GY302 Mineralogy

Carbonates, Nitrates

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Carbonates, Borates

- Carbonate anion: CO_2^{2-}
- Borate anion: BO_4^{4-}
- Nitrate anion: NO_3^-
- Cations are dominated by +2 metallic elements.

Class V: Borates (Drawer 6)

Borax	$Na_2B_4O_5(OH)_4 \cdot 8H_2O$	Monoclinic
*Colemanite	$Ca_2B_6O_{11} \cdot 5H_2O$	Monoclinic
Kernite	$Na_2B_4O_6(OH)_2 \cdot 3H_2O$	Monoclinic
Ulexite	$NaCaB_5O_6(OH)_6 \cdot 5H_2O$	Triclinic

Class V: Carbonates (Drawer 5)

Ankerite	$Ca(Fe,Mg,Mn)(CO_3)_2$	Trigonal
Aragonite	$CaCO_3$	Orthorhombic
Aurichalcite	$(Zn, Cu)_5(CO_3)_2(OH)_6$	Monoclinic
Azurite	$Cu_3(CO_3)_2(OH)_2$	Monoclinic
*Bismutite	$Bi_2(CO_3)_2O_2$	Orthorhombic
Calcite	$CaCO_3$	Trigonal
Cerussite	$PbCO_3$	Orthorhombic
Dolomite	$CaMg(CO_3)_2$	Trigonal
Hydrozincite	$Zn(CO_3)_2(OH)_6$	Monoclinic
*Magnesite	$MgCO_3$	Trigonal
Malachite	$Cu_2(CO_3)_2(OH)_2$	Monoclinic
Rhodochrosite	$MnCO_3$	Trigonal
Siderite	$FeCO_3$	Trigonal
Smithsonite	$ZnCO_3$	Trigonal
Strontianite	$SrCO_3$	Orthorhombic
*Trona	$Na_3(HCO_3)(CO_3) \cdot 2H_2O$	Monoclinic
Witherite	$BaCO_3$	Orthorhombic

Carbonates, Nitrates, Borates

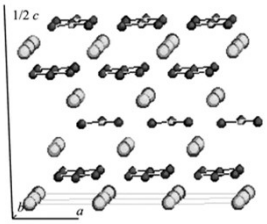
- There are 70 carbonate minerals, over 60 borates and a few nitrates.
- All 3 types of minerals involve planar anion groups….
- … with the exception of BO_4^{4-} which is tetrahedral.
- Oxygen atoms are strongly covalently bonded in the anion (especially in CO_3^{2-}), but bonding between the anion and the cation is ionic.

Carbonates, Nitrates, Borates

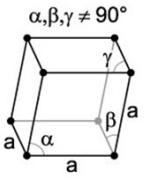
- Carbonates are by far the most important of the Class V minerals, three of which (calcite, dolomite and aragonite) comprise about 40% of all sedimentary rocks and more than 20% of the entire geological column.
- They are both biogenic and chemically precipitated.

Carbonates

- Calcite Group (point group= $\underline{3}$ 2/m):
  - Calcite ($CaCO_3$)
  - Magnesite ($MgCO_3$)
  - Siderite ($FeCO_3$)
  - Rhodochrosite ($MnCO_3$)
  - Smithsonite ($ZnCO_3$)

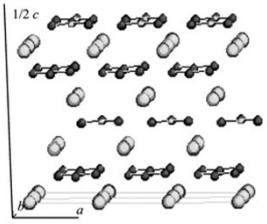


Calcite

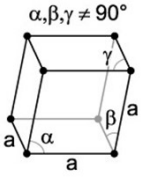


Carbonates

- Dolomite Group (point group = $\underline{3}$):
  - Dolomite ($CaMg(CO_3)2$)
  - Ankerite ($CaFe(CO_3)2$)
  - Kutnahurite ($CaMn(CO_3)2$)
  - Zincian Dolomite ($CaZn(CO_3)2$)

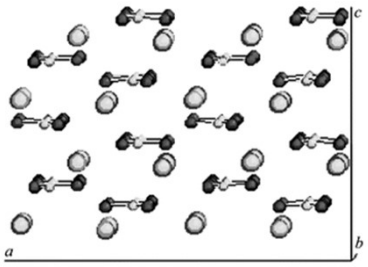


Calcite



Carbonates

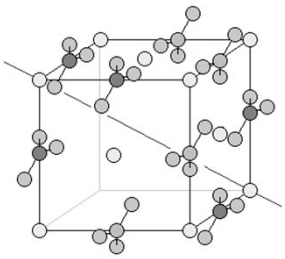
- Aragonite Group (2/m 2/m 2/m):
  - Aragonite ($CaCO_3$)
  - Witherite ($BaCO_3$)
  - Strontianite ($SrCO_3$)
  - Cerussite ($PbCO_3$)



Aragonite

Carbonates

- Calcite and Dolomite both possess 6-fold (Octahedral) coordination
- The only difference is that dolomite lacks 2/m symmetry because of alternating Ca-Mg layers



Calcite ($CaCO_3$)

- Crystal system, point group: Trigonal, $\underline{3}2/m$
- Habit: crystals common; form is variable from rhombohedral {01$\underline{1}$2}, {02$\underline{2}$1}, {40$\underline{4}$1}, to scalenohedral ("dogstooth") {21$\underline{3}$1} to tabular {0001} to massive granular. Twinning is common in Calcite.
- Cleavage and fracture: {10$\underline{1}$1} perfect.
- Hardness: 3.0.
- S.G. : 2.711 (pure).
- Color and Streak: colorless to a variety of colors depending on impurities. Streak is white to gray.
- Luster and light transmission: Vitreous. Transparent to translucent.
- Diagnostic: double refraction, hardness, habit, and reaction with HCl.
- Occurrence: very common in Earth's crust has a chemical or biochemical sedimentary mineral or in hydrothermal deposits. When metamorphosed a sedimentary protolith forms marble. Also commonly occurs as a cement in quartz sandstones. Can also occur in mafic and ultramafic rocks as a primary or secondary mineral.

Name origin:from the German *Calcit*, a term coined in the 19th century from the Latin word for lime, *calx* (genitive calcis) with the suffix -ite used to name minerals. It is thus etymologically related to chalk..

Magnesite ($MgCO_3$)

- Crystal system, point group: Trigonal, $\underline{3}2/m$
- Habit: crystals uncommon; rhombohedral {10$\underline{1}$1} or prismatic along c axis. Commonly massive.
- Cleavage and fracture: {10$\underline{1}$1} perfect.
- Hardness: 4.0.
- S.G. : 3.09 (pure).
- Color and Streak: colorless, white-gray, yellow-brown. Streak is white.
- Luster and light transmission: Vitreous. Transparent to translucent.
- Diagnostic: similar to calcite but scarcely affected by cold HCl. Compact masses may resemble chert but is much softer.
- Occurrence: occurs rarely as a chemical sedimentary rock, or as an alteration product of Mg silicates. May also occur in dolostone.

Name origin : unknown.

Siderite ($FeCO_3$)

- Crystal system, point group: Trigonal, $\bar{3}2/m$
- Habit: crystals common; rhombohedral {10$\bar{1}$1} . Commonly massive. Crystal faces are often curved or composite. Also massive.
- Cleavage and fracture: {10$\bar{1}$1} perfect.
- Hardness: 4.0.
- S.G. : 3.09 (pure).
- Color and Streak: Yellowish-brown, gray-brown, brown, green-gray. Streak is white.
- Luster and light transmission: Vitreous. Transparent to translucent.
- Diagnostic: distinguished from other carbonates by color, S.G. and alteration to Fe oxides; slowly soluble with effervescence in cold HCl.
- Occurrence: widespread as a bedded deposit in sedimentary rocks associated with shale and/or coal seams (reducing anoxic); also in hydrothermally produced ore deposits as a gangue mineral.

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Name origin: name from the Greek word σίδηρος *sideros,* "iron".

Rhodochrosite ($MnCO_3$)

- Crystal system, point group: Trigonal, $\bar{3}2/m$
- Habit: crystals uncommon; rhombohedral {10$\bar{1}$1} ; commonly massive granular.
- Cleavage and fracture: {10$\bar{1}$1} perfect.
- Hardness: 4.0.
- S.G. : 3.69 (pure).
- Color and Streak: various shades of pink, rose, or rose-red; also yellow-gray to brown. Streak is white.
- Luster and light transmission: Vitreous. Transparent to translucent.
- Diagnostic: soluble in warm HCl with effervescence; Pink color, cleavage, and hardness distinguish this mineral.
- Occurrence: occurs as a gangue mineral in low- to moderate T hydrothermal deposits. It is associated with Pb-Zn-Cu-Ag sulfide ores along with other carbonates. Ore of Mn.

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Name origin: name is derived from the Greek word ῥοδόχρως meaning *rose-colored* .

Smithsonite ($ZnCO_3$)

- Crystal system, point group: Trigonal, $\underline{3}2/m$
- Habit : crystals uncommon; rhombohedral {10$\underline{1}$1} or {02$\underline{2}$1} faces curved and rough; typically botryoidal; massive.
- Cleavage and fracture: {10$\underline{1}$1} perfect.
- Hardness: 4.0-4.5.
- S.G. : 4.43 (pure).
- Color and Streak: gray-white to dark gray; green-brown, apple green, blue, yellow. Streak is white.
- Luster and light transmission: Vitreous. Transparent to translucent.
- Diagnostic: effervescence in warm HCl, hardness=4, high S.G.
- Occurrence: mainly a secondary mineral forming from oxidized zones of ore deposits via alteration of primary Zn minerals.

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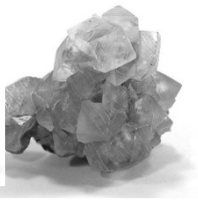

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Name origin: named in 1832 by François Sulpice Beudant in honor of English chemist and mineralogist James Smithson (c.1765–1829), whose bequest established the Smithsonian Institution and who first identified the mineral in 1802.

Dolomite [$CaMg(CO_3)_2$]

- Crystal system, point group: Trigonal, $\underline{3}$
- Habit :crystals common; rhombohedral {10$\underline{1}$1} or tabular on {0001}; also curved "saddle-shaped" rhombs; massive. Lamellar twinning common.
- Cleavage and fracture: {10$\underline{1}$1} perfect.
- Hardness: 3.5-4.0.
- S.G. : 2.85.
- Color and Streak: colorless, white, gray, green, yellow-brown, pink, rose. Streak is white.
- Luster and light transmission: Vitreous to pearly. Transparent to translucent.
- Diagnostic: dissolves readily in warm HCl, but not in cold HCl distinguishes it from calcite.
- Occurrence: widespread in chemical and biochemical carbonate sedimentary rocks, especially after diagenetic alteration.

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Name origin: first described by Carl Linnaeus in 1768. In 1791, it was described as a rock by the French naturalist and geologist Déodat Gratet de Dolomieu (1750–1801), first in buildings of the old city of Rome, and later as samples collected in the mountains now known as the Dolomite Alps of northern Italy. Nicolas-Théodore de Saussure first named the mineral (after Dolomieu) in March 1792.

Aragonite $CaCO_3$

- Crystal system, point group: Orthorhombic, 2/m2/m2/m.
- Habit : crystals common; most are twinned; prismatic along c-axis; also acicular; columnar aggregates.
- Cleavage and fracture: {010} distinct. Fracture is conchoidal.
- Hardness: 3.5-4.0.
- S.G. : 2.93.
- Color and Streak: colorless to white; also gray, yellowish, blue, green, violet, or rose-red. Streak is white.
- Luster and light transmission: Vitreous to pearly. Transparent to translucent.
- Diagnostic: S.G., effervescent in HCl, Hardness; distinguished from calcite by hardness, cleavage.
- Occurrence: widespread in chemical and biochemical carbonate sedimentary rocks; also forms from hydrothermal activity. Biochemical CaCO3 is exclusively the aragonite polymorph.

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Name origin: type location for aragonite is Molina de Aragón in the Province of Guadalajara in Castilla-La Mancha, Spain, for which it was named in 1797.

Witherite ($BaCO_3$)

- Crystal system, point group: Orthorhombic, 2/m2/m2/m.
- Habit : crystals uncommon; twinned on {110} yielding pseudo-hexagonal di-pyramids; also short prisms parallel to c-axis; faces typically rough and horizontally striated; massive; columnar.
- Cleavage and fracture: {010} distinct
- Hardness: 3.0-3.5.
- S.G. : 4.308.
- Color and Streak: colorless to milky white; also gray, yellowish, brown, green. Streak is white.
- Luster and light transmission: Vitreous. Transparent to translucent.
- Diagnostic: high S.G.; soluble with effervescence in dilute HCl.
- Occurrence: not a common mineral; an important source of Ba; usually formed from hydrothermal fluids and is associated with Fluorite, Barite, and Galena.

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Name origin: named after William Withering (1741–1799) an English physician and naturalist who in 1784 published his research on the new mineral.

Strontianite ($SrCO_3$)

- Crystal system, point group: Orthorhombic, 2/m2/m2/m.
- Habit : crystals uncommon; short or long prismatic parallel to c-axis; commonly pseudo-hexagonal; also massive, columnar.
- Cleavage and fracture: {110} nearly perfect.
- Hardness: 3.5.
- S.G. : 3.785.
- Color and Streak: white to gray, yellowish, or greenish. Streak is white.
- Luster and light transmission: Vitreous. Translucent.
- Diagnostic: effervescence in dilute HCl; high S.G.; cleavage.
- Occurrence: low-T hydrothermal mineral associated with barite, celestite, and calcite in veins.

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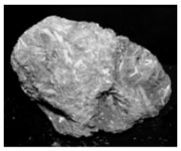
Name origin: named in 1791 for the locality, Strontian, Argyllshire, Scotland, where the element strontium had been discovered the previous year.

Cerrusite ($PbCO_3$)

- Crystal system, point group: Orthorhombic, 2/m2/m2/m.
- Habit : crystals common; tabular on {010}; or di-pyramidal and pseudo-hexagonal; also massive, dense compact masses.
- Cleavage and fracture: {110}; {021} distinct. Conchoidal fracture.
- Hardness: 3.0-3.5.
- S.G. : 6.582.
- Color and Streak: colorless to white to gray; or smoky. Streak is white.
- Luster and light transmission: Adamantine. Translucent.
- Diagnostic: soluble in warm nitric acid with effervescence; high S.G. and luster.
- Occurrence: common in the upper portions of oxidized zones in ore deposits that contain galena; often associated with anglesite.



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Name origin: name is from the Latin *cerussa*, white lead.

Malachite [$Cu_2(CO_3)(OH)_2$]

- Crystal system, point group: Monoclinic, 2/m.
- Habit : crystals rare; typically prismatic to fine acicular, grouped in “roses”; commonly massive.
- Cleavage and fracture: {201} perfect, {010} distinct . Fracture is uneven on massive material.
- Hardness: 3.5-4.0.
- S.G. : 4.05.
- Color and Streak: bright green. Streak is pale green.
- Luster and light transmission: Silky, velvety, or dull. Translucent.
- Diagnostic: green color, typically banded, and effervescence in cold dilute HCl; commonly botryoidal.
- Occurrence: widespread as a secondary Cu mineral. Associated with other Cu minerals including Azurite.

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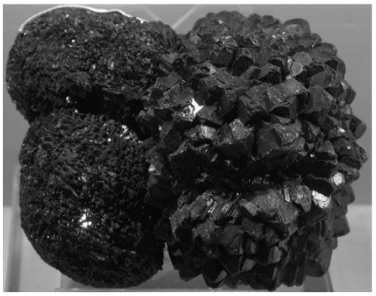
Name origin: from Greek Μολοχίτης λίθος *molochites lithos*, "mallow-green stone", from μολόχη *molochē*, variant of μαλάχη *malāchē*, "mallow".[5] The mineral was given this name due to its resemblance to the leaves of the mallow plant. .

Azurite [$Cu_3(CO_3)_2(OH)_2$]

- Crystal system, point group: Monoclinic, 2/m.
- Habit : crystals common; with diverse habits; typically short prismatic; also massive.
- Cleavage and fracture: {011} perfect, {100} distinct. Conchoidal.
- Hardness: 3.5-4.0.
- S.G. : 3.77.
- Color and Streak: azure-blue to dark blue. Streak is light blue.
- Luster and light transmission: vitreous. Transparent.
- Diagnostic: blue color, hardness, effervescence in cold HCl, and association with malachite.
- Occurrence: a secondary Cu mineral in oxidizing zone of Cu ore deposits. Associated with other Cu minerals including Malachite.



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Name origin: mentioned in Pliny the Elder's Natural History under the Greek name *kuanos* (κυανός: "deep blue," root of English *cyan*) and the Latin name *caeruleum*. .