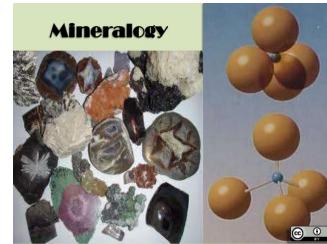


Mineralogy 2017



Lecture (March 20th)
MTech (GT+GPT) Semester II
Crystallography and Mineralogy



Today

- Hydroxides
- Carbonates



Hydroxides

Gibbsite Al(OH)_3

Crystal structure: Monoclinic



Composition

Minor amounts of Fe may substitute for Al

Occurrence and Associations

Usually Gibbsite is present as a secondary mineral associated with aluminum deposits, bauxites, and laterites.

Commonly associated with Diaspore and böhmite, and other aluminum hydroxides.

Related Minerals

Gibbsite is similar in structure to brucite, Mg(OH)_2

Polymorphs include bayerite, doyleite, and nordstrandite.

Other related minerals include diaspore and böhmite, [both AlO(OH)],

and bauxite, a mixture of gibbsite, böhmite, and diaspore.

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Hydroxides

Brucite Mg(OH)_2

Crystal structure: Hexagonal



Composition

Minor amounts of Fe, Mn, and Zn may substitute for Mg.

Occurrence and Associations

Brucite occurs in veins of mafic rocks, serpentinite, or talc-chlorite schists, and in metamorphosed carbonates or marls. Associated minerals include chlorite and other secondary magnesium minerals in mafic rocks and calcite, dolomite, talc, magnesite, and periclase in carbonates.

Related Minerals

Brucite is isostructural with gibbsite, Al(OH)_3 . It is isotypical with pyrochroite, Mn(OH)_2 ; amakinitite, $(\text{FeMg})(\text{OH})_2$; portlandite, $\text{Ca}(\text{OH})_2$; and theophrastite, $\text{Ni}(\text{OH})_2$.

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Hydroxides

Manganite MnO(OH) **Crystal structure:** Monoclinic



Composition

Minor amounts of Fe and Zn may substitute for Mn.

Occurrence and Associations

Manganite is an uncommon secondary mineral found in veins with other Mn oxides or hydroxides, carbonates, limonite, and barite.

Related Minerals

A number of manganese oxides and hydroxides are closely related, including pyrolusite, MnO_2 ; partridgeite and bixbyite, both Mn_2O_3 ; hausmannite, Mn_3O_4 ; hollandite, $\text{Ba}_2\text{Mn}_8\text{O}_{16}$; romanechite, $\text{BaMn}_9\text{O}_{16}(\text{OH})_4$; pyrochroite, $\text{Mn}(\text{OH})_2$; vernadite, $\text{Mn}(\text{OH})_4$; and takanelite.

Mixture of these manganese minerals is called Wad/ Wadd/ Wadt.

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Hydroxides

Goethite FeO(OH) **Crystal structure:** Orthorhombic



Composition

Mn and absorbed water are often present up to several weight percent.

Occurrence and Associations

Goethite is a widely distributed secondary mineral formed by the weathering of Fe-rich compounds. It concentrates in sediments, gossans, and laterites. Common associated minerals include siderite, pyrite, magnetite, and many residual weathering products.

Bog ore is a porous, poorly consolidated form of goethite.

Limonite refers to a mixture of hydrous iron oxides of variable chemistry and crystallinity.

Related Minerals

Lepidocrocite, akaganeite, and feroxyhyte are all rare polymorphs of goethite.

Diaspore has the same structure except that Al replaces two-thirds of the Fe.

Other related minerals are manganite, $\text{MnO}(\text{OH})$; heterogenite, $\text{CoO}(\text{OH})$; and montroseite, $(\text{V}, \text{Fe})\text{O}(\text{OH})$.

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Hydroxides



Diaspore AlO(OH)

Crystal structure: Orthorhombic

Composition

Minor Fe or Mn may replace Al.

Occurrence and Associations

Diaspore structure is the same as that of goethite, except that Al replaces two-thirds of the Fe. It is generally close to end member composition.

Diaspore is found in emery deposits with corundum, magnetite, spinel, and chlorite; in bauxites with other aluminum oxides and hydroxides; and as a rare mineral in some pegmatites.

Related Minerals

Böhmite is a polymorph of diaspore. Diaspore is isostructural with goethite and close in composition to gibbsite, Al(OH)_3 .

Bauxite is a mixture of gibbsite, böhmite, and diaspore.

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Hydroxides



Romanechite (Psilomelane)
 $\text{BaMnO}_9(\text{OH})_4$

Crystal structure:
Monoclinic

Composition

As, V, W, Co, Cu, Ni, Mg, Ca, and alkalis may be present in small or trace amounts.

Occurrence and Associations

Romanechite is a rare secondary mineral associated with pyrolusite, manganite, calcite, and hematite.

Related Minerals

Related minerals include pyrolusite, MnO_2 ; manganite, MnO(OH) ; cryptomelane, $\text{KMn}_8\text{O}_{16}$; hollandite $\text{BaMn}_8\text{O}_{16}$;

and wad, a mixture of manganese oxides and hydroxides.

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Carbonates

Calcite CaCO_3

Crystal structure:
Hexagonal



Composition

Mg, Fe, Mn, Zn, and a number of others may substitute for some of the Ca; except for Mn, most solid solutions are quite limited

Occurrence and Associations

Calcite is a common and widespread mineral. It is an essential and major mineral in limestones and marbles, occurs in cave deposits, and occurs as a vein mineral with other carbonates, sulfides, barite, fluorite, and quartz. Calcite also occurs in some rare carbonate-rich igneous rocks and is a common cement in some sandstones. Calcite is common as a weathering product. Organic calcite is common in shells and skeletal material.

Related Minerals

Calcite has two polymorphs, aragonite and vaterite.

It is isostructural with magnesite, MgCO_3 ; siderite, FeCO_3 ; sphærocobaltite, CoCO_3 ; smithsonite, ZnCO_3 ; nitratite, NaNO_3 ; dolomite, $(\text{Ca},\text{Mg})(\text{CO}_3)_2$; and gaspeite, $(\text{Ni},\text{Mg},\text{Fe})(\text{CO}_3)_2$.

Calcite and rhodochrosite form extensive solid solutions at room temperature and a complete solid solution above about 550°C.

Calcite forms limited solid solutions with ankerite, $(\text{Ca},\text{Fe})(\text{CO}_3)_2$; dolomite, $(\text{Ca},\text{Mg})(\text{CO}_3)_2$; and kutnohorite, $(\text{Ca},\text{Mn})(\text{CO}_3)_2$, at all temperatures. 9

Carbonates

Aragonite CaCO_3

Crystal structure
Orthorhombic



Structure & Composition

Solid solutions are much more restricted than for calcite. Aragonite is usually near end member composition, with only minor amounts of Sr, Pb, or Zn substituting for Ca.

Occurrence and Associations

Aragonite is found as disseminated carbonate in gypsum beds, as hot spring deposits, as precipitates from Ca-oversaturated waters, associated with sedimentary iron ores, in oxidized zones of ore deposits, in some cave formations, and in blueschist facies metamorphic rocks. It also occurs in shells and other organic carbonate material. Associated minerals typically include gypsum, siderite, celestite, sulphur, limonite, calcite, malachite, azurite, smithsonite, and cerussite.

Related Minerals

Aragonite has two significant polymorphs, calcite and vaterite. Strontianite, SrCO_3 ; witherite, BaCO_3 ; cerussite, PbCO_3 ; and niter, KNO_3 , are all isostructural with aragonite.

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Carbonates

Magnesite MgCO_3

Crystal structure:
Hexagonal

Composition

Magnesite is isostructural with calcite.
Large amounts of Fe commonly substitute for Mg. Mn, Ca, Ni, and Zn may also be present in small amounts.



Occurrence and Associations

Magnesite is most common in veins or masses as an alteration product of mafic minerals.

It also occurs in some Mg-rich schists and as a primary mineral in some rare chemical sediments and is found as a replacement for calcite or dolomite in limestone.

Related Minerals

Magnesite is isostructural with calcite and many other minerals. It forms complete solid solutions with siderite, FeCO_3 and with gaspeite, $(\text{Ni}, \text{Mg}, \text{Fe})(\text{CO}_3)$.

Related minerals include hydromagnesite, $\text{Mg}_5(\text{CO}_3)_4 (\text{OH})_2 \cdot 4\text{H}_2\text{O}$.

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Carbonates

Siderite $\text{Fe}(\text{CO}_3)_3$

Crystal structure:
Hexagonal

Composition

Siderite is isostructural with calcite.



Occurrence and Associations

Siderite is a relatively common mineral found in veins with galena, pyrite, chalcopyrite, and tetrahedrite; as a rock-forming mineral associated with limestone, clay, shale, coal or ironstone; as a replacement mineral in limestone; and less commonly in metamorphic rocks.

Related Minerals

Siderite is isostructural with calcite and a number of other minerals (see calcite). It forms complete solid solutions with rhodochrosite, MnCO_3 , and magnesite, MgCO_3 .

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Carbonates

Rhodochrosite $MnCO_3$

Crystal structure:
Hexagonal

Structure & Composition
Rhodochrosite is isostructural with calcite.



Zn commonly replaces some Mn; Ca, Mg, Cd, and Co may be present in limited amounts.

Occurrence and Associations

Rhodochrosite is uncommon. It is found with other manganese minerals in Mn-rich metamorphic rocks, as a primary mineral in sulfide veins and some replacement bodies, and as a secondary mineral in residual deposits.

Related Minerals

Rhodochrosite has the same structure as calcite and number of other minerals.

It forms solid solutions with calcite, $CaCO_3$; siderite, $FeCO_3$; and kutnohorite, $(Ca Mn)(CO_3)_2$.

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Carbonates

Dolomite $CaMg(CO_3)_2$

Crystal structure:
Hexagonal



Structure & Composition

Dolomite is isostructural with calcite. Fe and Mn may substitute for Mg in substantial amounts.

Co, Pb, Zn, Ce, or excess Ca may also be present.

Occurrence and Associations

Dolomite is a common mineral, found in massive carbonate sediments and in marbles, often with calcite. It also occurs in hydrothermal veins with fluorite, barite, other carbonates, and quartz, and as a secondary mineral or alteration product in limestone.

Related Minerals

Dolomite is isostructural with calcite, $CaCO_3$, nordenskiöldine, $CaSnB_2O_6$; and a number of other minerals. Huntite, $CaMg_3(CO_3)_4$, is quite similar.

Dolomite forms solid solutions with ankerite, $CaFe(CO_3)_2$; kutnohorite, $CaMn(CO_3)_2$; minrecordite, $CaZn(CO_3)_2$; and norsethite, $BaMg(CO_3)_2$.

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Carbonates

Ankerite $\text{CaFe}(\text{CO}_3)_2$

Crystal structure:
Hexagonal



Structure & Composition

Ankerite is isostructural with calcite, dolomite, and many other minerals (refer calcite).

It may contain substantial Mg replacing Fe.

Minor amounts of Mn, Co, Pb, Zn, Ce, or excess Ca may also be present.

Occurrence and Associations

Ankerite is most common in Precambrian iron formations. It is also found in veins and as replacements in limestones.

Related Minerals

Ankerite is isostructural with calcite, CaCO_3 , dolomite, $\text{CaMg}(\text{CO}_3)_2$, and a number of other minerals (Please refer calcite and dolomite).

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