavage:

__ Perfect - a smooth plane free of imperfections.
__ Excellent - smooth but not perfect plane.
__ Distinct - a well defined plane.
__ Good - a well defined plane but with rough surfaces.
__ Poor - the plane is barely visible and the rough surface is dominant.
__ None - the broken surface is jagged and rough

Fracture:

__ Conchoidal - Fracture resembling a semicircular shell, with a smooth, curved surface. An good illustration of a conchoidal fracture is a large chip in a piece of glass. This fracture is also known as "shelly" in some references.
__ Uneven - Fracture that leaves a rough or irregular surface.
__ Hackly - Fracture that resembles broken metal, with rough, jagged, points. True metals exhibit this fracture. This fracture is also known as "jagged".
__ Splintery - Fracture that forms elongated splinters. All fibrous minerals fall into this category.
__ Earthy or crumbly - Fracture of minerals that crumble when broken.
__ Even or smooth - Fracture that forms a smooth surface.
__ Subconchoidal - Fracture that falls somewhere between conchoidal and even; smooth with irregular rounded corners.

Transparency:

__ Transparent - if you can see through the mineral it is transparent.
__ Translucent - if light passes through a mineral but you can't see objects clearly through it they are said to be translucent.
__ Opaque - light does not pass through even thin sections of the mineral.

Hardness:

__ 1.0 - Lead pencil
__ 2.4 - Fingernail
__ 3.5 - Copper penny
__ 4.5 - Iron nail
__ 5.1 - Inexpensive pocket knife
__ 5.5 - Window glass
__ 6.5 - Good steel file
__ 7.0 - Porcelin streak plate

Luster:

__ Adamantine - transparent to translucent minerals with a high refractive index. They display extraordinary brilliance and shine and are very rare. Examples: diamond, cerussite and zircon.
__ Dull - poor reflective qualities, much like unglazed porcelain. Most minerals with a dull luster have a rough or porous surface. Also referred to as earthy. Example: kaolinite.
__ Greasy - appears as if it were coated with grease, often also feels greasy. Examples: Opal and cordierite.
__ Metallic - opaque and reflective, like metal. Examples: galena, pyrite, magnetite.
__ Pearly - similar to the inside of a mollusk shell or shirt button. Examples: muscovite and stilbite.
__ Resinous - the luster of many yellow, dark orange, or brown minerals with moderately high refractive indices. Example: amber.
__ Silky - optical properties similar to silk cloth also having a fine fibrous structure. Examples: asbestos, ulexite and the satin spar type of gypsum. Fibrous is similar but coarser.
__ Submetallic - opaque to nearly opaque and reflects well. Similar to metallic but duller. Thin splinters or sections are translucent. Examples: sphalerite, cinnabar and cuprite.
__ Vitreous - reflective properties similar to glass. The most common mineral luster; Examples: calcite, quartz, topaz, beryl, tourmaline and fluorite.
__ Waxy - appears as if it were coated with a layer wax. Examples: jade and chalcedony.

Notes:

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