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## MINERALS OF ARIZONA

By F. W. GALBRAITH

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## ACKNOWLEDGMENTS

This description of the minerals of Arizona has been largely compiled from publications and manuscripts. Numerous persons were also consulted regarding undescribed mineral deposits, and much valuable information was given by A. L. Flagg and Edwin Over. The writer is especially indebted to Robert E. Heineman for the use of the mineral files of the Arizona Bureau of Mines and to Dr. Eldred Wilson for editing the manuscript.

A complete list of publications on Arizona mineralogy is to be found in the Arizona Bureau of Mines Bulletin No. 146, *Bibliography of the Geology and Mineral Resources of Arizona*, and it would be impracticable to reproduce here all the references consulted. Material has been drawn freely from many of them, much of it without change. References in the text other than those listed below are to Bulletin 146.

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- 3:27 Wilson, E. D.—Geology and ore deposits of the Courtland-Gleeson region, Arizona: Univ. Ariz., Ariz. Bur. Mines Bull. 123, 1927.
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- 4:25 Lausen, Carl, and Wilson, E. D.—Gold and copper deposits near Payson, Arizona: Univ. Ariz., Ariz. Bur. Mines Bull. 120, 1925.
- 4:25-2 Ross, C. P.—Ore deposits of the Saddle Mountain and Banner districts, Arizona: U.S. Geol. Survey Bull. 771, 1925.

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- 5:25 Ross, C. P.—Geology and ore deposits of the Aravaipa and Stanley districts, Graham County, Arizona: U.S. Geol. Survey Bull. 763, 1925.

### **Greenlee County**

- 6:05 Lindgren, Waldemar—The copper deposits\*of the Clifton-Morenci districts, Arizona: U.S. Geol. Survey Prof. Paper 43, 1905.

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### **Mohave County**

- 8:09 Schrader, F. C.—Mineral deposits of the Cerbat Range, Black Mountains, and Grand Wash Cliffs, Mohave County, Arizona: U.S. Geol. Survey Bull. 397, 1909.
- 8:31 Lausen, Carl—Geology and ore deposits of the Oatman and Katherineine districts, Arizona: Univ. Ariz., Ariz. Bur. Mines Bull. 131, 1931.
- 8:36 Hewett, D. F., and others—Mineral resources of the region around Boulder Dam: U.S. Geol. Survey Bull. 871, 1936.

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- 11:26 Short, M. N., and Ettliger, I. A.—Ore deposition and enrichment at the Magma mine, Superior, Arizona: Am. Inst. Min. Eng., Trans., vol. 74, pp. 174-222, 1926.
- 11:38 Peterson, N. P.—Geology and ore deposits of the Mammoth mining camp area, Pinal County, Arizona: Univ. Ariz., Ariz. Bur. Mines Bull. 144, 1938.

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### **Yavapai County**

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# MINERALS OF ARIZONA

BY F. W. GALBRAITH

## NATIVE ELEMENTS

Diamond	C	Selenium	Se	Gold	Au	Mercury	Hg
Graphite	C	Tellurium	Te	Silver	Ag	Platinum	Pt
Sulfur	S	Bismuth	Bi	Copper	Cu	Iron	Fe
Arsenic	As						

### DIAMOND

C. Colorless, white, or black, also pale shades of other colors. Luster adamantine to greasy. Transparent to opaque. H. = 10. G. = 3.516-3.525. Isometric. In octahedral crystals or fragments with perfect octahedral cleavage.

*Meteorite diamond.*—In 1891 a 40-pound meteoric mass from the Canyon Diablo area, Coconino County, was found to contain small cavities filled with tiny black diamonds. Subsequently, small diamonds imbedded in graphite have been found in other fragments from the same meteoric fall.

### GRAPHITE

C. Iron-black to dark steel-gray. Luster metallic to dull and earthy. Opaque. Streak dark gray. H. = 1-2. G. = 2.09-2.23. Rhombohedral. Crystals six-sided and tabular. Perfect basal cleavage yielding thin, flexible plates. Commonly in masses which are scaly or slaty, granular, compact, or earthy. Also as disseminated grains or scales.

In gneiss, schist, quartzite, or crystalline limestone, probably as the result of metamorphism; in granite and basic eruptive rocks, perhaps as an original constituent.

*Cochise County.*—Dos Cabezas Mountains, as thin veins or streaks in gold-quartz veins. Graphitic clay is reported in large quantities near Benson (1:10).

*Coconino County.*—As small nodules in the Canyon Diablo and Elden meteorites.

*Mohave County.*—Cerbat Range, disseminated in pre-Cambrian schist of Canyon Station Wash.

### SULFUR

S. Various shades of yellow; greenish or reddish. Luster resinous. Transparent to translucent. H. = 1.5-2.5. G. = 2.05-2.09. Orthorhombic. Crystals pyramidal or thick tabular. Commonly massive or as incrustations.

Formed directly from volcanic gases by reduction of sulfate minerals, particularly gypsum, and by decomposition of sulfide ores. Commonly in small quantities in the pyritic waste on old mine dumps.

*Cochise County.*—At Tombstone, resinous amber-yellow sulfur, somewhat resembling yellow sphalerite, occurs as small crystals and replaces anglesite and galena in the Skip shaft fissure on the fourth level of the Empire mine.

*Coconino County.*—San Francisco Mountains, in small quantities at Sunset Crater and other near-by cinder cones.

*Pinal County.*—Two and one half miles east of Winkelman as tiny crystals, lining small vugs in a quartz vein.

*Yavapai County.*—United Verde mine, deposited under solfataric conditions caused by burning of a portion of the pyritic ore body.

### ARSENIC

As. Tin-white, commonly tarnished dark gray. Luster metallic. Opaque. Streak tin-white on fresh surface. H. = 3.5. G. = 5.7. Rhombohedral. Perfect basal cleavage, not prominent. Generally in fine granular, reniform, or stalactitic masses.

A primary mineral uncommon in large quantities. Mostly associated with silver, cobalt, or nickel ores, but also found in other sulfide deposits.

*Santa Cruz County.*—At the Double Standard mine, Patagonia district, 50 pounds or more was found in reniform masses attached to the walls of a small pocket in dolomitic limestone.

#### SELENIUM

Se. Tin-white. Luster metallic. Very soft. G. = 4.5. Rhombohedral, with good cleavage parallel to the negative rhombohedron.

A relatively rare element. The following is the first authentic occurrence of native selenium as a mineral.

*Yavapai County.*—United Verde mine, as a coating of needlelike crystals on rock above the burning pyritic ore body. The crystals are up to 2 centimeters in length and consist of a first-order prism and positive rhombohedron.

Certain plants in the upper Verde Valley carry toxic amounts of selenium obtained from the soil.

#### TELLURIUM

Te. Color and streak tin-white. Luster metallic. Rhombohedral. Crystals prismatic. Perfect prismatic cleavage. Commonly columnar to fine granular massive.

A mineral of rare occurrence.

*Cochise County.*—At Tombstone microscopic blebs in galena are thought to be tellurium (3:38).

*Yuma County.*—Specimens submitted to the Arizona Bureau of Mines from Granite Wash Hills, 4 miles north of Vicksburg.

#### BISMUTH

Bi. Silver-white with reddish hue, commonly tarnished. Luster metallic. Opaque. Streak silver-white on fresh surface. H. = 2.5. Sectile. G. = 9.8. Rhombohedral. Perfect basal cleavage. Generally reticulated, arborescent, foliated, or granular.

An uncommon primary mineral in veins in granite, gneiss, or other crystalline rocks, accompanying ores of cobalt, nickel, silver, or tin; less commonly with galena.

*Maricopa County.*—Vulture district, Cleopatra mine. Also southeast of Granite Reef Dam and in the Salt River Valley.

*Mohave County.*—Aquarius Range, 30 miles south of Hackberry, with gadolinite.

*Pima County.*—Sierrita Mountains, Esmeralda mine.

*Yavapai County.*—Bradshaw Mountains, in the Humbug Creek placers and on Minnehaha Flats. A low-grade deposit is reported on Buckhorn Wash, east of Brooks Hill.

#### GOLD

Au. Golden-yellow to pale yellow. Luster metallic. Opaque. Streak yellow. H. = 2.5-3. Sectile, malleable, and ductile. Hackly fracture. G. = 15.6-19.3. Isometric. Distinct crystals rare. Skeletal crystals common with filiform, reticulated, or dendritic shapes. Also massive, and in thin plates, flattened grains, or scales.

Widely distributed in small quantities. Most abundant in quartz veins or in placer deposits from weathering of primary gold ores. Less commonly in the oxidized zone of sulfide deposits.

Most gold of the early days in Arizona was recovered from placers. These deposits, readily worked, soon declined in importance, but placer gold is still produced in many localities of the state. Much of the present gold production is from copper sulfide ores.

It is impracticable to list the numerous Arizona mines and prospects in which gold occurs. Descriptions and references are given in Arizona Bureau of Mines Bulletins 137 and 142, further references in Arizona Bureau of Mines Bulletin 146, and production figures in Bulletin 140.

#### LODE DEPOSITS

*Cochise County.*—Warren (Bisbee) and Turquoise districts, with ores of copper, silver, and lead. Tombstone district, with lead-silver ores.

Pearce district, with silver ores. Dragoon Mountains, Manzero district. Dos Cabezas Mountains, Dos Cabezas and Teviston districts. Huachuca Mountains. Swisshelm Mountains.

*Gila County.*—Globe-Miami district, with ores of copper and silver. Dripping Spring Mountains, Barnes district, with ores of copper, lead, and silver. Payson district.

*Graham County.*—Galiuro Mountains, Rattlesnake district. Graham Mountains, Aravaipa and Stanley districts. Gila Mountains. Santa Teresa Mountains.

*Greenlee County.*—Clifton-Morenci district, with ores of copper and silver.

*Maricopa County.*—Vulture district, with lead and silver. Cave Creek district. Phoenix Mountains. Big Horn Mountains.

*Mohave County.*—Black Mountains, San Francisco and Katherine districts. Cerbat Range, Cerbat, Chloride, Stockton Hill, and Mineral Park districts. Hualpai Mountains, Maynard district, with ores of silver. Gold Basin district.

*Pima County.*—Ajo district, with ores of copper and silver. Baboquivari Mountains. Comobabi and Empire mountains with ores of copper, lead, and silver.

*Pinal County.*—Superior and Ray districts, with copper, silver, and lead ores. Mammoth district. Casa Grande district, with ores of copper and silver. Goldfield Mountains, Goldfield district.

*Santa Cruz County.*—Oro Blanco Mountains, with ores of lead, silver, and copper. Santa Rita Mountains. Patagonia Mountains.

*Yavapai County.*—Verde district, with copper and silver ores. Bradshaw Mountains at the Big Bug, Peck, Walker, and Tiger districts with ores of copper, silver, and lead; Hassayampa and Black Canyon districts with lead-silver ores; Pine Grove and Agua Fria districts, with copper-silver ores; Groom Creek, Turkey Creek, Bradshaw, and Tip Top districts, with silver. Santa Maria Mountains, Eureka district, with copper, silver, and lead ores. Date Creek Mountains, Martinez district. Wickenburg Mountains, Black Rock district.

*Yuma County.*—Kofa and Gila mountains, with silver. Harquahala Mountains, with ores of copper and lead. Williams Mountains, Cienega district, with copper ores. Castle Dome Mountains, Castle Dome district, with lead-silver ores. Also in the Plomosa, Sheep Tanks, Dome Rock, Laguna, Trigo, and Gila Bend mountains.

#### PLACER DEPOSITS

*Cochise County.*—Small production from Dos Cabezas, Teviston, Huachuca, Gleeson, Pearce, and Gold Gulch (Bisbee) placers.

*Gila County.*—Small production from Dripping Spring, Barbossa, Globe-Miami, and Payson placers.

*Greenlee County.*—Clifton-Morenci placers, along San Francisco and Chase creeks.

*Maricopa County.*—Vulture, San Domingo, and Hassayampa placers.

*Mohave County.*—Gold Basin, Chemehuevis, Lewis, Wright Creek, Lookout, and Silver Creek placers.

*Pima County.*—Greaterville, Quijotoa, Papago, and Horseshoe Basin districts. Less important are the Las Guijas, Old Baldy, Baboquivari, Armagosa and Alder Canyon placers. A \$228 nugget was found at Greaterville in 1924.

*Pinal County.*—Canada del Oro placers.

*Santa Cruz County.*—Oro Blanco, Mowry, Harshaw, Tyndall, Nogales, and Palmetto placers.

*Yavapai County.*—Weaver Creek, Rich Hill, Lynx Creek, Big Bug, Minnehaha, Hassayampa, Groom Creek, Copper Basin, Placerita, and Black Canyon districts are the most important. Smaller production from several other deposits. A 271-gram nugget was found on Weaver Creek

in 1930, and in 1932-33 several nuggets up to more than 3 ounces were recovered from the same general area.

*Yuma County.*—La Paz, Gila City (Dome), Plomosa, La Cholla, Oro Fino, Laguna, Castle Dome, and Kofa districts have yielded most of the production. Less important are the Muggins, Trigo, and Harquahala placers.

#### SILVER

Ag. Color and streak silver-white, commonly gray to black by tarnish. Luster metallic. Opaque. H. = 2.5-3. Sectile, ductile, and malleable. Hackly fracture. G. = 10.1-11.1. Isometric. Crystals malformed and acicular, reticulated, or arborescent. Commonly as grains, plates, or scales.

Most commonly secondary in the upper portions of silver-bearing deposits, or in the zone of sulfide enrichment with chalcocite. Less commonly of primary origin, disseminated in galena or tetrahedrite.

*Cochise County.*—Tombstone, as disseminated flakes at the Empire mine, and as small masses of wire silver, Flora Morrison mine. Bisbee district, in small amounts, with secondary chalcocite, more rarely with kaolin. Commonwealth mine, Pearce, with cerargyrite, embolite, and jarosite.

*Gila County.*—Globe district, as minute flakes in calcite at the Continental mine, as stout wires in the oxidized ore of the Old Dominion mine. Fine specimens from placers 4 miles north of Globe. At Richmond Basin, one of the chief ore minerals in fairly large masses. At Payson, as wire silver in the oxidized ore of the Silver Butte mine.

*Graham County.*—Aravaipa district, at the La Clede mine.

*Mohave County.*—Cerat Range, Distaff mine, as chunks of several pounds' weight in the deeper workings; Lucky Boy and Samoa mines, Chloride district; Golden Bee and Queen Bee mines, Mineral Park district; Banner group, Stockton Hills district, in solid chunks and masses of wire silver; Tennessee-Schuylkill mine, Wallapai district.

*Pima County.*—Tortillita Mountains, Apache property, with chalcocite and cerargyrite. Cerro Colorado Mountains, Cerro Colorado mine with stromeyerite and tetrahedrite.

*Pinal County.*—Superior district, in the enriched ore of the Silver King mine, as magnificent crystallized and wire specimens; in the upper portions of the Magma mine. Galiuro Mountains, Little Treasure mine, Saddle Mountain district, as wire silver in small cavities.

*Santa Cruz County.*—Patagonia Mountains, Domino mine, Palmetto district, with crystallized cerussite and wulfenite; Worlds Fair mine, Harshaw district, with tetrahedrite. Santa Rita Mountains, as small crystals surrounded by magnetite in diorite on the southern slopes of the range.

*Yavapai County.*—United Verde mine, as a thin layer of high-grade ore immediately above the sulfide ore body. Bradshaw Mountains, at several properties, as the Dos Oris mine, Hassayampa district, with argentite and cerargyrite; Arizona-National mine, Big Bug district, as wire silver in cavities with argentite; Goodwin properties, Turkey Creek district, with cerargyrite; Thunderbolt mine, Black Canyon district, with proustite; Tip Top mine, Tip Top district, with ruby silver and cerargyrite. Monte Cristo mine, Wickenburg Mountains, with niccolite and chloanthite in rich ores of primary origin.

#### COPPER

Cu. Copper-red, commonly tarnished iridescent, green, or black. Luster metallic. Opaque. Streak copper-red. H. = 2.5-3. Sectile, ductile, and malleable. Hackly fracture. G. = 8.8-8.9. Isometric. Distinct crystals rare, but commonly in distorted groups or twisted and wirelike forms. Sheets and irregular masses may reach large size.

Of secondary origin; widely distributed in the oxide zone of many copper deposits, accompanied by cuprite, malachite, tenorite, and limonite. Also in beds of sedimentary rocks and in cavities of certain volcanic rocks. May pseudomorphously replace such minerals as cuprite, azurite, and chalcopryrite.

*Cochise County.*—Bisbee district, abundant in oxidized ore of the Copper Queen mine above the third level, as masses of several hundred pounds' weight. Fine specimens of crystallized material, some coated with native silver, were taken from a single pocket. Calumet and Arizona mine, as small crystals, irregular networks throughout cuprite and in earthy mixtures of cuprite, limonite, and kaolin. Courtland-Gleeson district, as large arborescent masses.

*Gila County.*—Globe district, as small hackly particles in mineralized quartzite, Old Dominion mine. Dripping Spring Mountains, Christmas mine.

*Greenlee County.*—Clifton-Morenci district, common in upper parts of the veins, mostly with cuprite at the upper limit of the chalcocite zone. Arizona-Central mine, Williams vein, as solid copper up to 8 inches thick with fibrous structure and probably pseudomorphous after chalcocite.

*Pima County.*—Santa Rita Mountains, at various properties in the Helvetia district. Silver Bell Mountains, Silver Bell and El Tiro mines.

*Pinal County.*—Ray district, abundant in the upper workings. Galiuro Mountains, as twisted and wirelike masses in oxidized ore, Copper Prince mine.

*Yavapai County.*—United Verde Extension mine, locally abundant with cuprite.

## MERCURY

Hg. Tin-white. Luster brilliant metallic. G. = 13.6. Small fluid globules in gangue.

Comparatively rare in the metallic state. Of secondary origin, formed from the alteration of cinnabar with which it is commonly associated.

*Gila County.*—Mazatzal Mountains, small amounts in the Slate Creek deposits.

*Mohave County.*—Maynard district, Hualpai Mountains, with cerussite.

## PLATINUM

Pt. Alloyed with iron, iridium, or palladium. Color and streak whitish steel-gray. Luster metallic. Opaque. H. = 4-4.5. Sectile, malleable, and ductile. G. = 14-19. Isometric. Crystals rare. As grains or scales.

A rare mineral. Almost invariably in peridotite, serpentine, or in placers derived from them.

*Maricopa County.*—San Domingo placers and along the Gila River, opposite the old Riverside Stage station.

*Yavapai County.*—In black sands near Columbia and Prescott.

## IRON

Fe. Color and streak steel-gray to iron-black. Luster metallic. Opaque. H. = 4.5. G. = 7.3-7.8. Malleable. Fracture hackly. Isometric. Crystals rare. Perfect cubic cleavage. Strongly magnetic. Meteoric iron is commonly alloyed with nickel, generally in amount from 5 to 10 per cent, and may contain appreciable quantities of platinum. Unusual compounds such as *schreibersite* (Fe,Ni)<sub>3</sub>P, *moissanite*, CSi, and *cohenite* (Fe,Ni,Co)<sub>3</sub>C occur in meteorites.

Terrestrial iron is of extremely rare occurrence, but several important meteoric falls are known.

*Coconino County.*—The Canyon Diablo iron has been described by F. N. Guild (1:10) as follows:

One of the most famous occurrences of meteoric iron in the world is that of the Canon Diablo iron, found in the immediate vicinity of a slight elevation, variously known as Crater Mountain, Coon Butte, and Meteor Mountain. It is located in the plateau region of Arizona, about twelve miles from the Santa Fe station known as Canon Diablo, and thirty-five miles from Flagstaff. The iron is found in fragments scattered on the surface of the ground in sizes varying from that of a bean to masses weighing over one hundred pounds. In all it is said that nearly twenty tons of the material have been gathered and distributed to various museums and private collections in all parts of the world.

The locality is especially interesting—not only on account of the meteoric masses found there, but because of the interesting question as to the origin of the elevation apparently so intimately connected with them. The composition of the iron, as shown

by the following analyses made by H. Moissan, of Paris, varies greatly in different parts of the same fragment.

Iron.....	91.12	95.06	91.09	92.08
Nickel.....	3.07	5.07	1.08	7.05

Small quantities of silica, magnesia and phosphorus are also reported.

The San Francisco Mountains meteorite was discovered about 1920 on the lower northern slopes of the San Francisco Mountains. The Elden meteorite, a small mass of 3.5 kilograms, discovered in 1927 near Mt. Elden, is an intergrowth of nickel-iron and graphite in nearly equal proportions. As similar nodules are known from the Canyon Diablo iron, this occurrence is believed to be a part of that fall. The Winona meteorite, part iron, part stone, was discovered in 1928 in a prehistoric ruin near Winona.

*Gila County.*—Gun Creek meteorite, discovered in the Sierra Ancha Mountains in 1909.

*Navajo County.*—The Holbrook meteoric fall, a shower of some 3,000 stones containing iron, took place at Aztec, July 19, 1912. The largest complete stone weighed 14.5 pounds.

Analysis of fragment of Holbrook meteorite  
(J. E. Whitfield, Analyst)

Schreibersite .....	0.11	Metal .....	4.85
Troilite .....	7.56	Silicates .....	87.48

The Navajo meteorite, found in 1921, consisted of a small shower, the main fall weighing about 3,000 pounds.

*Pima County.*—The Tucson meteorites are described by Guild (1:10) as follows:

Two important masses of meteoric iron have been discovered in the vicinity of Tucson, but thoroughly reliable data as to the exact point where they fell seem to be lacking. . . .

According to Mr. L. Fletcher, the attention of the scientific world was first called to these meteorites through the entomologist, Dr. J. L. LeConte, in 1851. He reported that "while passing through the village of Tucson in the preceding February, he had observed two large pieces of meteoric iron used by the blacksmiths of the town as anvils."

In 1854, Professor Shephard gave a brief account of these meteorites, in which he states that according to information furnished him, they were found in a canyon of the Santa Rita Mountains, about 25 or 30 miles south of Tucson. Both were reported as being used as anvils, and one was described as being of a peculiar annular form.

The dimensions of the annular meteorite, or Irwin Iron, now in the Smithsonian Museum at Washington, are given by Whitney as follows: Greatest exterior diameter, 49 inches; least exterior diameter, 38 inches; greatest width of central opening, 26½ inches; least width of central opening, 23 inches; greatest thickness at right angles to plane of ring, 10 inches; width of thickest part of ring, 17½ inches; width of narrowest part, 2¾ inches; weight, 1,400 lbs. This fragment is further known as the Tucson meteorite, the Signet, the Ring Meteorite, the Ainsa, the Muchacho, etc.

The other fragment from Tucson was of the shape of an elongated flattened slab. Its length was 49 inches, average breadth 18 inches, and varying in thickness from 2 to 5 inches. Its weight was determined to be 632 lbs. It was taken possession of by Gen. Carleton and sent to San Francisco. Hence it is known in Mineralogical literature as the Carleton Meteorite.

As a result of the investigations on polished surfaces of these two meteoric masses, it is generally believed that they were portions of the same mass, or at least both were members of the same meteoric shower.

The chemical composition is illustrated by the following analysis:

	Smith	Genth	Brush
Fe.....	85.54	83.47	81.65
Ni.....	8.55	9.44	9.17
Co.....	0.61	0.42	0.44
Cu.....	0.03	0.008	0.08
P.....	0.12	0.10	0.49
Al <sub>2</sub> O <sub>3</sub> .....	Trace	Trace	Trace
CaO.....		0.46	1.16
MgO.....	2.04	2.59	2.43
Cr <sub>2</sub> O <sub>3</sub> .....	0.21		
SiO <sub>2</sub> .....	3.02	2.89	2.63

*Yavapai County.*—The Weaver meteorite, some 80 pounds in weight, found in the Weaver Mountains near Wickenburg in 1898, is of special interest because of its high percentage of nickel and cobalt.

Analyses of the Weaver meteorite

	W. B. Alexander, Analyst	F. Hawley, Analyst
Iron.....	79.60	81.81
Nickel.....	18.80	16.63
Cobalt.....	1.60	1.18

SULFIDES, TELLURIDES, ARSENIDES, ANTIMONIDES

Realgar	AsS	Metacinnabar	HgS
Orpiment	As <sub>2</sub> S <sub>3</sub>	Alabandite	MnS
Stibnite	Sb <sub>2</sub> S <sub>3</sub>	Pentlandite	(Fe,Ni)S
Jeromite	(As,Se)S	Cinnabar	HgS
Bismuthinite	Bi <sub>2</sub> S <sub>3</sub>	Niccolite	NiAs
Tetradymite	Bi <sub>2</sub> (Te,S) <sub>3</sub>	Pyrrhotite	Fe <sub>1-x</sub> S
Molybdenite	MoS <sub>2</sub>	Troilite	FeS
Dyscrasite	Ag <sub>3</sub> Sb	Covellite	CuS
Domeykite	Cu <sub>3</sub> As	Bornite	Cu <sub>3</sub> FeS <sub>4</sub>
Rickardite	Cu <sub>3</sub> Te <sub>2</sub>	Chalcopyrite	CuFeS <sub>2</sub>
Galena	PbS	Pyrite	FeS <sub>2</sub>
Argentite	Ag <sub>2</sub> S	Cobaltite	CoAsS
Hessite	Ag <sub>2</sub> Te	Smaltite	CoAs <sub>2</sub>
Chalcocite	Cu <sub>2</sub> S	Chloanthite	NiAs <sub>2</sub>
Stromeyerite	(Ag,Cu) <sub>2</sub> S	Marcasite	FeS <sub>2</sub>
Cubanite	CuFe <sub>2</sub> S <sub>4</sub>	Arsenopyrite	FeAsS
Sphalerite	ZnS		

REALGAR

AsS. Aurora-red to orange-yellow. Luster resinous. Transparent to translucent. Streak orange-red. H. = 1.5-2. Sectile. G. = 3.56. Monoclinic. Crystals short prismatic, striated vertically. Also coarse or fine granular, compact, or as an incrustation.

Most commonly a minor associate of other arsenic minerals and stibnite, also as a volcanic sublimate, or as a deposit from hot springs.

*Pinal County.*—In 1915 several pounds of realgar and orpiment were discovered in an undefined locality near the junction of the Gila River and Hackberry Wash.

ORPIMENT

As<sub>2</sub>S<sub>3</sub>. Lemon-yellow. Luster pearly to resinous. Subtransparent to subtranslucent. Streak paler than the color. H. = 1.5-2. Sectile. G. = 3.4-3.5. Monoclinic. Highly perfect prismatic cleavage; cleavage faces vertically striated. In foliated or columnar masses.

Of secondary origin resulting from alteration of other arsenic minerals. Most commonly associated with realgar but is rarer in its occurrence.

*Pinal County.*—In 1915 several pounds of orpiment and realgar were discovered in an undefined locality near the junction of the Gila River and Hackberry Wash.

STIBNITE

Sb<sub>2</sub>S<sub>3</sub>. Color and streak lead-gray to steel-gray. Luster metallic, splendent. H. = 2. G. = 4.52-4.62. Orthorhombic. Perfect brachypinacoidal, less perfect basal, macropinacoidal, and prismatic cleavages. Crystals prismatic, striated vertically or horizontally, and curved or twisted. Commonly massive, with bladed or granular structure. Pure mineral 71.7% Sb.

Most important ore of antimony. A primary mineral, formed at shallow depth. Generally in quartz veins with silver and lead minerals, barite, calcite, realgar, or cinnabar. Readily alters to antimony oxide.

*Gila County.*—Near Payson, small amounts in some copper ores. Reported in Mazatzal Mountains on Slate Creek.

*Graham County.*—Stanley district, in contact-metamorphic ores, Cold Spring prospect.

*Mohave County.*—Cerberat Range, with galena, sphalerite, and pyrite, Golden Gem and Vanderbilt mines, Cerbat district.

*Santa Cruz County.*—Patagonia Mountains, Dura mine, Nogales district.

*Yavapai County.*—Bradshaw Mountains, Seventy-six and other veins of the Tip Top district; near the Tuscumbia mine, Bradshaw district, Malley Hill mine on Lynx Creek; Turkey Creek district; Robinson property, Walker district.

*Yuma County.*—Dome Rock Mountains, 8 miles southwest of Quartzsite, as radiating blades with cervantite and stibiconite.

JEROMITE

A sulfide of arsenic containing some selenium. Color black, cherry-red on thin edges. Opaque.

*Yavapai County.*—Known only from the United Verde mine, Jerome, formed from burning of the pyritic ore body (Lausen, 28).

#### BISMUTHINITE

$\text{Bi}_2\text{S}_3$ . Lead-gray with yellow or iridescent tarnish. Luster metallic. Opaque. Streak lead-gray.  $H. = 2$ . Somewhat sectile.  $G. = 6.4-6.5$ . Orthorhombic. In acicular crystals. Massive, foliated, or fibrous. Pure mineral 81.2% Bi.

A rare mineral, mostly in primary deposits related to igneous rocks. Also found in the secondary sulfide zone.

*Mohave County.*—Aquarius Range, small quantities with gadolinite and native bismuth in pegmatite.

*Yavapai County.*—Bradshaw Mountains, Swallow mine, Castle Creek district, altering to bismite. Eureka district, 45 miles west of Prescott, in pegmatites.

#### TETRADYMITITE

$\text{Bi}_2(\text{Te,S})_3$ . Pale steel-gray. Luster metallic, splendent. Opaque.  $H. = 1.5-2$ .  $G. = 7.2-7.6$ . Rhombohedral. Perfect basal cleavage. Commonly in bladed forms or foliated to granular masses.

An uncommon mineral in gold-quartz veins, near-surface hydrothermal deposits, and contact-metamorphic zones.

*Yavapai County.*—Bradshaw Mountains, in small quantity, Montgomery mine; in quartz associated with pyrite near Bradshaw City, and from near Minnehaha.

#### MOLYBDENITE

$\text{MoS}_2$ . Bluish lead-gray. Luster metallic. Opaque. Streak lead-gray, commonly tinged with green.  $H. = 1-1.5$ . Somewhat sectile and greasy.  $G. = 4.7-4.8$ . Hexagonal. Crystals hexagonal in form and commonly tabular. Perfect basal cleavage, yielding thin plates which are flexible but not elastic. In foliated or granular masses or in scales. Pure mineral 60% Mo.

The only common mineral of molybdenum, and widely distributed. A deep-seated, primary mineral in granitic rocks or quartz veins, with chalcopyrite, or with tin and tungsten ores. Also as a result of contact metamorphism.

*Cochise County.*—Little Dragoon Mountains, in copper ores, Johnson district.

*Gila County.*—Miami district, in small quantities through the copper ores.

*Greenlee County.*—Clifton-Morenci district, in veins with pyrite, chalcopyrite, and sphalerite.

*Mohave County.*—Cerat Range, O.K. mine, Gold Basin district, with galena and wolframite; Samoa mine, Chloride district. Hualpai Mountains, Leviathan and American mines, Maynard district; Deluge Wash area, in small quantities at several properties.

*Pima County.*—Santa Rita Mountains, Helvetia district, Leader, Ridely, and Pauline mines, and in many prospects in Madera and Providencia canyons; Cuprite district, as small masses in chalcopyrite ore, Cuprite mine. Silver Bell district, at a small prospect north of the Kurtz shaft. Baboquivari Mountains, Gold Bullion mine, in quartz veins. Sierrita Mountains, Mineral Hill-Twin Buttes region. At Ajo in small amounts.

*Pinal County.*—Galiuro Mountains, Copper Creek district, the most important ore mineral at the Childs-Aldwinkle mine, and as fine crystallized specimens, in smaller quantities at the Copper Prince, Old Reliable, and other properties. (Rhenium, an element discovered in 1924 with properties similar to manganese, is known to occur in extractable quantities only in the mineral molybdenite. The rhenium content of the Childs-Aldwinkle molybdenite concentrates, 320 to 580 parts per million, is the highest so far known.)

*Santa Cruz County.*—Patagonia Mountains, Santo Nino mine,  $2\frac{1}{2}$  miles southwest of Duquesne, as large bodies of fine-grained, massive material, and as disseminated grains in quartz monzonite. Bonanza mine, Duquesne, where smaller quantities were mined; Benton and Line Boy properties; and in a prospect 4 miles southwest of Duquesne, with scheelite.

*Yavapai County*.—Bradshaw Mountains, Black Hawk, Blue Bird, and Squaw Peak mines. Eureka district, in thin veins, Bagdad mine.

## DYSCRASITE

Ag<sub>2</sub>Sb. Color and streak silver-white to tin-white. Luster metallic. Opaque. H. = 3.5-4. Sectile. G. = 9.44-10.02. Orthorhombic. Crystals rare. Good basal cleavage. Commonly massive. Pure mineral 72.9% Ag.

A primary mineral generally with other silver minerals, galena, and barite. Extremely rare in the United States.

Reported in Arizona with ores of silver and lead, but no exact localities are given (1:17).

## DOMEYKITE

Cu<sub>2</sub>As. Tin-white to steel-gray, readily tarnished. Luster metallic. Opaque. Somewhat malleable. G. = 7.2-7.75. Reniform and botryoidal; also massive or disseminated.

A rare mineral.

*Cochise County*.—Specimens of this mineral were received many years ago at the University of Arizona (1:10), but the exact locality from which they were obtained or other data regarding them is unknown.

## RICKARDITE

Cu<sub>2</sub>Te<sub>2</sub>. Deep purple, dulling upon exposure. Luster metallic. Opaque. H. = 3.5. G. = 7.5. As disseminated grains accompanying copper sulfides.

A rare mineral found in only a few copper deposits.

*Cochise County*.—Bisbee district, as small purple fragments in a sample of sulfide pulp from the 1,400-foot level of the Junction mine (Crawford, 30).

## GALENA

PbS. Dark gray. Luster metallic. Opaque. Streak dark lead-gray to grayish black. H. = 2.5-2.75. G. = 7.4-7.6. Isometric. Commonly in cubes or cubo-octahedrons, less commonly in octahedral crystals. Perfect cubic cleavage. In cleavable and granular masses. Pure mineral 86.6% Pb.

A widely distributed primary mineral with copper, zinc, and silver sulfides, barite, and fluorite. The important ore of lead, but may contain appreciable quantities of silver.

Galena has been reported from several hundred properties in the state, only the more important of which are listed.

*Cochise County*.—Tombstone district, in ores of both the "roll deposits" and the fissure veins. Extensively replaced by cerussite, to a smaller extent by anglesite. Dragoon Mountains, Turquoise district, as scattered bunches in the copper sulfide ores.

*Gila County*.—Dripping Spring Mountains, "79" mine, Banner district.

*Maricopa County*.—A specimen from near Wickenburg, exact locality unknown, contains 4 per cent thallium.

*Mohave County*.—Cerberat Range and Grand Wash Cliffs, common in ores of many properties. McCracken Mountains, McCracken mine.

*Pima County*.—Sierrita Mountains, Senator Morgan and Paymaster mines, near Twin Buttes; the main ore mineral of the Sunshine mine, Papago district. Santa Rita Mountains, abundant at several properties. Quijotoa Mountains, Morgan mine, with argentite. Cerro Colorado Mountains, Cerro Colorado mine, with tetrahedrite, stromeyerite, and native silver. Empire Mountains, Chief, Prince, and other properties of the Hilton group.

*Pinal County*.—Superior district, Silver King mine; in fairly large bodies in the Belmont mine; and in the sphalerite ore of the Magma mine. Galiuro Mountains, the principal ore mineral of the Blue Bird mine. Mammoth mine, in the sulfide zone and altered to cerussite and anglesite in the oxide zone. Galiuro Mountains, Saddle Mountain district, Adjust mine, containing silver, and at the Saddle Mountain and Little Treasure properties.

*Santa Cruz County.*—Patagonia Mountains, abundant in nearly all districts. Mowry mine, yielded as high as 3,800 ounces of silver per ton. Flux mine, as excellent specimens of cubo-octahedral crystals. Santa Rita Mountains, at most of the properties. Oro Blanco Mountains, Montana mine, with sphalerite.

*Yavapai County.*—Bradshaw Mountains, at several properties in the Walker, Hassayampa, Big Bug, Turkey Creek, Peck, Pine Grove, Tiger, Tip Top, and Castle Creek districts, in many places with tetrahedrite. Golden Turkey mine, as cubo-octahedral crystals with highly splendid faces. Black Hills, Shea property, Verde district; Shylock mine, Black Hills district. Eureka district, Bagdad mine.

*Yuma County.*—Trigo Mountains, Black Rock, Chloride, Silver King, and Silver Glance properties. The highly argentiferous galena at the Red Cloud mine probably contains argentite. Castle Dome Mountains, Flora Temple, Senora, Little Dome, Hull, Lincoln, and Adams properties. Harquahala Mountains, Bonanza mine.

#### ARGENTITE

Ag<sub>2</sub>S. Color and streak dark lead-gray. Luster metallic. Opaque. H. = 2-2.5. Completely sectile and malleable with hackly fracture. G. = 7.20-7.36. Isometric. Crystals octahedral or cubic in parallel or reticulated groups. More commonly as disseminated grains or small masses. Pure mineral 87.1% Ag.

A primary mineral of lead-silver ores, commonly with other silver minerals, galena, tetrahedrite, and cobalt-nickel ores. Also a secondary mineral of the zone of sulfide enrichment with chalcocite and native silver.

*Cochise County.*—Tombstone, in oxidized ores from alteration of argentiferous tetrahedrite. Pearce, with cerargyrite, bromyrite, embolite, and iodyrite, Commonwealth mine.

*Gila County.*—Richmond Basin, the chief primary mineral, in masses up to several pounds in weight.

*Graham County.*—Aravaipa district, in veins of the Grand Reef system.

*Mohave County.*—Cerbat Range, Keystone, Golden Star, and Queen Bee mines, Mineral Park district; Prince George mine and veins of the Banner group, Stockton Hill district; various properties in the Cerbat district.

*Pima County.*—Santa Rita Mountains, Blue Jay mine, Helvetia district. Sierrita Mountains, Sunshine mine, Papago district. Quijotoa Mountains, Morgan mine.

*Pinal County.*—Superior district, Silver King mine, in large quantity on the upper levels; Belmont property as small blebs in galena. Dripping Spring Mountains, Little Treasure mine, Saddle Mountains district.

*Santa Cruz County.*—Santa Rita Mountains, the Alto, Eureka, Ivanhoe, Montezuma, and Empress of India mines, Tyndall district; Augusta, Happy Jack, and Anaconda mines, Wrightson district. Patagonia Mountains, La Plata and Meadow Valley mines, Redrock district; January, Blue Eagle, Flux, and American mines, Harshaw district.

*Yavapai County.*—Bradshaw Mountains, Dos Oris mine, Hassayampa district, with native silver and cerargyrite; Arizona National, Big Bug district, in galena with freibergite and in cavities with wire silver. Wickenburg Mountains, Monte Cristo mine, in primary ore with native silver, niccolite, chloanthite, and proustite.

*Yuma County.*—Trigo Mountains, where the highly argentiferous galena of the Red Cloud mine probably contains argentite.

#### HESSITE

Ag<sub>2</sub>Te. Lead-gray to steel-gray. Luster metallic. Opaque. H. = 2.5-3. Nearly sectile. G. = 8.31-8.45. Isometric (?). Cleavage indistinct. Massive, compact, or as small disseminated grains.

One of the commonest tellurides, but abundant in only a few districts of the United States.

*Cochise County.*—Tombstone, West Side mine, as bands and disseminations in quartz with cerargyrite and gold. Flora Morrison mine, altering to native silver.

## CHALCOCITE—Copper Glance

Cu<sub>2</sub>S. Dark lead-gray, commonly tarnished black. Luster metallic. Opaque. Streak dark gray. H. = 2.5-3. Nearly sectile. G. = 5.5-5.8. Orthorhombic. Crystals rare. Generally massive, with granular, compact, or sooty texture. Pure mineral 79.8% Cu.

A valuable copper mineral of wide distribution. Rare as a primary mineral, most abundant as a replacement of other sulfides in the zone of secondary enrichment. Many copper deposits of the state owe much of their value to secondary chalcocite.

*Cochise County.*—Bisbee district, most important in disseminated ore, locally abundant as a secondary mineral in limestone replacement deposits. Courtland-Gleeson district, an important constituent of the enriched ores.

*Coconino County.*—Grand Canyon, in small high-grade bodies at several places.

*Gila County.*—Globe district, Old Dominion mine, as compact massive bodies. Miami district, the essential mineral of the disseminated sulfide deposits.

*Graham County.*—Aravaipa district, Ten Strike group.

*Greenlee County.*—Clifton-Morenci district, the principal ore mineral of the disseminated and vein deposits, in places as solid seams 2 to 3 feet thick.

*Maricopa County.*—Cave Creek, Red Rover mine, with argentiferous tetrahedrite.

*Mohave County.*—Grand Wash Cliffs, Grand Gulch, Bronze L, and Copper King mines.

*Pima County.*—Ajo, disseminated in a narrow band bordering the New Cornelia ore body on the south. Sierrita Mountains, as large, nearly pure masses, Glance and Queen mines, Twin Buttes. Silver Bell Mountains, as the sooty variety in veins and disseminated ores, Silver Bell district.

*Pinal County.*—Superior district, as large, nearly pure secondary bodies in the Magma mine, and an important constituent of the primary ores on the lower levels. At the Belmont as fine-grained sooty material. With native silver in the upper levels of the Silver King mine. At Ray the essential mineral of the disseminated ores. Galiuro Mountains, at several properties, and at the Childs-Aldwinkle primary chalcocite occurs on the lower levels.

*Santa Cruz County.*—Santa Rita Mountains, in rather large bodies, Ivanhoe mine, Tyndall district.

*Yavapai County.*—In oxidized ores of the United Verde mine, and in pure massive bodies of exceptionally large size, United Verde Extension mine. Eureka district, Bagdad mine. As disseminated mineralization in the Copper Creek district.

## STROMEYERITE

(Ag,Cu)<sub>2</sub>S. Color and streak dark steel-gray. Luster metallic. Opaque. H. = 2.5-3. G. = 6.15-6.3. Orthorhombic. Commonly massive. Pure mineral 53% Ag, 31.2% Cu.

An uncommon secondary mineral of the zone of sulfide enrichment. Formed in the same manner as secondary chalcocite, with which it is associated. In places with native silver.

*Cochise County.*—Tombstone, probably an important source of silver, Empire and Toughnut mines.

*Gila County.*—Globe district, Old Dominion mine; Richmond Basin, Mack Morris mine.

*Pima County.*—Cerro Colorado Mountains, Cerro Colorado mine, with tetrahedrite and native silver.

*Pinal County.*—Superior district, Silver King mine, the most important silver mineral of the ores. Galiuro Mountains, with tennantite in the lower levels of the Blue Bird mine.

## CUBANITE—Chalmersite

$\text{CuFe}_2\text{S}_4$ . Brass-yellow to bronze-yellow, like chalcopyrite. Luster metallic. Opaque. Strongly magnetic.  $H. = 3.5$ .  $G. = 4.7$ . Orthorhombic. In thin elongated prisms, vertically striated. Also massive.

Most commonly as an intergrowth with chalcopyrite, distinguishable only by microscopic methods.

Many, if not all, of the chalcopyrite occurrences in the state contain cubanite.

## SPHALERITE—Zinc Blende

$\text{ZnS}$ . Mostly yellow, brown, or black; also red, green, or white. Luster resinous to metallic. Transparent to translucent. Streak lighter than the mineral.  $H. = 3.5-4$ .  $G. = 3.9-4.1$ . Isometric-tetrahedral. Crystals tetrahedrons or distorted and rounded forms of the dodecahedron and tristetrahedron. Perfect dodecahedral cleavage. Most commonly cleavable or granular massive. Pure mineral 67% Zn.

The most common sulfide with the exception of pyrite, and a constituent of most sulfide ores. Closely associated with galena. Only the more important localities are listed.

*Cochise County*.—Tombstone, Silver Thread and Sulphuret mines, less abundant elsewhere. Little Dragoon Mountains, in copper ores, Johnson district. Courtland-Gleeson district, as scattered bunches in the pyritic ores, in places well crystallized.

*Graham County*.—Aravaipa and Stanley districts.

*Greenlee County*.—Clifton-Morenci district, in large quantities in the deeper parts of the mines.

*Mohave County*.—Cerbat Range, in most ores of the district.

*Pima County*.—In unoxidized ores of the Santa Rita and Empire mountains. Sierrita Mountains, San Xavier district, as small bodies in limestone; Paymaster mine, Olive Camp.

*Pinal County*.—Superior district, the Belmont and Magma mines. At the Silver King mine it was the most abundant sulfide mineral in the ore, and cleavage masses of light sea-green color were held together by threads of native silver. Galiuro Mountains, Adjust, Saddle Mountains, and Little Treasure properties, Saddle Mountains district. Mammoth mine, on the lower levels, but extensively altered to smithsonite and hemimorphite in the oxidized zone.

*Santa Cruz County*.—Common in copper and silver ores of the Patagonia and Santa Rita mountains. As magnificent crystal groups at the Westinghouse property, Duquesne. Oro Blanco Mountains, with galena, Montana mine.

*Yavapai County*.—In pyritic ore, United Verde mine; and Copper Chief mine, Verde district. Bradshaw Mountains, most of the districts. Davis mine, Hassayampa district, as an unusual golden-yellow variety.

## METACINNABAR

$\text{HgS}$ . Grayish black. Black streak.  $H. = 3$ .  $G. = 7.7$ . Isometric-tetrahedral. Rarely in small crystals, more commonly massive.

An uncommon mineral of secondary origin in the upper portions of cinnabar deposits.

*Yuma County*.—Dome Rock Mountains, as a thin coating on cinnabar, Colonial property.

Other occurrences of black material on cinnabar may be this mineral.

## ALABANDITE

$\text{MnS}$ . Black. Luster submetallic. Opaque. Streak olive-green to dark grayish green.  $H. = 3.5-4$ .  $G. = 3.95-4.04$ . Isometric. Good cubic cleavage. As cleavable masses or as disseminated grains. Pure mineral 63.2% Mn.

An uncommon primary mineral, associated with sulfides of copper, zinc, lead, and silver, and with rhodochrosite.

*Cochise County*.—Tombstone, Lucky Cuss mine. Bisbee district, Higgins mine. Chiricahua Mountains, Hilltop mine.

*Santa Cruz County*.—Patagonia Mountains, Trench mine.

## PENTLANDITE

(Fe,Ni)S. Light bronze-yellow. Luster metallic. Opaque. Streak light bronze-brown. H. = 3.5-4. G. = 5. Isometric. Octahedral cleavage. Massive or granular. Pure mineral 22% Ni.

The most important ore mineral of nickel. Generally with pyrrhotite and chalcopyrite in basic igneous rocks.

*Mohave County*.—Near Littlefield, in basic dikes with pyrrhotite and chalcopyrite.

## CINNABAR

HgS. Scarlet, dark red, reddish brown. Luster adamantine to dull or earthy. Transparent to opaque. Streak scarlet to brownish red. H. = 2.25. G. = 8-8.2. Rhombohedral-trapezohedral. Perfect prismatic cleavage. As finely granular or cleavable masses, crystalline incrustations, or earthy coatings. Pure mineral 86.2% Hg.

The ore mineral of mercury. Of near-surface origin as veins, replacement deposits, or impregnations.

*Gila County*.—Dripping Spring Mountains, Cowboy mine.

*Maricopa and Gila counties*.—Mazatzal Mountains, mainly on Slate, Alder, and Sycamore creeks. Phoenix Mountains, the Rico, Mercury, and Eureka groups of claims.

*Mohave County*.—Northern Black Mountains (River Range), the Fey mine, Gold Basin district.

*Pima County*.—Roskrige Range, Roadside mine. Cerro Colorado Mountains, west of Cerro Colorado mine.

*Pinal County*.—Mickey Welch claims, south of Casa Grande.

*Yavapai County*.—Copper Basin district, Mercury, Cinnabar Queen, Zero Hour, and Shylock properties. White Picacho district, Westerdahl claims.

*Yuma County*.—Dome Rock Mountains, French, American, and Colonial properties, 8 miles southwest of Quartzsite.

## NICCOLITE

NiAs. Pale copper-red. Luster metallic. Opaque. Streak pale brownish black. H. = 5-5.5. G. = 7.33-7.67. Hexagonal. Generally massive; also reniform, columnar, reticulated, arborescent. Pure mineral 43.9% Ni.

An uncommon mineral of primary origin, found in large quantities only in a few localities. Generally associated with cobalt and silver-arsenic minerals and with primary native silver.

*Yavapai County*.—With chloanthite and native silver, Monte Cristo mine.

## PYRRHOTITE

Fe<sub>1-x</sub>S. Brownish bronze, readily tarnished. Luster metallic. Opaque. Streak grayish black. H. = 3.5-4.5. G. = 4.58-4.64. Hexagonal. May show distinct basal parting. Commonly in granular masses or disseminated grains.

Abundant in certain basic igneous rocks, sparingly in some copper sulfide ore bodies, particularly those of metamorphic origin, and in some gold ores. Generally associated with pyrite, chalcopyrite, or magnetite. May contain nickel, due to small enclosed grains of pentlandite.

*Mohave County*.—Near Littlefield, in basic dikes with chalcopyrite and pentlandite.

*Pima County*.—Santa Rita Mountains, with pyrite, Helvetia district; as blebs in sphalerite, Busterville mine, Cuprite district. Sierrita Mountains, in chalcopyrite ores of Twin Buttes.

*Yavapai County*.—With gold ores of the Bradshaw Mountains.

## TROILITE

FeS. Light grayish brown. Luster metallic. Streak black. H. = 3.5-4.5. G. = 4.75-4.82. Considered the end member of the pyrrhotite series.

Differs from pyrrhotite in that it contains no dissolved sulfur. Found in meteorites, where there is always an excess of iron.

*Navajo County*.—In the stones of the Holbrook meteorite.

## COVELLITE

CuS. Dark indigo-blue, turns purple when wet. Luster submetallic to resinous. Opaque. Streak black. H. = 1.5-2.5. G. = 4.6. Hexagonal. Crystals generally thin plates. Perfect basal cleavage. Commonly cleavable, granular massive, or as crusts. Pure mineral 66.4% Cu.

A secondary mineral, in many places associated with chalcocite but less abundant. Also as a primary mineral with other sulfides. Probably present in small quantities in all oxidized copper deposits of Arizona.

*Cochise County*.—At Tombstone, lining boxwork structures formed by removal of primary minerals, and easily mistaken for sooty chalcocite.

*Gila County*.—Payson area, in small amounts replacing chalcopyrite and bornite. Dripping Spring Mountains, Christmas mine, Banner district, with secondary chalcocite.

*Graham County*.—As films and blebs in enriched ore, Aravaipa district.

*Greenlee County*.—Clifton-Morenci district, Ryerson and Montezuma mines.

*Pinal County*.—Superior district, sparingly distributed in the Magma mine. Mammoth mine, replacing chalcopyrite. Sierrita Mountains, La Coronado mine, Mineral Hill district.

*Santa Cruz County*.—Patagonia Mountains, as films on other sulfides at several properties.

## BORNITE

Cu<sub>5</sub>FeS<sub>4</sub>. Pinchbeck-brown on fresh fracture. Tarnishes rapidly to iridescent peacock colors. Luster metallic. Opaque. Streak grayish black. H. = 3. G. = 4.9-5.4. Isometric. Commonly massive, with finely granular to compact structure. Pure mineral 63.3% Cu.

An important copper ore in many mines of the state. Almost invariably associated with either chalcopyrite or chalcocite, generally with both. Predominantly primary, but small amounts of secondary bornite are common in enriched ores. Also in contact-metamorphic deposits.

*Cochise County*.—Courtland-Gleeson district, Leadville, Great Western, Copper Belle, and Tejon mines. Little Dragoon Mountains, Johnson district. Bisbee district, important in the Campbell and other ore bodies.

*Coconino County*.—Grand Canyon, as high-grade bodies of bornite, chalcocite, and cuprite at several places.

*Gila County*.—Globe district, common in primary ore, Old Dominion mine; also secondary and forming a distinct blanket beneath the chalcocite zone.

*Mohave County*.—Grand Wash Cliffs, Bronze L mine. Atlanta and Pinkham mines, Chloride district.

*Pima County*.—Ajo, concentrated around pegmatitic bodies in the Cornelia quartz monzonite. Tucson Mountains, disseminated in porphyry, Arizona Tucson property. Silver Bell Mountains, in oxidized ore, Silver Bell district. Santa Catalina Mountains, in contact ores, Stratton-Daily camp.

*Pinal County*.—Superior district, as exceedingly rich ore found to the deepest levels of the Magma mine. Galiuro Mountains, Copper Creek district, Childs-Aldwinkle mine. Dripping Spring Mountains, Adjust mine, Saddle Mountain district.

*Santa Cruz County*.—In small quantities at several properties of the Patagonia and Santa Rita mountains.

*Yavapai County*.—Black Hills, Yaeger mine, as an extensive shoot of high-grade ore.

*Yuma County*.—Buckskin Mountains, Planet mine.

## CHALCOPYRITE

CuFeS<sub>2</sub>. Brass-yellow, commonly with a dull or iridescent tarnish. Luster metallic. Opaque. Streak greenish black. H. = 3.5-4. G. = 4.1-4.3. Tetragonal-sphenoidal. Crystals of tetrahedral habit. Compact massive, reniform or botryoidal. Pure mineral 34.5% Cu.

The most important ore mineral of copper. In appreciable quantity in

nearly all copper sulfide ore deposits. Predominantly of primary origin in veins and replacement bodies, as disseminated particles in granitic and schistose rocks, and in zones of contact metamorphism.

Chalcopyrite is so widely distributed through the ore deposits of Arizona that only the more important localities are listed.

*Cochise County.*—Bisbee district, important in primary ores, in places as large massive bodies. Tombstone, the most abundant copper mineral of the district. Courtland-Gleeson district, the main ore mineral of the pyritic bodies. Little Dragoon Mountains, Johnson district.

*Gila County.*—Globe district, Old Dominion mine, as large masses in Mescal limestone, and forming the bulk of the ore at the Summit mine. Miami district, in the protore of the Miami and Inspiration mines. Payson district, the chief mineral of the copper deposits. Dripping Spring Mountains, Christmas mine.

*Graham County.*—In the Aravaipa and Stanley districts.

*Greenlee County.*—Clifton-Morenci district, in the lower levels of the veins, and disseminated in limestone near porphyry contacts.

*Mohave County.*—Cerbat Range, common in nearly all copper mines and prospects. Grand Wash Cliffs, the main ore mineral at the Bronze L and Copper King mines.

*Pima County.*—The most important copper mineral of the Santa Rita, Silver Bell, and Sierrita mountains. Santa Catalina Mountains, with garnet and epidote in the contact deposits near Marble Peak. Ajo, as scattered grains in the Cornelia quartz monzonite.

*Pinal County.*—Superior district, Magma and Belmont mines. Galiuro Mountains, Copper Creek district, in all properties but especially the Childs-Aldwinkle.

*Santa Cruz County.*—Santa Rita Mountains, the most abundant ore mineral in most of the districts. Patagonia Mountains, Santo Nino mine, with large bodies of massive molybdenite.

*Yavapai County.*—The main ore mineral in the pyritic ore body of the United Verde mine, and abundant at the Copper Chief and Shea properties. Bradshaw Mountains, chiefly in the Big Bug, Agua Fria, Black Canyon, and Pine Grove districts. Eureka district, Bagdad mine.

*Yuma County.*—Buckskin Mountains, Planet mine. Harquahala Mountains, Golden Eagle mine.

#### PYRITE

FeS<sub>2</sub>. Bright brass-yellow. Luster metallic. Opaque. Streak black. H. = 6-6.5. G. = 4.95-5.1. Isometric-pyritohedral. Crystals cubic or pyritohedral. Also in granular to compact masses and disseminated grains.

The commonest sulfide mineral. May be accompanied by gold and copper and constitutes an important ore of these metals.

Abundant in most sulfide ores; only a few localities are listed.

*Cochise County.*—Bisbee district, in large massive bodies.

*Greenlee County.*—Clifton-Morenci district, as large crystals, Hudson and Fairplay veins.

*Pima County.*—Tucson Mountains, Arizona Tucson mine, as crystals from 1/8 to 1/4 inch in diameter with remarkably abundant crystal faces.

*Pinal County.*—Superior district, as large crystals, Belmont mine. Ray district, Iron Cap mine, as perfect pyritohedral crystals up to 1 inch in diameter in soft clay gangue. Galiuro Mountains, as excellent crystals, Childs-Aldwinkle mine.

*Santa Cruz County.*—Patagonia Mountains, as striated and twinned crystals and crystal aggregates up to 8 inches in diameter, 3 R mine, and as large crystal groups near the molybdenite bodies of the Santo Nino mine.

*Yavapai County.*—United Verde mine, one of the large pyritic ore bodies of the world.

*Yuma County.*—Dome Rock Mountains, Don Welsh prospect, as crystals an inch or more in diameter.

## COBALTITE

CoAs<sub>2</sub>. Silver-white with pinkish cast. Luster metallic. Opaque. Streak grayish black. H. = 5.5. G. = 6-6.3. Isometric-tetartoidal. Crystals cubic or pyritohedral. Perfect cubic cleavage. Granular to compact massive. Pure mineral 34.5% Co.

An uncommon mineral generally found in small amount in metamorphic rocks, less commonly in veins, and associated with other cobalt and nickel minerals.

*Pima County*.—Comobabi Mountains, from a single unspecified locality in the Cobabi district.

*Yavapai County*.—Black Hills, near the old Prudential claim, along the contact between Bradshaw granite and greenstone of the Yavapai schist. Altered at surface to erythrite.

## SMALTITE—CHLOANTHITE

Probably CoAs<sub>2</sub> to NiAs<sub>2</sub>. Tin-white to steel-gray, commonly tarnished. Luster metallic. Opaque. Streak grayish black. H. = 5.5-6. G. = 5.7-6.8. Isometric-pyritohedral. Massive or in imitative shapes. Percentages of cobalt and nickel vary widely.

Smaltite is the commonest cobalt mineral; the nickel member, chloanthite, is rarer. Generally in veins with other cobalt and nickel minerals or with ores of silver and copper.

*Graham County*.—Specimens of smaltite submitted to the Arizona Bureau of Mines for identification were reported to have been obtained from a vein in the Santa Teresa Mountains.

*Yavapai County*.—Wickenburg Mountains, as chloanthite with native silver, Monte Cristo mine.

## MARCASITE

FeS<sub>2</sub>. Pale bronze-yellow, deepening upon exposure. Luster metallic. Opaque. Streak grayish or brownish black. H. = 6-6.5. G. = 4.85-4.90. Orthorhombic. Tabular or pyramidal crystal groups common. Also massive, radiating fibrous, stalactitic or globular.

Less common than pyrite and formed under near-surface conditions. Generally in replacement deposits or as concretions in sedimentary rocks.

*Mohave County*.—Black Mountains, as thin plates in quartz, Moss mine, Oatman district.

*Pima County*.—Sierrita Mountains, as an alteration of pyrrhotite, Glance and Queen mines, Twin Buttes area; as thin coatings and veinlets, Mineral Hill and San Xavier districts.

*Yavapai County*.—Bradshaw Mountains, as small colloform masses in partly oxidized ore, Iron Queen mine, Big Bug district.

## ARSENOPYRITE

FeAsS. Steel-gray to tin-white. Luster metallic. Opaque. Streak grayish black. H. = 5.5-6. G. = 5.9-6.2. Orthorhombic. In diamond-shaped, prismatic or flattened crystals. Distinct prismatic cleavage. Also as columnar, granular, or compact masses.

The commonest arsenic mineral. Abundant in many gold-quartz veins and in some places the chief gold-bearing ore. Also with ores of tin and tungsten, sparingly in sulfide ores.

*Mohave County*.—Cerbat Range, in some mines of the Chloride and Mineral Park district, notably the Minnesota-Connor, Windy Point, and Queen Bee.

*Yavapai County*.—Sparingly at the United Verde and Shea properties, Verde district. Bradshaw Mountains, as crystals, Boggs mine, Big Bug district, and as massive material at several other properties. Eureka district, in a vein with bismuthinite, near the Hillside mine.

## SULFO SALTS

Jamesonite	Pb <sub>4</sub> FeSb <sub>6</sub> S <sub>14</sub>	Tetrahedrite	(Cu,Fe,Ag) <sub>12</sub> Sb <sub>4</sub> S <sub>18</sub>
Dufrenoyite	Pb <sub>2</sub> As <sub>2</sub> S <sub>5</sub>	Tennantite	(Cu,Fe,Ag) <sub>12</sub> As <sub>4</sub> S <sub>18</sub>
Freieslebenite	Ag <sub>4</sub> Pb <sub>3</sub> Sb <sub>4</sub> S <sub>11</sub>	Stephanite	Ag <sub>5</sub> SbS <sub>4</sub>
Diaphorite	Ag <sub>4</sub> Pb <sub>3</sub> Sb <sub>4</sub> S <sub>11</sub>	Polybasite	Ag <sub>10</sub> Sb <sub>2</sub> S <sub>11</sub>
Bournonite	PbCuSbS <sub>3</sub>	Pearceite	Ag <sub>16</sub> As <sub>2</sub> S <sub>11</sub>
Aikinite	PbCuBiS <sub>3</sub>	Enargite	Cu <sub>3</sub> AsS <sub>4</sub>
Pyrargyrite	Ag <sub>3</sub> SbS <sub>3</sub>	Famatinite	Cu <sub>3</sub> SbS <sub>4</sub>
Proustite	Ag <sub>3</sub> AsS <sub>3</sub>		

### JAMESONITE

Pb<sub>4</sub>FeSb<sub>6</sub>S<sub>14</sub>. Steel-gray to dark lead-gray. Luster metallic. Opaque. Streak grayish black. H. = 2-3. G. = 5.5-6. Monoclinic. Crystals acicular or capillary. Fibrous or compact massive.

An uncommon primary mineral in small quantities with other sulfo salts, galena, stibnite, and tetrahedrite. Probably many occurrences credited to jamesonite are of some other lead sulfo salt in fibrous form.

*Yavapai County*.—Reported from the Bradshaw Mountains with native gold (1:17).

### DUFRENOYSITE

Pb<sub>2</sub>As<sub>2</sub>S<sub>5</sub>. Dark lead-gray. Luster metallic. Opaque. Streak reddish brown. H. = 3. G. = 5.55-5.57. Monoclinic. Crystals highly modified. Perfect clinopinacoidal cleavage. Also massive.

A rare species which may be isomorphous with jamesonite.

*Mohave County*.—Reported from the Mineral Park district (1:17), but the exact locality is not known.

### FREIESLEBENITE

Ag<sub>4</sub>Pb<sub>3</sub>Sb<sub>4</sub>S<sub>11</sub>. Color and streak light steel-gray to dark lead-gray. Luster metallic. Opaque. H. = 2. G. = 6.2-6.4. Monoclinic. Crystals prismatic. In granular masses or disseminated grains.

A rare mineral occurring with other silver ores and reported from only a few American localities.

*Yuma County*.—Castle Dome, where a small amount was mined.

### DIAPHORITE

Ag<sub>4</sub>Pb<sub>3</sub>Sb<sub>4</sub>S<sub>11</sub>. Like freieslebenite, but orthorhombic in form. H. = 2.5. G. = 6-6.2.

Reported under the name *brongniardite*, as occurring with other argentiferous ores (1:17). No specific localities were given.

### BOURNONITE

PbCuSbS<sub>3</sub>. Color and streak steel-gray, lead-gray, or iron-black. Luster metallic, brilliant. Opaque. H. = 2.5-3. G. = 5.7-5.9. Orthorhombic. Crystals commonly repeated twins, forming wheel-shaped forms. Imperfect brachypinacoidal cleavage. In granular to compact masses.

One of the commoner sulfo salts of primary origin, generally in lead-silver deposits with galena, tetrahedrite, or stibnite.

*Cochise County*.—Tombstone, sparingly with other copper-antimony minerals.

*Pima County*.—Santa Rita Mountains, Busterville mine, Cuprite district.

*Yavapai County*.—Bradshaw Mountains, as crystallized material in masses of calcite, Boggs mine, Big Bug district.

### AIKINITE

PbCuBiS<sub>3</sub>. Blackish lead-gray. Opaque. G. = 6.1-6.8. In acicular crystals, also massive.

A rare mineral found at few localities in the world.

*Pima County*.—Roskrige Range, in small quantities, Roadside mine.

### PYRARGYRITE—Ruby Silver

Ag<sub>3</sub>SbS<sub>3</sub>. Black; ruby-red by transmitted light. Luster adamantine to metallic. Transparent in very thin splinters. Streak purplish red. H. = 2.5. G. = 5.77-5.86. Rhombohedral-hemimorphic. Crystals prismatic. Distinct prismatic cleavage. Most commonly in small disseminated masses or grains. Pure mineral 59.9% Ag.

A primary mineral of the upper portions of silver sulfide deposits, formed by late hydrothermal solutions. Commonly associated with other silver minerals, galena, and tetrahedrite.

*Pinal County*.—Galiuro Mountains, Little Treasure mine, Saddle Mountain district.

*Santa Cruz County*.—Patagonia Mountains, Alta mine, Harshaw district, with embolite and fluorite; Sonoita mine, Palmetto district.

*Yavapai County*.—Bradshaw Mountains, Tillie Starbuck mine, Hassayampa district.

#### PROUSTITE—Ruby Silver

$\text{Ag}_2\text{AsS}_3$ . Color and streak scarlet vermilion. Luster adamantine. Transparent to translucent.  $H. = 2-2.5$ .  $G. = 5.57-5.64$ . Rhombohedral-hemimorphic. Crystals acute rhombohedral or scalenohedral. Distinct prismatic cleavage. As disseminated grains or compact masses. Pure mineral 65.4% Ag.

A primary mineral of the upper portions of silver sulfide deposits, formed by late hydrothermal solutions and generally associated with pyrargyrite.

*Cochise County*.—Pearce Hills, Commonwealth mine, with tetrahedrite.

*Mohave County*.—Cerbat Range, Minnesota-Connor and Merrimac mines, Chloride district; Gold Star mine, Mineral Park district; Paymaster mine, Cerbat district; in relatively large quantities at the Cupel mine, Stockton Hill district.

*Pinal County*.—Superior district, Belmont mine, as minute blebs in galena.

*Yavapai County*.—Bradshaw Mountains, Davis mine, Hassayampa district, with polybasite; with native silver and cerargyrite in a vein near the Thunderbolt mine, Black Canyon district; Morgan mine, Turkey Creek district; with native silver and cerargyrite, Tip Top mine, Tip Top district. Wickenburg Mountains, with argentite in primary silver ores, Monte Cristo mine.

#### TETRAHEDRITE—TENNANTITE—Gray Copper

$(\text{Cu,Fe,Ag})_{12}\text{Sb}_4\text{S}_{13}$  to  $(\text{Cu,Fe,Ag})_{12}\text{As}_4\text{S}_{13}$  and forming a continuous series. Dark lead-gray to steel-gray. Luster metallic. Opaque. Streak dark gray in tetrahedrite to brownish in tennantite.  $H. = 3-4$ .  $G. = 4.4-5.1$ . Isometric-tetrahedral. Crystals tetrahedral in habit. Also granular or compact massive. Pure mineral from 46.7 to 52.7% Cu. Appreciable silver content not unusual.

Tetrahedrite and tennantite are seldom differentiated. They occur as primary constituents of copper, lead, and silver ores, are commonly argentiferous, and then become important ores of silver. *Freibergite* is argentiferous tetrahedrite containing from 3 to 30 per cent of silver.

*Cochise County*.—Tombstone, particularly at the Toughnut, Lucky Cuss, and Ingersol mines, but common in most ores of the district, and containing silver. Pearce Hills, Commonwealth mine, with proustite.

*Gila County*.—Globe district, as crystals in cavities, Old Dominion mine. Richmond Basin, Helene vein, as silver-bearing tennantite. Payson district, the main ore mineral of the Silver Butte mine.

*Graham County*.—Aravaipa district, Grand Reef mine.

*Mohave County*.—Cerbat Range, a common constituent of the high-grade silver ores, commonly associated with proustite.

*Pima County*.—Santa Rita Mountains, Silver Spur mine, Helvetia district; Summit mine, Greaterville district; Busterville mine, Cuprite district. Sierrita Mountains, Helmet Peak mine, San Xavier district. Cerro Colorado Mountains, Cerro Colorado mine, with stromeyerite and native silver.

*Pinal County*.—Superior district, Silver King mine. Assays showed up to 3,000 ounces of silver per ton; much of the value was probably due to undetected stromeyerite. Abundant in the Magma mine below the 900-foot level. Galiuro Mountains, Blue Bird and Childs-Aldwinkle mines, Copper Creek district, with stromeyerite.

*Santa Cruz County*.—Santa Rita and Patagonia mountains, at several localities. As fine crystals, American Boy mine, Wrightson district.

*Yavapai County*.—Wickenburg Mountains, with enargite, niccolite, and native silver, Monte Cristo mine. Black Hills, United Verde, Shea, Yaeger, and Shylock mines. Bradshaw Mountains, at several properties of the Walker, Hassayampa, Agua Fria, and other districts.

## STEPHANITE

$\text{Ag}_5\text{SbS}_4$ . Color and streak iron-black. Luster metallic. Opaque.  $H. = 2-2.5$ .  $G. = 6.2-6.3$ . Orthorhombic. Crystals short prismatic or tabular. Also compact, massive, and disseminated. Pure mineral 68.5% Ag.

A common primary mineral in the upper portions of silver deposits with other silver minerals, galena, and tetrahedrite.

*Santa Cruz County*.—Patagonia Mountains, Golden Rose mine, Patagonia district.

*Yavapai County*.—Bradshaw Mountains, Tuscumbia mine, Bradshaw district.

## POLYBASITE

$\text{Ag}_{10}\text{Sb}_2\text{S}_{11}$ . Iron-black; cherry-red in thin splinters. Luster metallic. Opaque. Streak black.  $H. = 2-3$ .  $G. = 6-6.2$ . Monoclinic. Crystals short, six-sided, tabular prisms with beveled edges and triangular striations on the basal pinacoid. Also massive. Pure mineral 75.6% Ag.

A primary mineral of many silver veins, commonly in considerable amount. Resembles stephanite, with which it is generally associated.

*Mohave County*.—Cerbat Mountains, common in the silver ores of various districts.

*Pinal County*.—Superior district, as fine crystals from the upper levels of the Silver King mine.

*Yavapai County*.—Bradshaw Mountains, Davis mine, Hassayampa district, with proustite.

## PEARCEITE

$\text{Ag}_{10}\text{As}_2\text{S}_{11}$ . Monoclinic, pseudorhombohedral. Other properties like polybasite, of which it is the arsenical variety.

Similar in occurrence to polybasite but is less common.

*Mohave County*.—Cerbat Range, reported in small amount from some of the high-grade silver ores.

## ENARGITE

$\text{Cu}_3\text{AsS}_4$ . Grayish black to iron-black. Luster metallic. Opaque. Streak grayish black.  $H. = 3$ .  $G. = 4.43-4.45$ . Orthorhombic. Crystals prismatic and vertically striated. Perfect prismatic, distinct pinacoidal cleavage. Commonly massive, granular or columnar. Pure mineral 48.3% Cu.

Of uncommon occurrence, but in a few localities found in large amount as an important ore of copper. Of primary origin, with other copper sulfides.

*Pinal County*.—Superior district, in large quantity on the lower levels of the Magma mine. Galiuro Mountains, sparingly with tennantite, Childs-Aldwinkle mine.

*Yavapai County*.—Wickenburg Mountains, with tennantite, niccolite, and native silver, Monte Cristo mine.

## FAMATINITE

$\text{Cu}_5\text{SbS}_4$ . Gray with tinge of copper-red.  $H. = 3.4$ .  $G. = 4.57$ .

Famatinite is of rarer occurrence than enargite, with which it generally occurs.

*Cochise County*.—Tombstone, in small amount, Ingersol and Toughnut mines.

## HALIDES

Halite	NaCl	Cotunnite	PbCl <sub>2</sub>
Sal Ammoniac	NH <sub>4</sub> Cl	Fluorite	CaF <sub>2</sub>
Cerargyrite	AgCl	Atacamite	Cu <sub>2</sub> Cl(OH) <sub>3</sub>
Embolite	Ag(Br,Cl)	Boleite	Pb <sub>2</sub> CuAgCl <sub>2</sub> (OH) <sub>2</sub> (?)
Bromyrite	AgBr	Diaboleite	Pb <sub>2</sub> CuCl <sub>2</sub> (OH) <sub>2</sub>
Iodobromite	Ag(Br,Cl,I)	Matlockite	Pb <sub>2</sub> OCl <sub>2</sub>
Iodyrite	AgI		

### HALITE—Rock Salt

NaCl. Colorless or white. Luster vitreous. Transparent to translucent. Streak white. Taste saline. H. = 2.5. G. = 2.1-2.6. Isometric. Perfect cubic cleavage. Crystals cubic. Cleavable to granular massive.

An important source of salt, found in irregular sedimentary beds and formed by evaporation of inland seas or salt lakes. Commonly associated with gypsum or anhydrite.

*Gila and Maricopa counties.*—Throughout the Salt River Valley as incrustations. Derived from the evaporation of saline springs.

*Mohave County.*—With gypsum in badlands of the Virgin River Valley near the Nevada border.

*Yavapai County.*—Near Camp Verde, with thenardite, glauberite, mirabilite, and gypsum.

### SAL AMMONIAC

NH<sub>4</sub>Cl. White. As incrustations.

Most commonly a sublimation product about fumaroles.

*Yuma County.*—Reported from near Yuma.

### CERARGYRITE—Horn Silver

AgCl. Pearl-gray, grayish green, whitish to colorless. Turns violet-brown on exposure to light. Luster waxy. Transparent to translucent. Streak whitish. H. = 1-1.5. Sectile and malleable. G. = 5.552. Isometric. As small cubic crystals. Most commonly as waxy masses or crusts. Pure mineral 75.3% Ag.

An important silver mineral of oxidized silver deposits in arid regions, formed by reaction between descending waters containing chlorine and silver-bearing solutions. Horn silver ores have yielded much of the silver of the state.

*Cochise County.*—At Tombstone, probably abundant in oxidized ores of the district, but cannot be distinguished physically from other silver halides which are known to be present. Pearce Hills, with other silver halides and argentite at the Commonwealth mine. Dragoon Mountains, in oxidized lead-silver deposits of the Turquoise district.

*Gila County.*—Globe district, in many of the surficial ores; Old Dominion mine, with manganese oxides. Richmond Basin. In the Jumbo vein, massive cerargyrite forms plates ½ inch thick and several inches in diameter. Payson district, with native silver at the Silver Butte mine.

*Graham County.*—Aravaipa district, in the Bullis and Aravaipa groups.

*Mohave County.*—Cerbat Range, at several properties, principally in the Chloride, Mineral Park, Cerbat, Stockton Hills, White Hills, and Wallapai districts. Hualpai Mountains, at several properties in the Maynard district.

*Pima County.*—Santa Rita Mountains, Blue Jay mine, Helvetia district, and in the Greaterville district. Empire Mountains, Total Wreck mine. Quijotoa Mountains, Morgan mine. Tortillito Mountains, Apache property, Owl Head district. Cerro Colorado Mountains, Cerro Colorado and other mines.

*Pinal County.*—Superior district, as the chief near-surface ore mineral in the Belmont area.

*Santa Cruz County.*—Santa Rita Mountains, Ivanhoe mine, Tyndall district; Anaconda group, Wrightson district. Patagonia Mountains, La Plata and Meadow Valley mines, Redrock district; Hermosa and American mines, Harshaw district; Palmetto mine, Palmetto district.

*Yavapai County.*—Bradshaw Mountains, Dos Oris mine, Hassayampa district, with argentite and native silver; Thunderbolt mine, Black Canyon

district, with proustite and native silver; Tuscumbia mine, Bradshaw district, with stephanite; with ruby silver at the Tip Top mine, Tip Top district. At the Silver Belt mine, Big Bug district, where the presence of stone hammers and gads in ancient working indicates that the deposit was mined in prehistoric time.

*Yuma County*.—Trigo Mountains, Silver Clip and Red Cloud mines, as the principal silver mineral in the oxidized lead ores.

#### EMBOLITE—Horn Silver

Ag(Br,Cl). Grayish green and yellowish green to yellow. G. = 5.31-5.43. Other properties same as cerargyrite. Pure mineral 57.4 to 75.3% Ag.

So closely resembles cerargyrite that it is usually so identified, and the mineral is probably more common than is generally supposed. Origin similar to that of cerargyrite, with which it is commonly associated.

*Cochise County*.—At Tombstone, the principal silver mineral at the State of Maine mine. Pearce Hills, abundant at the Commonwealth and other properties of the district.

*Pinal County*.—Mammoth mine, as tiny yellowish cubo-octahedral crystals implanted on caledonite from the Collins vein.

*Santa Cruz County*.—Santa Rita Mountains, Ivanhoe mine, Tyndall district. Patagonia Mountains, Alta Mine, Harshaw district, with pyrrargyrite.

#### BROMYRITE—Horn Silver

AgBr. G. = 5.8-6. Other properties same as cerargyrite. Pure mineral 57.4% Ag.

Origin and associations similar to cerargyrite, from which it cannot be distinguished except by chemical analysis.

*Cochise County*.—At Tombstone, where in 1936 it was discovered in considerable quantity in ores of the Empire and Flora Morrison mines and is probably the most abundant silver halide in the ores of the district (3:38). Analysis by R. Carrillo as follows:

Cl	Br	I	Ag	Total
0.6	38.9	2.6	56.7	98.8

Pearce Hills, with embolite, Commonwealth mine.

*Gila County*.—Reported from ores of Richmond Basin.

*Graham County*.—Aravaipa district, in oxidized ores of the Aravaipa group.

*Mohave County*.—Much "green horn silver" is reported from the Cerbat Range and from the Maynard district, Hualpai Mountains (8:09). At the Tennessee-Schuylkill mine, Wallapai district.

*Santa Cruz County*.—Santa Rita Mountains, Walker mine, Wrightson district. Patagonia Mountains, Meadow Valley mine, Redrock district.

*Yavapai County*.—Bradshaw Mountains, the main ore mineral at the Peck mine, Peck district.

#### IODOBROMITE—Horn Silver

Ag(Br,Cl,I). Sulfur-yellow to greenish. G. = 5.713. Other properties same as cerargyrite.

Similar to, but rarer than, the silver halides already described.

*Gila County*.—Globe district, as thin seams and crusts in a vein of quartz and calcite at the Hechman mine.

#### IODYRITE—Horn Silver

AgI. Pale yellow or green. H. = 1-1.5. G. = 5.5-5.7. Hexagonal-hemimorphic. Except for the crystal form it is identical in appearance with the silver halides already described.

A rare silver mineral, reported from only a few localities in the world.

*Cochise County*.—Pearce Hills, with cerargyrite, bromyrite, embolite, and argentite, Commonwealth mine.

*Pima County*.—Cerro Colorado Mountains, Cerro Colorado mine.

## COTUNNITE

PbCl<sub>2</sub>. White to yellowish. Soft. G. = 5.3-5.8. Orthorhombic. Perfect basal cleavage. In acicular crystals and semicrystalline masses.

A rare mineral, found in small quantity in only a few places in the world. *Mohave County*.—Grand Wash Cliffs, as small veinlets replacing chalcocite at the Grand Gulch mine, Bentley district.

## FLUORITE—Fluorspar

CaF<sub>2</sub>. Most commonly colorless, white, green, purple, blue, yellow, and brown. Luster vitreous. Transparent to subtranslucent. H. = 4. G. = 3.01-3.25. Isometric. Perfect octahedral cleavage. Cubic and octahedral crystals common. Also granular massive with prominent cleavage; rarely columnar. Some specimens are fluorescent.

Occurs most commonly as a primary mineral in veins of which it is the chief constituent, or in the gangue of lead, zinc, and silver ores. It is also found in sedimentary rocks, such as dolomite and limestone, and in plutonic igneous rocks, such as granite and monzonite. Used chiefly as a flux in the making of steel.

*Cochise County*.—At Tombstone, locally abundant in some silicified areas, particularly at the Empire mine. Near Government Draw, purple crystals with quartz. In the Chiricahua Mountains small quantities have been mined from quartz veins near Paradise. Dragoon Mountains, in granite pegmatites with huebnerite.

*Gila County*.—Payson district, with epidote, Ox Bow mine.

*Graham County*.—Aravaipa district, Grand Reef mine and veins of the Landsman group. As crystals in barite veins of Stanley Butte.

*Greenlee County*.—In several properties near Duncan, some of which have produced.

*Maricopa County*.—Reported from the White Tank Mountains (1:17), and in veins near Aguila.

*Mohave County*.—Black Mountains, as white to pale green bands or as linings of cavities in the northern part of the Oatman district.

*Pima County*.—Santa Rita Mountains, New York mine, Helvetia district. Silver Bell Mountains, in considerable quantity in the old silver-lead pit near the Mammoth mine, and with barite and galena at several other properties in the Silver Bell district. Sierrita Mountains, as veins from a few inches to 2 feet in width, Neptune property.

*Pinal County*.—Mammoth mine, microscopically abundant but rarely visible.

*Santa Cruz County*.—Patagonia Mountains, as red material with embolite and pyrargyrite, Alta mine, Harshaw district.

*Yavapai County*.—Bradshaw Mountains, Springfield group, Pine Grove district; Swallow mine, Castle Creek district.

*Yuma County*.—Castle Dome Mountains, Castle Dome district, as greenish, purple, and rose-colored crystals and cleavage masses up to several inches in diameter, associated locally with galena, barite, and wulfenite. Material produced from the Big Dome claim showed the following analysis:

CaF <sub>2</sub>	CaCO <sub>3</sub>	SiO <sub>2</sub>
98.7 to 99.0	1.15 to 1.65	0.05 to 0.20

Trigo Mountains, Silver district, as crystalline to dense varicolored bands coating quartz, and as vein material with quartz and barite. Kofa or S.H. Mountains, in a vein near the King of Arizona mines. Buckskin Mountains, Chicago and Mammoth properties, with barite.

## ATACAMITE

Cu<sub>2</sub>Cl(OH)<sub>2</sub>. Bright green, dark emerald-green to blackish green. Luster adamantine to vitreous. Transparent to translucent. H. = 3-3.5. G. = 3.76-3.78. Orthorhombic. Highly perfect pinacoidal cleavage. Commonly in slender prismatic crystals, vertically striated. Also in confused crystalline aggregates, massive, fibrous, granular to compact and as sand. Pure mineral 45% Cu.

Of secondary origin, derived from malachite and cuprite under arid or semiarid conditions. Reported from only a few localities in Arizona, but is probably more widely distributed.

*Pinal County.*—Galiuro Mountains, as small green crystals with olivenite on the main level of the Old Reliable mine, Copper Creek district. Mammoth mine, as coarse granular aggregates of deep green color in a single specimen from the 400-foot level, Collins vein.

*Pima County.*—Cerro Colorado Mountains, Cerro Colorado mine.

*Yavapai County.*—Black Hills, in small quantities, United Verde mine.

## BOLEITE

$\text{PbCuAgCl}_2(\text{OH})_2$  (?). Indigo-blue. H. = 3-3.25. G. = 5.08. Tetragonal. Perfect basal, distinct prismatic cleavage. In twinned pseudocubic crystals.

A rare mineral found in some oxidized sulfide ore bodies in arid or semi-arid regions.

*Pinal County.*—Mammoth mine, as dark blue cubes with diaboite and cerussite from the 400-foot level, Collins vein.

## DIABOLEITE

$\text{Pb}_2\text{CuCl}_2(\text{OH})_2$ . Bright sky-blue. H. = 2.5. G. = 6.412. Tetragonal-hemimorphic. In thin platy to short, stubby crystals.

A rare secondary mineral previously known from only one locality in the world.

*Pinal County.*—Mammoth mine, in crystals of superb quality, with cerussite, wulfenite, and boleite.

## MATLOCKITE

$\text{Pb}_2\text{OCl}_2$ . Yellowish, grayish, or greenish. Luster adamantine to pearly. H. = 2-3. G. = 7.21. Tetragonal. Perfect basal cleavage. Crystals tabular.

A rare secondary mineral previously recorded only from the original locality at Matlock, England.

*Pinal County.*—Mammoth mine, as minute crystals on boleite from the 400-foot level, Collins vein, and as a large nodule coated with cerussite from the 500-foot level.

## OXIDES

Quartz		Ilmenite	Fe.TiO <sub>3</sub>
Tridymite	} SiO <sub>2</sub>	Spinel	MgAl <sub>2</sub> O <sub>4</sub>
Cristobalite		Magnetite	Fe <sub>3</sub> O <sub>4</sub>
Opal	SiO <sub>2</sub> .nH <sub>2</sub> O	Chromite	FeCr <sub>2</sub> O <sub>4</sub>
Claudetite	As <sub>2</sub> O <sub>3</sub>	Hetaerolite	ZnMn <sub>2</sub> O <sub>4</sub>
Bismite	Bi <sub>2</sub> O <sub>3</sub>	Coronadite	Mn <sub>2</sub> PbO <sub>5</sub> (?)
Tungstite	WO <sub>3</sub>	Minium	Pb <sub>3</sub> O <sub>4</sub>
Cervantite	Sb <sub>2</sub> O <sub>3</sub>	Delafossite	CuFeO <sub>2</sub>
Stibiconite	H <sub>2</sub> Sb <sub>2</sub> O <sub>5</sub>	Rutile	} TiO <sub>2</sub>
Cuprite	Cu <sub>2</sub> O	Anatase	
Massicot	PbO	Pyrolusite	MnO <sub>2</sub>
Tenorite	CuO	Goethite	FeO(OH)
Paramelaconite	CuO (?)	Manganite	MnO(OH)
Corundum	Al <sub>2</sub> O <sub>3</sub>	Limonite	FeO(OH)+Fe <sub>2</sub> O <sub>3</sub> +H <sub>2</sub> O
Hematite	Fe <sub>2</sub> O <sub>3</sub>	Psilomelane	MnO <sub>2</sub>

## QUARTZ

SiO<sub>2</sub>. Colorless to various shades of yellow, red, brown, green, blue, and black. Luster vitreous and splendid to greasy or nearly dull. Transparent to opaque. Streak white. H. = 7. G. = 2.65-2.66. Rhombohedral-trapezohedral. No cleavage. Good conchoidal fracture. Commonly in prismatic crystals with the prism faces horizontally striated. Massive forms are common and in great variety, from granular to flintlike.

The most common of minerals, comprising about three fifths of the earth's crust. An essential component of many igneous and metamorphic rocks, sandstone, quartzite, gravel, and sand. It forms a large part of mineral veins and is deposited from waters of hot springs.

Quartz is so widespread and abundant that only a few typical occurrences are listed.

### PHENOCRYSTALLINE QUARTZ

#### Rock crystal

Clear, colorless quartz, whether in distinct crystals or not. A common constituent of mineral veins but rare in large flawless masses which are of considerable value. Many localities other than those listed exist in the state.

*Cochise County.*—Little Dragoon Mountains, Johnson district, as well-formed crystals, some of which reach large size.

*Gila County.*—Globe district, Old Dominion mine, where crystals colored blue by chrysocolla line cavities in oxidized ore, and some of the massive quartz is brilliant red due to finely divided hematite. Payson district, as clear crystals up to 1 inch long at the Ox Bow mine.

*Graham County.*—As good crystals in druses of veins of the Tenstrike group, Aravaipa district.

*Mohave County.*—Oatman and Katherine districts, as colorless crystals in abundance in the gold veins.

*Pima County.*—Tucson Mountains, as geodes in basalt flows near "A" Mountain.

*Pinal County.*—Galiuro Mountains, Copper Creek district, as good crystals up to several inches long.

*Yavapai County.*—Bradshaw Mountains, Cash mine, Hassayampa district, where clear crystals lining open veins are accompanied by crystals of adularia, calcite, and ore minerals.

*Yuma County.*—As large crystals in pegmatites of pre-Cambrian granites over considerable areas.

#### Amethyst

Clear purple or bluish violet. Generally in crystals, less commonly massive. A valuable gem stone.

*Gila County.*—Mazatzal Mountains, as crystals lining vugs in Mazatzal quartzite of Four Peaks.

*Mohave County.*—Cerbat Range, as crystals in pre-Cambrian granite of the McConnico district, northeast of Boulder Spring. Black Mountains, as

bands in colorless quartz of gold veins of the Oatman and Katherine districts.

*Santa Cruz County*.—Sierra de Tordillo mine, Parker Canyon district. Patagonia Mountains, as large crystals in pegmatite near Duquesne.

#### Rose quartz

Rose red or pink; becomes paler upon exposure. Generally massive. Luster somewhat greasy. Color is perhaps due to titanium.

*Mohave County*.—Black Mountains, locally abundant in gangue of Moss mine, Oatman district. Specimens of good quality have been received from a locality 40 miles northeast of Kingman.

#### Sandstone and quartzite

Compacted or cemented quartz sand. Widely distributed in large quantities throughout the state. In some localities it has been quarried for building purposes.

### CRYPTOCRYSTALLINE QUARTZ

#### Chalcedony

Includes cryptocrystalline quartz with a waxy or greasy luster, either transparent or translucent, ranging from white through gray, blue, pale brown, dark brown, and black. Occurs as mammillary, botryoidal, or stalactitic masses, lining or filling cavities in rocks.

*Apache and Navajo counties*.—The main constituent of petrified wood at various localities, most abundant at the Petrified Forest, near Holbrook.

*Gila County*.—Globe district, Old Dominion mine, in places colored blue or green from intergrown chrysocolla or malachite.

*Mohave County*.—Black Mountains, Gold Road and Gold Ore veins, Oatman district. On the western slopes of the River Range.

*Pima County*.—Santa Rita Mountains, reported from the Greaterville district. Silver Bell district, El Tiro mine, as clear, nearly transparent material of a beautiful emerald-green color. Tucson Mountains, in cavities in basalt.

*Pinal County*.—Abundant in spherulites and irregular cavities in dacite-rhyolite flows.

*Santa Cruz County*.—Grosvenor Hills, near the old village of Santa Cruz.

*Yavapai County*.—In the vicinity of Morgan City and Slow Springs washes as spherulitic nodules in lava. Much of the chalcedony is fluorescent.

*Yuma County*.—Chocolate Mountains, excellent specimens. East of Parker, near milepost 87, Santa Fe Railway.

#### Chrysoprase

Strictly an apple-green chalcedony. Greenish and bluish chalcedony is commonly included in the term.

*Mohave County*.—River Range, Weaver district, and elsewhere on the western slopes.

*Gila County*.—"Blue chrysoprase," a blue or bluish-green copper-stained chalcedony, abundant at the Live Oak and Keystone mines, Miami district.

#### Agate

A variegated chalcedony, with colors either banded, irregularly clouded, or due to visible impurities, as of manganese oxide in "moss agate."

*Coconino and Mohave counties*.—As nodules in Kaibab limestone.

*Pima County*.—Tucson Mountains, geodes of blue and white agate abundant in basalts near "A" Mountain.

*Yavapai County*.—In the vicinity of Morgan City and Slow Springs washes, as spherulitic nodules in lava.

#### Onyx

Like agate, a banded chalcedony, but the layers are even and the banding parallel.

*Yavapai County*.—Near Morgan City and Slow Springs washes, as spherulitic nodules in lava.

#### Flint

Similar to chalcedony, but more opaque, of dull colors, generally gray, smoky brown, and brownish black.

*Coconino, Mohave, and Yuma counties*.—As irregular nodules in limestones, especially of the Kaibab formation, and as stream pebbles.

#### Chert

Any impure, flinty rock, including hornstone and certain jaspers.

Abundant in many limestones of the state, as irregular sheets, lenses, and nodules.

#### Jasper

Impure, opaque, cryptocrystalline quartz, commonly red but also yellow, dark green, brown, and grayish blue.

Jasper, like chert, is widely distributed throughout the state, but in much smaller amount. It is most abundant as petrified wood of the Petrified Forest and elsewhere in Apache, Navajo, Mohave, and Yuma counties.

#### Silicified (petrified) wood

Cryptocrystalline quartz pseudomorphous after wood. Largely chalcedony and jasper, commonly beautifully colored.

*Apache and Navajo counties*.—Principally in and around the Petrified Forest, where many square miles are in part covered by silicified logs, branches, and fragments. Also in the vicinity of Nazlini Canyon, north of Ganado, and at numerous other localities.

*Coconino, Mohave, and Yuma counties*.—Abundant along the Colorado River.

#### Lechatelierite

Naturally occurring fused quartz.

*Coconino County*.—At Meteor Crater, west of Winslow, where it was apparently formed by fusion of fine-grained sandstone.

#### TRIDYMITE

SiO<sub>2</sub>. Colorless to white. Luster vitreous. Transparent. Streak uncolored. H. = 7. G. = 2.28-2.33. Hexagonal or pseudo-hexagonal. In minute, thin tabular crystals.

Quartz, tridymite, and cristobalite may be considered as polymers. Quartz forms below 870° C., tridymite above 870°, and when heated to 1470° tridymite passes to cristobalite.

Chiefly in cavities in rhyolite, trachyte, and andesite, generally with sanidine, hornblende, or augite.

*Pima County*.—Roskrige Mountains, with cristobalite and anauxite in cavities in andesite.

#### CRISTOBALITE

SiO<sub>2</sub>. G. = 2.27. In white octahedrons.

The temperature polymer of quartz and tridymite, forming above 1470° C.

*Pima County*.—Roskrige Mountains, associated with tridymite and anauxite in cavities in andesite.

#### OPAL

SiO<sub>2</sub>.nH<sub>2</sub>O. Commonly white, yellow, red, brown, green, gray, blue. Vitreous to resinous, pearly or waxy. Transparent to opaque. Streak white. H. = 5.5-6.5. G. = 1.9-2.3. Amorphous. Massive, botryoidal, or stalactitic.

A colloid deposited at low temperature. Occurs in veins; deposited by hot springs; also formed by weathering of rocks. Makes up the siliceous skeletons of many sea organisms. Some precious opal is formed by replacement of wood. Varieties are based on differences of color, structure, or origin.

**Precious opal**

Exhibits a play of delicate colors.

*Maricopa County*.—Reported from the vicinity of Morristown.

**Common opal**

In part translucent, most commonly milk white, brown, green, or red.

*Cochise County*.—At Tombstone, as seams in ore, Lucky Cuss mine.

*Yavapai County*.—Bradshaw Mountains, with chalcedony, 14 miles from Mayer on the Agua Fria River. Eureka district, Bagdad mine, in quartz veins.

**Hyalite**

Colorless and clear or whitish and translucent. As concretions or crusts with a globular or botryoidal surface. Commonly in cavities in basalts or other lava flows.

*Mohave County*.—Eastern slopes of the Black Mountains, northwest of Kingman.

*Pinal County*.—Pinal Mountains, in cavities in dacite, Superior district.

*Santa Cruz County*.—Grosvenor Hills, near Santa Cruz.

*Yavapai County*.—Reported from several localities (1:17).

**Diatomaceous earth, diatomite, tripolite**

Earthy material resembling chalk, made up of siliceous shells of diatoms, in places as extensive deposits.

*Cochise County*.—Near Curtis, deposit 4 to 8 feet in thickness of considerable extent.

*Graham County*.—Near Solomonville, a partly eroded deposit originally 16 to 18 feet thick.

*Pinal County*.—Along the San Pedro River, south of Mammoth, pure, snow white in beds 40 to 70 feet thick covering an area of 10 to 12 square miles. Partial analysis by H. A. Mann:

SiO <sub>2</sub>	FeO-Fe <sub>2</sub> O <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>	NaCl	CaO	Ign. loss	Total
82.81	1.10	4.84	0.45	2.10	5.07	96.37

On the Gila River 20 miles east of Florence.

**CLAUDETITE**

As<sub>2</sub>O<sub>3</sub>. Colorless to white. H. = 2.5. G. = 3.85-4.15. Monoclinic. In thin platy crystals.

Formed as a sublimation product from mine fires.

*Yavapai County*.—United Verde mine, as silky crystals filling a small cavity above a burning ore body.

**BISMITE**

Bi<sub>2</sub>O<sub>3</sub>. Much so-called bismite is probably a bismuth hydroxide, and possibly the anhydrous oxide does not occur as a mineral. Straw-yellow. Pulverulent, earthy.

Secondary from oxidation of bismuth minerals, with which it is commonly associated.

*Yavapai County*.—Bradshaw Mountains, alteration product of bismuthinite at the Swallow mine, Castle Creek district. Eureka district, Bagdad mine.

*Yuma County*.—A low-grade deposit in quartz is reported from north of Vicksburg.

**TUNGSTITE**

WO<sub>3</sub>. Yellowish or yellowish green. Pulverulent or earthy.

Of secondary origin, formed probably by the alteration of primary tungsten minerals, such as wolframite, with which it is generally associated. Occurs as small amounts in most of the tungsten districts of Arizona.

## CERVANTITE

$Sb_2O_3$ . Yellow to white. Luster dull. Opaque.  $H. = 4.5$ .  $G. = 4$ . Orthorhombic. In acicular crystals; pulverulent or massive. Pure mineral 64.8% Sb.

A secondary mineral, most commonly formed from alteration of stibnite. Generally associated with stibnite and stibiconite.

*Yuma County*.—Dome Rock Mountains, as radiating blades partially altered to cervantite and stibiconite, in veins.

## STIBICONITE

$H_2Sb_2O_5$ . Pale yellow to yellowish white, grayish.  $H. = 4-5.5$ .  $G. = 5.1-5.28$ . Mostly amorphous. Pure mineral 74.9% Sb.

Commonly accompanies cervantite as an alteration product of stibnite or other antimony minerals.

*Yuma County*.—Dome Rock Mountains, as radiating blades of stibnite partially altered to cervantite and stibiconite, in veins.

## CUPRITE

$Cu_2O$ . Generally dark red to ruby-red, less commonly other shades. Luster adamantine to submetallic to earthy. Transparent to opaque. Streak some shade of red or brownish red.  $H. = 3.5-4$ .  $G. = 5.85-6.5$ . Isometric-plagiohedral. Crystals octahedrons, cubes, and dodecahedrons. Slender capillary crystals are known as *chalcotrichite*. Commonly massive or compact, earthy. Pure mineral 88.8% Cu.

In many oxidized copper deposits of the state. Commonly associated with malachite, tenorite, limonite, and native copper.

*Cochise County*.—Bisbee district, an important constituent of the ores. In the Copper Queen mine, mostly as earthy material mixed with limonite, also as crystals and chalcotrichite. At the Calumet and Arizona, as large crystalline masses associated with native copper, and in beautiful druses of ruby-red crystals, mostly simple cubes. Tombstone district, as bright red cubic crystals with connellite, brochantite, and malachite lining small cavities in the Toughnut mine. Dragoon Mountains, Courtland-Gleeson district, as aggregates of octahedral crystals.

*Gila County*.—Globe district, as massive material and chalcotrichite at the Continental and Buffalo mines, and as large dull octahedra at the Old Dominion mine. Mixed with limonite, it probably made up much of the high-grade "brown copper ore" of the Old Dominion and other mines of the district. Dripping Spring Mountains, "79" mine, Banner district.

*Greenlee County*.—Clifton-Morenci district, at the upper limit of the chalcocite zone, as cubic crystals and as chalcotrichite.

*Pima County*.—Santa Rita Mountains, at Rosemont, as crystal aggregates lining cavities. Silver Bell Mountains, as chalcotrichite and cubic crystals in small fractures. Tucson Mountains, disseminated in porphyry over a considerable area on the Saginaw and Arizona Tucson properties, Amole district.

*Pinal County*.—Ray district, as sparkling ruby-red aggregates of chalcotrichite in one of the stopes worked from the old Ray shaft.

*Santa Cruz County*.—Patagonia Mountains, Westinghouse property, Patagonia district. Oro Blanco Mountains, Montana mine, as fine bright crystals in vugs.

*Yavapai County*.—Black Hills, locally abundant and accompanied by native copper at the United Verde Extension mine, commonly as beautiful druses of crystallized material and as chalcotrichite.

## MASSICOT

$PbO$ . Yellow to reddish. Orthorhombic. Massive, scaly, or earthy.

An uncommon mineral of secondary origin, formed from alteration of other lead minerals.

*Gila County.*—Payson district, Silver Butte mine, as an earthy yellow powder associated with anglesite and galena.

*Maricopa County.*—Bighorn Mountains, Potter and Cramer group.

*Santa Cruz County.*—Patagonia Mountains, Flux mine, with cerussite.

*Yuma County.*—Trigo Mountains, Silver district, as earthy powder associated with cerussite and smithsonite.

#### TENORITE

CuO. Color and streak black. Luster metallic to earthy. Opaque. H. = 3-4. G. = 6.5. Triclinic. In minute black scales. Most common as black earthy material known as *melanconite*. Also in compact masses. Black, pitchy material from the Calumet and Arizona mine described as *melanochalcite* has been shown to be a variable mixture of tenorite, chrysocolla, and malachite.

Common in most of the oxidized copper deposits of the state. Generally associated with malachite, chrysocolla, cuprite, and limonite.

*Cochise County.*—Bisbee district, as earthy material mixed with manganese oxide. In 1904 a botryoidal growth of tenorite and wad was being deposited on the walls of a large natural cavern in limestone in the Calumet and Arizona mine. Dragoon Mountains, Maid of Sunshine, and other mines of the Courtland-Gleeson district.

*Gila County.*—Globe district, sparingly in oxidized ore. Miami district, Van Dyke mine, with chrysocolla.

*Greenlee County.*—Clifton-Morenci district, generally referred to as "copper pitch ore."

*Mohave County.*—With chrysocolla at the Emerald Isle mine, Kingman.

*Pima County.*—Santa Rita Mountains, Rosemont.

*Pinal County.*—Mammoth mine, as coal-black nodules surrounded by thin shells of chrysocolla.

*Santa Cruz County.*—Patagonia Mountains, Meadow Valley, Sunnyside, and Blue Eagle mines.

#### PARAMELACONITE

Essentially CuO. Black pyramidal crystals referred to the tetragonal system.

*Cochise County.*—Bisbee district, Copper Queen mine.

#### CORUNDUM

Al<sub>2</sub>O<sub>3</sub>. Blue, red, brown, gray, to nearly white. Luster adamantine to vitreous. Transparent to translucent. Streak uncolored. H. = 9. G. = 3.95-4.1. Rhombohedral. Crystals generally rough and rounded. Perfect basal and rhombohedral parting. Commonly massive.

An accessory mineral in metamorphic rocks, such as granular limestone, gneiss, and schist; an original constituent of some igneous rocks; or in placers.

Some igneous rocks in the state contain corundum, but the mineral is rare, and the gem varieties, ruby and sapphire, have not been reported.

#### HEMATITE

Fe<sub>2</sub>O<sub>3</sub>. Red, reddish brown, black. Luster splendent, metallic, to dull or earthy. Opaque. Streak bright red to reddish brown. H. = 5.5-6.5. G. = 4.9-5.3. Rhombohedral. Crystals tabular, in parallel groups or rosettes. Granular, earthy or compact massive, with botryoidal, stalactitic or lamellar structure. *Red ocher* is soft and earthy, *specularite* is brilliant crystalline material, *turgite* contains adsorbed water. Pure mineral 70% Fe.

One of the most abundant iron minerals. As the chief iron ore, in beds and irregular masses resulting from weathering. In smaller amounts commonly mixed with other iron compounds in the earthy material known as "limonite," which forms the gossan or capping of many sulfide ores. Also in deep-seated veins; widely distributed as an accessory in igneous and sedimentary rocks; formed by contact metamorphism.

No Arizona deposits of hematite are being worked for iron ore, but several are potential. Only a few characteristic occurrences can be listed.

*Coconino County.*—On the McBride claims, 17 miles south of Seligman, large deposits of earthy material form irregular lenses in limestone near the contact with diorite. Partial analysis as follows:

Fe	CaO	SiO <sub>2</sub>
61.0	4.5	2.0

*Gila County.*—Sierra Ancha Mountains, Canyon Creek, as a large deposit of cherty hematite, estimated at 10,000,000 tons, ranging from soft, pulverulent, bright red material to hard dark blue oxide.

*Yavapai County.*—A high concentration of hematite and magnetite exists in schist near Townsend Butte and the Howard Copper property. Extensive deposits are reported near Camp Wood.

*Yuma County.*—Buckskin Mountains, Planet mine, as extensive deposits with carbonate and silicate copper ores in a contact zone between limestone and diorite.

#### ILMENITE

FeTiO<sub>3</sub>. Iron-black. Luster metallic. Opaque. Streak black to brownish red. H. = 5-6. G. = 4.5-5. Influences the magnetic needle slightly. Tri-rhombohedral. In thin plates, massive, compact, or as imbedded grains.

A common accessory mineral in igneous rocks, especially gabbro and diorite. Less commonly as veins or large segregated masses near borders of the igneous rock.

*Gila and Pinal counties.*—A minor constituent of the Pinal schist.

*Yavapai County.*—Eureka district, with magnetite, as dikes and irregular bodies in gabbro. Bradshaw Mountains, in granite pegmatite near Cleator.

#### SPINEL

MgAl<sub>2</sub>O<sub>4</sub>. Various shades of red, blue, green, yellow, brown, and black. Luster vitreous to dull. Transparent to opaque. Streak white. H. = 8. G. = 3.5-4.1. Isometric. Crystals octahedral. Imperfect octahedral cleavage. *Picotite*, or *chrome spinel* is a variety between spinel proper and chromite.

An accessory mineral in many basic rocks, especially peridotites; as a metamorphic mineral in granular limestone and dolomite or their contact zones; in gneiss and schist; and in placer gravels, in places with corundum.

*Gila County.*—Large crystals of spinel, possibly picotite, in volcanic bombs of olivine near Peridot.

#### MAGNETITE

Fe<sub>3</sub>O<sub>4</sub>. Iron-black. Luster metallic and splendent to submetallic and dull. Opaque. Streak black. H. = 5.5-6.5. G. = 5.17-5.18. Strongly magnetic. Isometric. Octahedral crystals common. Also granular massive. *Lodestone* attracts particles of iron. Pure mineral 72.4% Fe.

An accessory mineral of many igneous rocks; in basic types may occur in large masses. Abundant in metamorphic rocks. The main constituent of black sands. No deposits of value as iron ore are known in the state, but some have been used as flux in smelting copper ores. Only a few characteristic occurrences can be listed.

*Coconino County.*—Grand Canyon, as octahedral crystals up to an inch in diameter in pegmatites.

*Gila County.*—Dripping Spring Mountains, Christmas mine, with a variety of contact silicates and sulfides. As large crystals in volcanic bombs of olivine from near Peridot.

*Greenlee County.*—Clifton-Morenci district, abundant in metamorphosed limestone, with garnet, amphibole, pyroxene, and sulfides. Mined as flux at the Manganese Blue and Arizona Central mines.

*Pima County.*—Santa Rita Mountains, abundant in contact-metamorphic copper ores at Rosemont camp. Sierrita Mountains, in contact ore bodies, Twin Buttes area.

*Yavapai County.*—Eureka district, as titaniferous magnetite in dikes and irregular bodies in gabbro. Partial analysis as follows:

Fe	Ti	Mn
60.35	8.40	Trace

Bradshaw Mountains, with hematite in schist near Townsend Butte and the Howard Copper property; as large crystals with apatite and sphene in granodiorite at the Springfield group, Pine Grove district. As large pieces of lodestone near Stoddard.

*Yuma County.*—Harcuvar Mountains, Yuma Copper property, with actinolite replacing limestone. Dome Rock Mountains, as crystals and masses of magnetite in wall rocks of the cinnabar veins.

## CHROMITE

$\text{FeCr}_2\text{O}_4$ . Iron-black to brownish black. Luster metallic to submetallic. Opaque. Streak brown. H. = 5.5. G. = 4.1-4.9. Isometric. Octahedral crystals. Commonly granular to compact massive. Pure mineral 68%  $\text{Cr}_2\text{O}_3$ .

As veins or masses in peridotite or in serpentine and formed by segregation. Generally associated with magnetite and ilmenite.

*Yuma County.*—Trigo Mountains, Eureka district, as disseminated grains and small masses with mariposite in mica schist.

## HETAEROLITE

$\text{ZnMn}_2\text{O}_4$ . Black. Opaque. Streak brownish black. H. = 6. G. = 4.85. Tetragonal. Crystals of octahedral habit. Perfect basal cleavage.

Rare, in small quantities with manganese oxides.

*Cochise County.*—Tombstone district, as tiny veinlets in manganite.

## CORONADITE

Probably  $\text{Mn}_2\text{PbO}_5$ . Galena-white. Opaque. Streak brownish black. H. = 4-5. G. = 5.5. Granular to fibrous.

A rare secondary mineral described from only two localities in the world. *Greenlee County.*—First described from Clifton-Morenci (6:05), as fairly large amounts at the west end of the Coronado vein. Analysis by W. F. Hillebrand as follows:

$\text{MnO}_2$	MnO	PbO	FeO	ZnO	CuO	$\text{H}_2\text{O}$	Total
56.68	6.11	25.96	.91	.10	.05	1.03	100.84

## MINIUM

$\text{Pb}_3\text{O}_4$ . Vivid red, mixed with yellow. Streak orange-yellow. H. = 2-3. G. = 4.6. Pulverulent or as crystalline scales.

Secondary, chiefly derived by alteration of galena or cerussite. Uncommon in large quantities.

*Maricopa County.*—Bighorn Mountains, Potter and Kramer group.

*Mohave County.*—Black Mountains, as pulverulent material in cavities in the Big Jim vein, Oatman district.

*Santa Cruz County.*—Patagonia Mountains, Flux mine, with cerussite.

*Yuma County.*—Castle Dome Mountains, Castle Dome district, with cerussite.

## DELAFOSSITE

$\text{CuFeO}_2$ . Color and streak black. H. = 5.5. Rhombohedral. In tabular or equidimensional crystals.

A rare mineral of secondary origin, occurring in a few oxidized copper deposits in the world.

*Cochise County.*—Bisbee district, Southwest mine, as small crystals and crystal aggregates at the lower zone of oxidation. Analysis by G. S. Bohart as follows:

Cu	Fe	O	Insol.	Total
41.24	37.22	21.79	0.25	100.00

## RUTILE

$\text{TiO}_2$ . Red, reddish brown, black. Luster metallic-adamantine. Transparent to opaque. Streak pale brown. H. = 6-6.5. G. = 4.18-5.2. Tetragonal. Crystals prismatic, commonly in complexly twinned groups. Distinct pinacoidal and prismatic cleavage. Also massive. Pure mineral 60% Ti.

Widespread in igneous rocks, gneiss, and mica schist. Less commonly in granular limestone or dolomite. May occur as an alteration of mica. Probably more abundant in the state than the following brief list of localities would indicate.

*Cochise County.*—An accessory in granite northwest of Bisbee.

*Gila and Pinal counties.*—An accessory in Madera diorite and Pinal schist.

*Santa Cruz County.*—Patagonia Mountains, as slender crystals in outcrops of the Santo Nino and Washington Camp areas.

*Yavapai County.*—Black Hills, as well-developed crystals at the United Verde mine. Bradshaw Mountains, with tourmaline in the gangue of the Howard Copper property, Black Canyon district.

#### ANATASE—Octahedrite

TiO<sub>2</sub>. Various shades of brown, indigo-blue, black. Greenish yellow by transmitted light. Luster adamantine to metallic. Transparent to opaque. Streak uncolored. H. = 5.5-6. G. = 3.82-3.95. Tetragonal. Crystals either octahedral or tabular. Perfect basal and pyramidal cleavage.

A rare mineral, generally derived from alteration of other titanium minerals. In granitic rocks or schist, associated with quartz, adularia, titanite, rutile, or brookite.

*Graham County.*—Stanley district, Friend mine.

#### PYROLUSITE

MnO<sub>2</sub>. Commonly contains a little water. Black. Luster metallic to dull. Opaque. Streak black and sooty. H. = 2-2.5. Soils the fingers. G. = 4.73-4.86. Tetragonal, but commonly pseudomorphous after manganite. Crystals are known as *pollanite*. In granular, fibrous, or columnar masses, or as dendritic or reniform coatings. Pure mineral 63.2% Mn.

Secondary, formed by dehydration of manganite or psilomelane, with which it is generally associated. Commonly in small quantities in many oxidized ore deposits and in places contains sufficient silver to be mined for that metal. Widely distributed in small amount throughout the state, and only the more important localities are listed.

*Cochise County.*—Tombstone district, in commercial quantities in the Oregon-Prompter, Lucky Cuss, Telephone, and Bunker Hill mines.

*Greenlee County.*—Clifton-Morenci district, in black, sooty masses, mixed with iron oxides in metamorphosed limestone.

*Maricopa County.*—Big Horn Mountains, Aguila district, with manganite or psilomelane.

*Mohave County.*—Artillery Mountains, as large deposits, with psilomelane. Also reported 4 miles south of Boulder Dam, in veins. Little Chemehuevis Valley, in veins and shear zones, Arizona Manganese claims, with psilomelane. Near Colorado River, 18 miles north of Parker Dam.

*Pinal County.*—Superior district, in the outcrop of the Magma vein and in silver deposits.

*Santa Cruz County.*—Patagonia Mountains, Mowry mine, with psilomelane. Also in the Hardshell, North Mowry, Hermosa, and Black Eagle mines.

*Yavapai County.*—In the northern part of the Aguila district. On Castle Creek, 23 miles northeast of Morristown.

*Yuma County.*—Dobbins claims, 6 miles east of Bouse, and a locality 2½ miles west of Bouse. Deposits are reported from section 36, T. 10 N., R. 14 W.

#### GOETHITE

FeO(OH). Brown to yellow. Luster imperfect adamantine to dull. Opaque. Streak brownish yellow to ochre-yellow. H. = 5-5.5. G. = 4.28. Orthorhombic. Crystals prismatic or flattened. Perfect pinacoidal cleavage. Most characteristically with concentric or radiated fibrous structure or as earthy masses. Pure mineral 62.9% Fe.

Most commonly the dominant constituent of the impure mixture known as "limonite," the most abundant oxidation product of other iron minerals. Reported as pure material from only one locality in the state.

*Cochise County*.—Bisbee district, as thick botryoidal crusts with fibrous structure, Shattuck mine.

## MANGANITE

MnO(OH). Dark steel-gray to iron-black. Luster metallic. Opaque. Streak reddish brown to nearly black. H. = 4. G. = 4.2-4.4. Orthorhombic. Crystals commonly prismatic and deeply striated vertically. Perfect pinacoidal and prismatic cleavage. Also columnar or stalactitic. Pure mineral 62.4% Mn.

Commonly with other manganese oxides in deposits of secondary origin. Also in veins.

*Cochise County*.—Tombstone district, as needlelike crystals in parallel groups and as soft fibers lining cavities.

*Gila County*.—Globe district, as needlelike crystals with earthy psilomelane.

*Maricopa County*.—Big Horn Mountains, Aguila district, with pyrolusite and psilomelane.

*Santa Cruz County*.—Patagonia Mountains, Mowry mine.

*Yavapai County*.—Castle Creek. With pyrolusite and psilomelane in the northern part of the Aguila district.

*Yuma County*.—Planet district.

## LIMONITE—Brown Iron Ore

A mixture of ferric iron minerals, principally goethite and hematite. Yellow, brown, black. Luster submetallic to dull. Streak yellowish brown. In compact, botryoidal, or earthy masses. *Brown ocher* or *yellow ocher* is soft and earthy. Percentages of Fe vary widely.

Of secondary origin, the commonest alteration product of other iron minerals. Abundant in the gossan or capping of most sulfide ore deposits. Also deposited by ground waters in bogs or marshes, forming low-grade iron ores.

No commercial deposits of limonite are known in the state. It is so widely distributed in small quantities throughout the mining districts that occurrences need not be listed.

## PSILOMELANE

Chiefly MnO<sub>2</sub>, with various adsorbed impurities, principally barium and water. Color iron-black to dark gray. Luster submetallic, dull. Opaque. Streak very dark brown to black. H. = 5-7. Prominent conchoidal fracture. G. = 3.3-4.7. Orthorhombic. As compact botryoidal masses or as earthy material known as *wad*. Pure mineral 64.5% Mn.

The commonest manganese mineral. Of secondary origin, generally associated with pyrolusite, manganite, or limonite.

*Cochise County*.—Bisbee district, as bodies of considerable size. Tombstone district, in veins and replacements, and containing silver.

*Coconino County*.—Long Valley region, as nodules and masses in Kaibab formation, Iron Mine Canyon.

*Gila County*.—Globe district, as wad along faults.

*Graham County*.—Reported at Aravaipa, replacing a fibrous mineral.

*Greenlee County*.—Ash Peak district, in shear zones with pyrolusite.

*Maricopa County*.—Big Horn Mountains, Aguila district, with manganite and pyrolusite.

*Mohave County*.—Artillery Mountains, in extensive bedded deposits. Little Chemehuevis Valley. Topock district.

*Pinal County*.—Superior district, abundant in fractures and fault planes. Globe district, in surface gash veins, Old Dominion mine. Black Hills. Camp Grant Wash, Tarr and Harper mine. Florence district, Chamberlain mine. Galiuro Mountains, Blue Bird mine, Copper Creek district. Mammoth mine, as botryoidal masses.

*Santa Cruz County*.—Santa Rita Mountains, Rosario group. Patagonia Mountains, Mowry, La Plata, Hermosa, Jarrilla, and Isabella mines.

*Yavapai County*.—Castle Creek district, 23 miles northeast of Morristown. Near Mayer.

*Yuma County*.—Granite Wash Hills, 6 miles east of Bouse. Also 33 miles west of Congress Junction.

CARBONATES, NITRATES, BORATES

Calcite	$\text{CaCO}_3$	Malachite	$\text{Cu}_2\text{CO}_3(\text{OH})_2$
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	Azurite	$\text{Cu}_3(\text{CO}_3)_2(\text{OH})_2$
Ankerite	$\text{Ca}(\text{Mg,Fe,Mn})(\text{CO}_3)_2$	Rosasite	$(\text{Cu,Zn})_2\text{CO}_3(\text{OH})_2$
Magnesite	$\text{MgCO}_3$	Aurichalcite	$(\text{Zn,Cu})_5(\text{CO}_3)_2(\text{OH})_4$
Siderite	$\text{FeCO}_3$	Hydrozincite	$\text{Zn}_5(\text{CO}_3)_2(\text{OH})_6$
Rhodochrosite	$\text{MnCO}_3$	Bismutite	$\text{Bi}_2\text{O}_3\cdot\text{CO}_2\cdot\text{H}_2\text{O} (?)$
Smithsonite	$\text{ZnCO}_3$	Nitratine	$\text{NaNO}_3$
Aragonite	$\text{CaCO}_3$	Niter	$\text{KNO}_3$
Witherite	$\text{BaCO}_3$	Nitrocalcite	$\text{Ca}(\text{NO}_3)_2\cdot n\text{H}_2\text{O}$
Cerussite	$\text{PbCO}_3$	Gerhardtite	$\text{Cu}_2\text{NO}_3(\text{OH})$
Phosgenite	$(\text{Pb,Cl})_2\text{CO}_3$	Colemanite	$\text{Ca}_2\text{B}_6\text{O}_{11}\cdot 5\text{H}_2\text{O}$

CALCITE

$\text{CaCO}_3$ . White to colorless or pale shades of gray, red, green, blue, yellow; brown or black when impure. Luster vitreous to earthy. Transparent to opaque. Streak white or grayish. H. = 3. G. = 2.7. Rhombohedral. Perfect rhombohedral cleavage. Commonly in crystals of rhombohedral or scalenohedral habit. Also cleavable massive, granular, columnar, stalactitic, or chalky.

Most common as limestone and marble. Also a common vein mineral. Several varieties are based on color, structure, and impurities.

Ordinary calcite

Crystals and cleavable masses, so common that only a few typical occurrences are listed.

*Cochise County*.—Bisbee district, as masses of crystals in oxidized ore. Tombstone district, as coarsely crystalline aggregates along the flanks of the "roll deposits," and as snow-white linings of caverns in manganese ore bodies. Chiricahua Mountains, Crystal Cave, as crystal aggregates.

*Gila County*.—Globe district, Old Dominion mine, as fine groups of scalenohedral crystals in cavities in limestones.

*Mohave County*.—Grand Canyon, north side, as groups of white and amber scalenohedral crystals. Sand crystals, consisting of sand grains cemented by calcite crystals, occur in sediments of the Big Sandy Valley.

*Santa Cruz County*.—Santa Rita Mountains, as magnificent groups of scalenohedral crystals at Onyx Cave.

*Yavapai County*.—Bradshaw Mountains, as beautiful specimens of crystallized calcite, quartz, adularia, and ore minerals, Cash mine, Hassayampa district.

Limestone

By far the commonest variety, occurring in rock masses with either compact or granular structure. Widely distributed throughout the sedimentary rocks of the state, particularly those of the Paleozoic era. The most extensive limestone deposits in northern Arizona are the Redwall and Kaibab formations, in southern Arizona the Escabrosa, Naco, and Snyder Hill formations.

Marble

Coarsely crystalline limestone, generally formed by metamorphism of originally fine-grained or compact limestone. Widely distributed in the state, but only occurrences suitable for industrial use are listed.

*Cochise County*.—Chiricahua Mountains, as extensive deposits near Ft. Bowie in Immigrant Canyon and at the head of Whitetail Creek. Dragoon Mountains, a few miles southeast of Dragoon station, quarried to some extent.

*Gila County*.—Quarried 10 miles west of Globe, at the foot of Sleeping Beauty Mountain.

*Pima County*.—Santa Rita Mountains, quarried 6 miles north of Helvetia.

*Yuma County*.—Gila Mountains, very pure deposits south of Dome station.

**Stalactite, stalagmite**

Stalactites are cylinders or cones that hang from the roofs of limestone caverns and are formed by the evaporation of water charged with calcium carbonate. Stalagmites are of the same material covering the floors of caverns, in places rising in cones to meet the stalactites. Most *oriental alabaster*, *onyx marble*, and *Mexican onyx* is stalagmite.

*Cochise County*.—Stalactites were abundant in the oxidized zone of the Copper Queen mine, Bisbee, locally colored with salts of copper. A cavern 340 feet in diameter and 80 feet high, lined with stalactitic calcite, was discovered on the 300-foot level of the Shattuck mine in 1914.

*Pima County*.—Both stalactites and stalagmites abound in Colossal Cave, on the southern slope of the Rincon Mountains.

*Santa Cruz County*.—In Onyx Cave, Santa Rita Mountains.

**Travertine**

Compact calcareous material deposited by springs or streams, generally distinctly banded and variously colored. Also called *onyx marble* or *Mexican onyx*.

*Gila County*.—Natural Bridge, south of Pine.

*Coconino County*.—Havasupai Falls, south of the Grand Canyon. In Havasu Canyon similar deposits at Mooney, Bridal Veil, and other falls.

*Maricopa County*.—On Camp Creek, west of Cave Creek, a deposit of soft travertine contains boulders prevailing green and yellow with veins of brown and red.

*Mohave County*.—Abundant at the mouth of the Grand Canyon. Some miles to the west deposits up to 200 feet thick cap Greggs Breccia.

*Santa Cruz County*.—Santa Rita Mountains, at Cave Hill, Greaterville district, as brown material unusually free from cracks.

*Yavapai County*.—Bradshaw Mountains, Big Bug Creek, near Mayer, where deposits of banded material, colored by iron oxides, have yielded much decorative stone. A similar deposit is on Cave Creek. Another deposit is reported from the Eureka district.

**DOLOMITE**

$\text{CaMg}(\text{CO}_3)_2$ . White, reddish, greenish white, rose-red, green, brown, gray, and black. Luster vitreous to pearly. Transparent to subtranslucent to opaque.  $H. = 2.5-4$ .  $G. = 2.8-2.9$ . Tri-rhombohedral. Crystals of rhombohedral habit with curved faces. Perfect rhombohedral cleavage. Commonly coarse or fine granular massive, resembling crystalline limestone or marble.

Most common as a rock, like limestone in occurrence. Also as a vein mineral with metalliferous ores. Dolomites and dolomitic limestones are widely distributed in the state.

*Cochise County*.—Tombstone district, as massive beds interbedded with limestone and shale in the Naco formation.

*Coconino County*.—Analyses of the Kaibab limestone in the vicinity of Flagstaff show the formation there to be highly dolomitic. Analyses of Kaibab limestone from Grand Canyon:

	I	II
Silica.....	34.10	17.00
Iron and alumina.....	1.60	1.00
Calcium carbonate.....	33.81	48.20
Magnesium carbonate.....	26.43	34.40
	95.94	100.60

*Greenlee County*.—Clifton-Morenci district, as beds in the lowest part of the Modoc formation, and in the upper part of the Morenci shales. Sparingly in the Longfellow limestone.

*Pima County*.—Sierrita Mountains, San Xavier district, as coarsely crystallized material in fissures.

*Yavapai County*.—Black Hills, a fairly abundant gangue mineral at the United Verde mine. Bradshaw Mountains, at the Tillie Starbuck mine, Hassayampa district, as small rhombohedrons coating walls of cavities.

*Yuma County.*—Harquahala Mountains, as a bed several feet thick near the Bonanza mine.

## ANKERITE

$\text{Ca}(\text{Mg,Fe,Mn})(\text{CO}_3)_2$ . White, gray, reddish.  $H. = 3.5$ .  $G. = 2.95-3.1$ . Rhombohedral. Perfect rhombohedral cleavage. Most commonly cleavable massive, granular, or compact.

Probably rather widely distributed in metamorphosed limestones and metallic veins of the state, but reported only from those localities listed.

*Gila County.*—Payson district, with tetrahedrite, Silver Butte mine.

*Yavapai County.*—Black Hills, in pyritic ore of the United Verde mine. Bradshaw Mountains, Arizona-National mine, Big Bug district; Howard Copper and Kay Copper properties, Black Canyon district; M and M veins, Tiger district; Tillie Starbuck mine, Hassayampa district, as small rhombohedrons associated with dolomite in cavities.

## MAGNESITE

$\text{MgCO}_3$ . White, grayish white, yellowish, and brown. Luster vitreous.  $H. = 3.5-4.5$ .  $G. = 3.0-3.12$ . Rhombohedral. Generally compact massive; also granular to cleavable.

May be formed from alteration of rocks rich in magnesium or through action of magnesium-bearing waters upon calcite. As a minor constituent of limestones of dolomites, probably extensively distributed in Arizona.

*Greenlee County.*—Sparingly in beds of the Longfellow limestone.

## SIDERITE

$\text{FeCO}_3$ . Generally some shade of brown or gray. Luster vitreous to dull. Translucent to opaque. Streak white.  $H. = 3.5-4$ .  $G. = 3.83-3.88$ . Rhombohedral. Crystals rhombohedral, with curved faces. Perfect rhombohedral cleavage. Commonly cleavable or granular massive. Also in botryoidal and globular forms, compact or earthy. Pure mineral 48.2% Fe.

May be formed by action of organic matter upon iron carbonate solutions, by surface alteration of iron silicates, or by replacement of limestone.

*Cochise County.*—Bisbee district, boxwork siderite has proved a guide to ore.

*Gila County.*—Dripping Spring Mountains, with wulfenite and vanadinite, McHur prospect, Banner district.

*Mohave County.*—Cerbat Range, a common gangue mineral in the Chloride and Gold Basin districts.

*Pima County.*—Santa Rita Mountains, Iron Mask mine, Old Baldy district, with magnetite and tourmaline. Empire Mountains, Hilton mines.

*Yavapai County.*—Bradshaw Mountains, Lynx Creek, in veins with chlorite and tourmaline; Gold Note group, Turkey Creek district; Peck and Swastika mines, Peck district, with native silver and bromyrite.

*Yuma County.*—Dome Rock Mountains, in cinnabar veins with tourmaline. Harcuvar Mountains, as nearly jet-black cleavable material with chalcopyrite, Cunningham Pass.

## RHODOCHROSITE

$\text{MnCO}_3$ . Rose-red, gray, dark red, or brown; commonly coated with a black oxidation product. Luster vitreous to pearly. Translucent to opaque. Streak white.  $H. = 3.5-4.5$ .  $G. = 3.45-3.6$ . Rhombohedral. Crystals like dolomite in habit. Perfect rhombohedral cleavage. Cleavable to granular or compact massive.

In sedimentary deposits in origin similar to siderite. Also as gangue, particularly in veins of lead and silver, and generally associated with other manganese minerals.

*Cochise County.*—Tombstone, as small grains in oxidized alabandite ore from the Lucky Cuss mine.

*Gila County.*—Banner district, in the London Range shaft.

*Santa Cruz County.*—Patagonia Mountains, Trench mine, with alabandite, sphalerite, and galena.

## SMITHSONITE—Calamine

ZnCO<sub>3</sub>. White or some shade of gray, green, blue, or brown. Luster vitreous to dull and earthy. Subtransparent to opaque. H. = 5.5. G. = 4.3-4.45. Rhombohedral. Perfect rhombohedral cleavage. In curved and cavernous crusts or bands, and botryoidal or reniform masses, with granular or fibrous structure. Also as friable or earthy masses known as *dry bone*. Pure mineral 52% Zn.

Secondary, formed by action of carbonate waters upon zinc sulfide or by reaction between sulfate waters and limestone. Generally in the oxidized zone and commonly accompanied by the zinc silicate, hemimorphite. In places an important zinc ore.

*Cochise County*.—Tombstone district, as tiny rhombohedral crystals, Toughnut mine. Turquoise district, as incrustations and crystalline masses, Mystery and Silver Bill mines.

*Greenlee County*.—Shannon Mountain, Clifton-Morenci district.

*Pima County*.—Empire Mountains, Hilton mines. Sierrita Mountains, as dry bone, San Xavier district. Silver Bell district, as earthy mixtures of smithsonite and cerussite.

*Pinal County*.—Mammoth mine, as crusts and porous masses.

*Santa Cruz County*.—Patagonia Mountains, Westinghouse property, Duquesne, with cerussite, anglesite, chrysocolla, and cuprite.

*Yuma County*.—Trigo Mountains, with cerussite and yellow lead oxide in cellular to crystalline masses.

## ARAGONITE

CaCO<sub>3</sub>. White, gray, yellow, green, and violet. Luster vitreous. Transparent to translucent. Streak white. H. = 3.5-4. G. = 2.93-2.95. Orthorhombic. Crystals generally acicular. Distinct pinacoidal and prismatic cleavages. In columnar or fibrous masses, or as stalactitic, globular, or coralloidal forms. *Flos ferri* is a coralloidal variety, in groupings of delicate interlacing stems.

Less common than calcite, formed from springs and from saline solutions that contain sulfate, thus occurring in beds of gypsum. Also in cavities in lavas and in limestone caverns.

*Cochise County*.—At Bisbee, as magnificent coralloidal groups of flos ferri in limestone caverns. Dragoon Mountains, as stalactites and stalagmites lining solution cavities in silver-lead deposits, Turquoise district.

*Pima County*.—Empire Mountains, as large fibrous and stalactitic masses, Hiltano district. Santa Rita Mountains, as flos ferri in Onyx cave. Sierrita Mountains, in fissures of the San Xavier district, commonly stained by copper.

## WITHERITE

BaCO<sub>3</sub>. White, yellowish, grayish. Luster vitreous to dull. Streak white. Subtransparent to translucent. H. = 3-3.75. G. = 4.27-4.35. Orthorhombic. Distinct pinacoidal cleavage. Massive, columnar, or granular. Pure mineral 77.7% BaO.

Of infrequent occurrence, most commonly in veins with galena. May be formed by direct crystallization from solutions carrying barium carbonate or by action of carbonated waters upon other barium minerals.

*Yuma County*.—Castle Dome Mountains, as gangue in lead ores, Castle Dome district.

## CERUSSITE

PbCO<sub>3</sub>. White to gray. Luster adamantine, vitreous, resinous, silky, or pearly. Transparent to subtranslucent. Streak uncolored. H. = 3-3.5. G. = 6.46-6.574. Orthorhombic. Commonly as tabular, less commonly as prismatic or pyramidal crystals. Distinct prismatic cleavage. Massive or granular, rarely fibrous. Pure mineral 77.5% Pb.

A common secondary mineral of oxidized lead deposits, formed by reaction between carbonated waters and lead minerals or solutions. Generally as a concentric layer about anglesite which surrounds a core of unaltered galena.

*Cochise County*.—At Tombstone, the most common lead mineral of the district. Bisbee district, in Hendricks Gulch, as impure "sand carbonate" bunches in limestone, near a fault fissure. Chiricahua Mountains, as large

twinned crystals, Hilltop mine. The principal lead mineral of the Turquoise district.

*Gila County.*—The ore mineral at the London-Arizona mine, Banner district. "79" mine, as "sand carbonate" and as beautifully crystallized material with anglesite, wulfenite, and vanadinite.

*Graham County.*—Aravaipa and Stanley districts.

*Greenlee County.*—Clifton-Morenci district, Hormeyer mine, with gold ore.

*Mohave County.*—Cerbat Range, Chloride, Mineral Park, and Gold Basin districts, in some properties associated with free gold; Tennessee-Schuylkill mine, Wallapai district. McCracken Mountain, McCracken mine.

*Pima County.*—Santa Rita Mountains, Golden Gate and Blue Jay mines, Helvetia district; Greaterville district. Empire Mountains, Total Wreck and Hilton mines. Sierrita Mountains, San Xavier district, as "sand carbonate"; Paymaster mine, Olive camp, as massive and crystallized material. Silver Bell Mountains, in silky crystals and as earthy mixtures with smithsonite, El Tiro and other mines. Quijotoa Mountains, Morgan mine, with cerargyrite.

*Pinal County.*—Mammoth mine, as magnificent twinned and reticulated crystal aggregates, Collins vein. A single crystal in the collection of the U.S. National Museum at Washington exhibits the following forms: (001), (010), (100), (110), (130), (012), (023), (011), (032), (021), (031), (041), (051), (102), (302), (111), (112), (211). Galiuro Mountains, Blue Bird and other lead deposits, Copper Creek district; Saddle Mountain group, Saddle Mountain district.

*Santa Cruz County.*—Santa Rita Mountains, Victor, Ivanhoe, and Rosario properties, Tyndall district; American Boy mine, Wrightson district. Patagonia Mountains, Flux and Domino mines as splendid crystals and as massive material at several other properties.

*Yavapai County.*—Black Hills, Copper Chief mine, Verde district. Bradshaw Mountains, Silver Belt mine, with cerargyrite in ancient workings.

*Yuma County.*—Trigo Mountains, Red Cloud mine, as crystal specimens up to 1½ inches long. Many of the crystals were arrow-shaped twins.

#### PHOSGENITE

(Pb,Cl)<sub>2</sub>CO<sub>3</sub>. White, gray, yellow. Luster adamantine. Transparent to translucent. Streak white. H. = 2.75-3. G. = 6-6.3. Tetragonal. In prismatic crystals with basal cleavage.

A rare secondary mineral, generally with cerussite in oxidized lead deposits.

*Pinal County.*—Mammoth mine, as slender prismatic crystals with diableite, 400-foot level, Collins vein.

#### MALACHITE

Cu<sub>2</sub>CO<sub>3</sub>(OH)<sub>2</sub>. Color and streak green. Luster adamantine to earthy. Translucent to opaque. H. = 3.5-4. G. = 3.9-4.03. Monoclinic. Distinct crystals rare. Perfect basal, less perfect clinopinacoidal cleavage. Most commonly massive or incrusting, with botryoidal surface and a banded, divergent, or fibrous structure. Pure mineral 57.5% Cu.

A common alteration product in oxidized copper deposits. Generally associated with other secondary copper minerals, particularly azurite, cuprite, and tenorite. Only the more important occurrences are listed.

*Cochise County.*—Bisbee district, as magnificent specimens from the Copper Queen mine, one of the outstanding American localities, commonly as geodes lined with velvety crystals. Courtland-Gleeson district, in large masses at the Maid of Sunshine mine, in some places as small but superb crystals.

*Coconino County.*—Kaibab Plateau, impregnated in chert beds of wide extent.

*Gila County.*—Globe district, a considerable part of the ore of the Buffalo, Big Johnny, Buckeye, and other mines, but nowhere in large masses. Miami

district, Inspiration mine, with malachite, chrysocolla, chalcedony, and quartz aggregates of great beauty. Payson district, as stout prismatic crystals in porous quartz, Silver Butte mine.

*Greenlee County.*—Clifton-Morenci district, one of the most common oxidized ores in the limestone deposits, intimately associated with kaolin, limonite, azurite, and brochantite. Fine radiating groups of crystals were obtained from the Standard mine, near Metcalf.

*Navajo County.*—White Mesa district, as irregular masses in beds of sandstone.

*Pima County.*—Santa Rita Mountains, as globular masses and veinlets, Rosemont camp. Sierrita Mountains, abundant in the San Xavier district, and the most important oxidized mineral at Mineral Hill.

*Yavapai County.*—Black Hills, as fine specimen material with crystallized azurite, Yaeger mine.

*Yuma County.*—Buckskin Mountains, Planet mine.

## AZURITE

$\text{Cu}_3(\text{CO}_3)_2(\text{OH})_2$ . Azure-blue to Berlin-blue. Luster vitreous to silky. Transparent to subtranslucent. Streak blue.  $H. = 3.5-4$ ,  $G. = 3.77-3.89$ . Monoclinic. Characteristically in aggregates of small crystals. Two perfect cleavages. Also massive or dull and earthy. Pure mineral 55.3% Cu.

Of secondary origin, formed by action of carbonated waters upon copper minerals or of copper solutions upon limestone. Commonly found in oxidized copper ores, associated with malachite, limonite, cuprite, and native copper.

*Cochise County.*—Bisbee district, as magnificent crystal specimens at the Copper Queen mine, one of the outstanding American localities. Courtland-Gleeson district, in small amount and as large crystallized masses.

*Coconino County.*—Kaibab Plateau, as an extensive impregnation in chert beds.

*Gila County.*—Payson district, as crystallized masses at the Silver Butte, Golden Wonder, and Bishops Knoll mines.

*Greenlee County.*—Clifton-Morenci district, as large bodies in the Long-fellow, Detroit, Manganese Blue, and Shannon mines. Sheaflike and spherical masses, up to 40 pounds in weight, were found in cavities or in kaolinized shale.

*Pima County.*—Sierrita Mountains, common in the San Xavier district. Santa Rita Mountains, as fine crystallized specimens from the Copper Mountain prospect of the Anaconda group.

*Pinal County.*—Superior District, as small but beautifully crystallized groups in the open cut at the Silver King mine.

*Yavapai County.*—Black Hills, as fine specimen material from the Yaeger mine, Black Hills district.

## ROSASITE

$(\text{Cu,Zn})_2\text{CO}_3(\text{OH})_2$ . Bright green to sky-blue. In mammillary spherules which break up into rectangular plates.

A rare mineral, in composition near the commoner aurichalcite.

*Cochise County.*—Tombstone district, as bright green mammillary spherules in siliceous lining of vugs and between hemimorphite crystals, Toughnut and Empire mines.

## AURICHALCITE

$(\text{Zn,Cu})_2(\text{CO}_3)_2(\text{OH})_6$ . Pale green to sky-blue. Luster pearly. Translucent.  $G. = 3.64$ . Monoclinic. One perfect cleavage. As drusy incrustations or as fibrous seams.

A secondary mineral of oxidized copper and zinc ores.

*Cochise County.*—Tombstone district, as plumose aggregates of pale blue crystals on the west side of the Quarry "roll." Bisbee district, in upper portions of the Copper Queen ore body. Turquoise district, as incrustations and drusy linings of cavities in oxidized lead-silver deposits.

*Pima County*.—Empire Mountains, as small radiating fibrous masses and seams with smithsonite and hemimorphite, Lone Mountain mine. Sierrita Mountains, in fissures in garnetized limestone, San Xavier district.

#### HYDROZINCITE

$Zn_5(CO_3)_2(OH)_6$ . White, grayish, or yellowish.  $H. = 2-2.5$ .  $G. = 3.58-3.8$ . Monoclinic. Crystals minute, thin blades. Massive, fibrous, earthy, or compact, commonly as incrustations.

A secondary mineral formed from alteration of sphalerite. Generally associated with smithsonite but less common.

*Cochise County*.—Tombstone district, in a small seam with aurichalcite and hemimorphite on the west side of the Quarry "roll."

*Yuma County*.—Castle Dome Mountains, with gypsum in fissures, Senora claims.

#### BISMUTITE

Perhaps  $Bi_2O_3 \cdot CO_2 \cdot H_2O$ . White, green, yellow, and gray. Luster vitreous to dull.  $H. = 4$ .  $G. = 7$ . As incrustations and earthy or compact masses.

Of secondary origin, generally formed by alteration of bismuthinite or native bismuth, but probably may form from any bismuth mineral.

*Mohave County*.—Hualpai Mountains, east of Yucca.

*Yavapai County*.—Eureka district, in prospects near the Badad mine, with bismuthinite.

#### NITRATINE—Soda Niter

$NaNO_3$ . White, reddish brown, gray, and lemon-yellow. Luster vitreous. Transparent.  $H. = 1.5-2$ .  $G. = 2.24-2.29$ . Taste cooling. Rhombohedral. Perfect rhombohedral cleavage. Massive, as incrustations, or in beds.

The main source of commercial nitrates. Formed by evaporation of ground waters in arid climate, deposits commonly beds.

*Mohave County*.—Artillery Mountains, reported 3 miles south of Artillery Peak.

#### NITER—Saltpeter

$KNO_3$ . Colorless to white. Luster vitreous. Transparent.  $H. = 2$ .  $G. = 2.1$ . Orthorhombic. Perfect prismatic, distinct pinacoidal cleavage. In thin crusts and silky tufts.

A product of evaporation or formed from guano or by action of bacteria upon other animal remains. In some caves or old mine workings, generally in such small amount as to escape observation.

*Coconino County*.—Walnut Canyon, as a thin white covering on limestone shelves in ancient cliff dwellings.

*Pinal County*.—Galiuro Mountains, Aravaipa Canyon, as thin crusts and in cracks below caves.

*Graham County*.—Peloncillo Mountains, associated with caves.

#### NITROCALCITE

$Ca(NO_3)_2 \cdot nH_2O$ . Colorless to white. One perfect cleavage. In efflorescent silky tufts and masses.

Generally in limestone caverns, probably formed from calcium carbonate and guano or other animal remains.

*Gila and Pinal counties*.—In fissures up to 6 or 8 inches wide in Mississippian limestone along the Gila River 2 miles above Winkelman.

#### GERHARDTITE

$Cu_2NO_3(OH)$ . Emerald-green.  $H. = 2$ .  $G. = 3.43$ . Orthorhombic. Two perfect cleavages. As pyramidal orthorhombic crystals and in mammillary coatings.

A secondary mineral formed in small amount in oxidized copper deposits under arid or semiarid conditions. Accompanies such minerals as atacamite, bronchantite, and copper carbonates.

*Greenlee County*.—On cliffs of granite porphyry in Chase Creek Canyon, as a bright green coating of small, roughly mammillary forms.

*Yavapai County*.—United Verde mine, as small crystals along fractures in massive cuprite. Analyzed by R. C. Wells as follows:

H <sub>2</sub> O	CuO	N <sub>2</sub> O <sub>5</sub>	Total
11.49	66.26	22.25	100.00

## COLEMANITE

Ca<sub>2</sub>B<sub>6</sub>O<sub>11</sub>.5H<sub>2</sub>O. Colorless to milky white, yellowish white, gray. Luster vitreous to adamantine. Transparent to translucent. H. = 4-4.5. G. = 2.42. Monoclinic. Crystals short prismatic. Perfect pinacoidal cleavage. Massive cleavable to granular and compact.

Most commonly formed by evaporation of inland bodies of salt water.

*Maricopa County*.—As crystallized, colorless material in a fossil egg from gravels of the Gila River.

SILICATES

Orthoclase	} $KAlSi_3O_8$	Hillebrandite	$Ca_2SiO_4 \cdot H_2O$
Microcline		$(Ca, K_2, Na_2)Al_2-$	Ptilolite
Plagioclase	$NaAlSi_3O_8 - CaAl_2Si_2O_8$	Analcime	$NaAlSi_2O_6 \cdot H_2O$
Enstatite	$MgSiO_3$	Thomsonite	$(Ca, Na_2)Al_2Si_2O_8 \cdot 2\frac{1}{2}H_2O$
Pyroxene	Complex series	Muscovite	$KAl_3Si_3O_{10}(OH)_2$
Wollastonite	$CaSiO_3$	Mariposite	Chrome mica
Anthophyllite	$(Mg, Fe)_7Si_8O_{22}(OH)_2$	Lepidolite	$K_2Li_3Al_3Si_7O_{21}(OH, F)_3$
Amphibole	Complex series	Zinnwaldite	Iron-lithia mica
Beryl	$Be_3Al_2Si_6O_{18}$	Biotite	$K(Mg, Fe)_3AlSi_3O_{10}(OH)_2$
Garnet	Complex series	Chlorite	$(Mg, Fe'')_5(Al, Fe''')_2Si_8-$
Olivine	$(Mg, Fe)_2SiO_4$	Vermiculite	$O_{10}(OH)_8$
Monticellite	$CaMgSiO_4$	Serpentine	Complex group
Fayalite	$Fe_2SiO_4$	Talc	$Mg_3Si_2O_7(OH)_1$
Willemite	$Zn_2SiO_4$	Sepiolite	$Mg_3Si_4O_{10}(OH)_2$
Dioptase	$H_2CuSiO_4$	Iddingsite	$Mg_3Si_3O_8 \cdot 2H_2O$
Idocrase	$Ca_{10}Al_1(Mg, Fe)_2Si_9O_{31}(OH)_4$	Glaucanite	$H_5MgFe_2Si_3O_{14}$ (?)
Zircon	$ZrSiO_4$	Kaolinite	$K_2(Mg, Fe)_2Al_6(Si_1O_{10})_3-$
Andalusite	} $Al_2SiO_5$	Nacrile	$(OH)_{12}$
Sillimanite			
Kyanite		Dickite	$Al_2Si_2O_7(OH)_4$
Gadolinite	$Y_2Fe''Be_2(SiO_4)_2O_2$	Anauxite	$Al_2Si_3O_8 \cdot 2H_2O$
Zoisite	$Ca_2Al_3(SiO_4)_3(OH)$	Montmorillonite	$(Al, Mg)_8(Si_4O_{10})_3(OH)_{10}-$
Clinozoisite	$Ca_2Al_3(SiO_4)_3(OH)$		$12H_2O$
Epidote	$Ca_2(Al, Fe)_3(SiO_4)_3(OH)$	Pyrophyllite	$Al_2Si_1O_{10}(OH)_2$
Piedmontite	$Ca_2(Al, Mn)_3(SiO_4)_3(OH)$	Nontronite	$H_4Fe_2Si_2O_9$ (?)
Allanite	Complex cerium-yttrium	Chrysocolia	$CuSiO_3 \cdot 2H_2O$
Hemimorphite	$Zn_4Si_2O_7(OH)_2 \cdot H_2O$	Shattuckite	$2CuSiO_3 \cdot H_2O$
Tourmaline	Complex borosilicate	Bisbeeite	$CuSiO_3 \cdot H_2O$
Dumortierite	$Al_3BSi_3O_{19}(OH)$	Thaumasite	$Ca_3Si_3O_8(CO_3)(SO_4) \cdot 15H_2O$
Sphene	$CaTiSiO_5$		
Staurolite	$Fe''Al_3Si_2O_{12}(OH)$		

ORTHOCLASE—Potash Feldspar

$KAlSi_3O_8$ . White or flesh-red, also colorless and gray. Luster vitreous to stony, pearly on cleavage faces. Transparent to opaque. Streak uncolored. H. = 6. G. = 2.56-2.58. Monoclinic. Crystals commonly Carlsbad twins. Perfect basal, less perfect clinopinacoidal, cleavage. Coarsely cleavable to granular massive.

An abundant constituent of acid igneous rocks and pegmatites, and in sandstones and conglomerates derived from them. Most commonly as disseminated grains of various sizes and as large masses in the pegmatites. Also formed extensively by action of mineralizing solutions on wall rocks of ore deposits. Widely distributed in all the acid igneous rocks of the state. Forms large phenocrysts up to 2 or 3 inches long in some granites of pre-Cambrian and later ages.

*Mohave County*.—Mined from pegmatites of the Cerbat and Hualpai Mountains.

Adularia

The pure or nearly pure potassium orthoclase, in transparent crystals commonly twinned according to the Baveno law. *Moonstone* is adularia with an opalescent play of colors.

*Gila County*.—Richmond Basin, an important gangue mineral of the veins.

*Mohave County*.—Oatman and Katherine districts, a common constituent of the veins as white bands up to 2 inches in width between layers of quartz, as plates, as grains, and locally as crystals with well-developed terminations. Gold is commonly associated with the adularia. Analysis by R. J. Leonard as follows:

SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	CaO	Na <sub>2</sub> O	K <sub>2</sub> O	Total
65.81	17.64	0.32	1.76	15.08	100.61

*Yavapai County*.—Bradshaw Mountains, as crystals in open portions of the Cash vein, Hassayampa district.

*Yuma County*.—Kofa Mountains, with banded chalcedony at the North Star mine. Little Horn Mountains, in the gold-quartz veins of the Sheep Tanks mine.

**Sanidine**

A transparent, glassy variety of orthoclase occurring as crystals in rhyolite, trachyte, or other lava flows.

*Gila and Pinal counties.*—Abundant as phenocrysts in dacite flows.

**MICROCLINE—Potash Feldspar**

$\text{KAlSi}_3\text{O}_8$ . White to creamy yellow, red, and green. Luster vitreous to stony, pearly on the cleavage. Transparent to opaque. Streak white. H. = 6-6.5. G. = 2.54-2.57. Triclinic. Crystals near orthoclase in angles and habit. Perfect basal, less perfect brachypinacoidal, cleavage. Cleavable to granular massive.

Widespread and occurs under the same conditions as orthoclase. Much of the potash feldspar commonly classed as orthoclase is microcline.

**ALBITE—ANORTHITE—Plagioclase**

$\text{NaAlSi}_3\text{O}_8$ - $\text{CaAl}_2\text{Si}_2\text{O}_8$ , and forming a continuous series. White to dark gray; also blue, red, or green. Luster vitreous to stony; pearly on cleavage surfaces. Transparent to opaque. Streak uncolored. H. = 6-6.5. G. = 2.60-2.76. Triclinic. Perfect basal, less perfect brachypinacoidal, cleavage. Characteristically twinned according to the Albite law, visible as numerous minute striations on the basal cleavage. As disseminated grains or imbedded crystals; also lamellar or granular massive. Intermediate members of the group are *oligoclase*, *andesine*, *labradorite*, and *bytownite*.

Essential constituents of igneous rocks of intermediate and basic composition. Also in gneisses, crystalline schists, pegmatites, and coarse arkosic sediments. Abundant and widespread in the rocks of the state.

**PYROXENE GROUP****ENSTATITE**

$\text{MgSiO}_3$ . Commonly contains iron. Gray, green, greenish black. Luster pearly to metalloid. Streak uncolored to grayish or brownish. Translucent to nearly opaque. H. = 5-6. G. = 3.1-3.5. Orthorhombic. Distinct prismatic cleavage at angle near  $90^\circ$ . Commonly foliated massive. *Hypersthene* contains more than 15% FeO.

Common in basic igneous rocks such as gabbro, norite, and peridotite, and in their extrusive equivalents. Commonly associated with calcic plagioclase feldspars. Makes up the bulk of some rocks, such as pyroxenites.

*Gila County.*—Dripping Spring Mountains, Banner district, Reagan claims, near the "79" mine.

*Navajo County.*—Twenty miles west of Dilkon, as dikes of hypersthene in shale.

*Pima County.*—At Ajo, in the basal facies of the Batamote andesite series.

*Santa Cruz County.*—Sparingly in the younger andesite of the Patagonia and Santa Rita mountains.

**PYROXENE**

In general  $(\text{Ca,Mg})\text{SiO}_3$ , but commonly containing iron, aluminum, or manganese. Generally some shade of green; also nearly colorless, white, gray, brown, or black. Luster vitreous to dull; in some varieties pearly or metalloid. Transparent to opaque. Streak white to gray and grayish green. H. = 5-6. G. = 3.2-3.6. Monoclinic. Crystals prismatic. Rather perfect prismatic cleavage at angle near  $90^\circ$ . Also granular massive, rarely columnar or fibrous.

A common mineral in igneous rocks, some of which consist almost entirely of pyroxene. Most abundant in dark-colored volcanic rocks; also in crystalline limestone, dolomite, and schist.

The pyroxene group includes several subspecies based on composition.

**Pigeonite**

A mixture of  $\text{MgSiO}_3$  and  $\text{CaMgSi}_2\text{O}_6$ . General physical properties like those of diopside. Occurs in diabase, basalt, gabbro, and other basic rocks, and also as a product of contact metamorphism.

*Cochise County.*—At Tombstone, as dark-green grains with idocrase in the contact silicate zone of the Lucky Cuss mine.

**Diopside**

$\text{CaMgSi}_2\text{O}_6$ . Iron generally present in small amounts, increasing as the mineral grades toward hedenbergite. White, yellowish, grayish to pale green, dark green, and black.  $G. = 3.2-3.38$ . In prismatic crystals, columnar aggregates, and granular masses. Generally of metamorphic origin, most abundant in crystalline limestones.

*Cochise County*.—Bisbee district, as grains in unoxidized pyritic ores. Tombstone, as small pale-green crystals in the contact zone of Comstock Hill. Little Dragoon Mountains, Johnson district, as small grains in metamorphosed limestone.

*Greenlee County*.—Clifton-Morenci district, common in metamorphosed limestones of the Longfellow formation.

*Pima County*.—Santa Rita Mountains, in wall rocks of ore bodies and in metamorphosed limestone, Helvetia district. Sierrita Mountains, in contact rocks, Twin Buttes area.

*Santa Cruz County*.—Patagonia Mountains, Westinghouse property, Duquesne.

*Yavapai County*.—Bradshaw Mountains, Henrietta mine, Big Bug district, with magnetite.

**Hedenbergite**

$\text{CaFeSi}_2\text{O}_6$ . Black to greenish black.  $G. = 3.4-3.58$ . In prismatic crystals, but generally massive with columnar or lamellar structure. Characteristically of metamorphic origin.

*Pima County*.—Sierrita Mountains, common as gangue, San Xavier district.

*Santa Cruz County*.—Patagonia Mountains, Westinghouse property, with diopside and other contact silicates.

**Augite**

Chiefly  $\text{Ca}(\text{Mg,Fe,Al})(\text{Al,Si})_2\text{O}_6$ . Greenish, brownish black, or black. As short, stout, prismatic crystals or as scattered grains. Most commonly in basic igneous rocks, as gabbro, diabase, and basalt. Widely distributed, and only a few typical occurrences are listed.

*Cochise County*.—Tombstone district, in diorite porphyry dikes and basaltic rocks.

*Gila and Pinal counties*.—Abundant in diabase sills which intrude rocks of the Apache group over large areas in central Arizona. In the Dripping Spring Mountains with olivine and iddingsite in Tertiary basalts.

*Yuma County*.—Abundant in metamorphosed limestones of the northern part of the county.

## WOLLASTONITE

$\text{CaSiO}_3$ . White to grayish, yellow, red, or brown. Luster vitreous, pearly on cleavage surfaces. Subtransparent to translucent. Streak white.  $H. = 4.5-5$ .  $G. = 2.8-2.9$ . Monoclinic. Crystals tabular or short prismatic. Perfect basal and orthopinacoidal cleavage. Cleavable massive, bladed, fibrous, or compact.

A contact mineral in crystalline limestones, common as gangue in contact-metamorphic ore deposits.

*Cochise County*.—Tombstone district, as radiating fibrous masses in the Silver Thread and West Side mines.

*Gila County*.—Dripping Spring Mountains, Christmas mine, Banner district.

*Pima County*.—Santa Rita Mountains, Rosemont camp, where large masses of limestone are completely altered to wollastonite. Sierrita Mountains, throughout metamorphosed rocks of the Mineral Hill area. Silver Bell district, locally abundant.

*Yuma County*.—Harcuvar Mountains, Cabrolla prospect, replacing entire beds of limestone.

## AMPHIBOLE GROUP

## ANTHOPHYLLITE

$(\text{Mg,Fe})_3\text{Si}_3\text{O}_{10}(\text{OH})_2$ . Brownish gray, brownish green, emerald-green. Luster vitreous. Transparent to subtranslucent. Streak uncolored or grayish.  $H. = 5.5-6$ .  $G. = 2.85-3.2$ . Orthorhombic. Perfect prismatic cleavage at angles near  $54^\circ$  and  $126^\circ$ . As lamellar or fibrous massive. *Gedrite* is a variety with considerable aluminum.

A metamorphic mineral common in schists and gneisses, less common in contact rocks.

*Mohave County*.—Hualpai Mountains, 10 miles east of Yucca, in schist.

*Santa Cruz County*.—Patagonia Mountains, as gedrite in gangue of the Westinghouse ores.

## AMPHIBOLE

In general  $(\text{Ca,Mg})\text{SiO}_3$ , but commonly containing iron, manganese, aluminum, sodium, or potassium. Black, various shades of green, dark brown, yellowish, or white. Luster vitreous to pearly. Translucent to opaque. Streak paler than color.  $H. = 5-6$ .  $G. = 2.9-3.4$ . Monoclinic. Crystals commonly prismatic. Perfect prismatic cleavage at angles near  $56^\circ$  and  $124^\circ$ . Granular massive, columnar, or fibrous.

Amphibole includes several subspecies based upon composition. They are common, widely distributed rock-forming minerals, abundant in certain igneous and metamorphic rocks.

**Grunerite**

$(\text{Fe,Mg})\text{SiO}_3$  with manganese generally present. Brown. Silky luster.  $G. = 3.4-3.6$ .

*Graham County*.—Santa Teresa Mountains, in limestone contact rocks, Stanley Butte district.

**Tremolite**

$\text{Ca}_2\text{Mg}_5\text{Si}_8\text{O}_{22}(\text{OH})_2$ . White to dark gray, generally with silky luster. Crystals commonly long bladed. In columnar or fibrous aggregates or granular masses. A common product of contact metamorphism, abundant in some schists, and in some contact ores.

*Cochise County*.—Bisbee district, the most abundant metamorphic gangue of the unoxidized pyritic ores. Tombstone district, as long fibrous masses, Toughnut mine. Little Dragoon Mountains, in metamorphic limestones.

*Greenlee County*.—Clifton-Morenci district, in metamorphosed limestones and in wall rocks of veins.

*Santa Cruz County*.—Patagonia Mountains, as gangue, Westinghouse property.

*Yuma County*.—Dome Rock Mountains, as asbestos in marbleized limestones of the northern part of the range.

**Actinolite**

$\text{Ca}_2(\text{Mg,Fe})_5\text{Si}_8\text{O}_{22}(\text{OH})_2$ . Bright grass-green, dark green to grayish green. Commonly in long prismatic crystals or in fibrous or bladed masses. Generally of metamorphic origin. *Mountain leather* is a fibrous variety in thin flexible sheets.

*Cochise County*.—Little Dragoon Mountains, in metamorphosed limestones, Johnson district.

*Graham County*.—Aravaipa and Stanley districts, as gangue of contact-metamorphic ores. Galiuro Mountains, as mountain leather, Ash Peak.

*Greenlee County*.—Clifton-Morenci district, as asbestos in honeycombed limonitic masses in metamorphic rocks.

*Mohave County*.—Black Mountains, Oatman district, as thin sheets of mountain leather between layers of quartz, Big Jim vein.

*Pima County*.—Sierrita Mountains, abundant in contact rocks, Twin Buttes district.

*Pinal County*.—Globe district, Old Dominion mine, as mountain leather along bedding planes of Mescal limestone.

*Santa Cruz County*.—Patagonia Mountains, Westinghouse property.

*Yavapai County*.—Bradshaw Mountains, in country rock, Iron Queen mine, Big Bug district.

*Yuma County*.—Harcuvar Mountains, Yuma Copper and Cabrola properties, as a replacement of limestone beds.

#### Hornblende

An amphibole containing aluminum with ferric or ferrous iron, magnesium, calcium, and alkalis. Light green to dark green to black. A common constituent of igneous rocks, generally most abundant in those of the diorite and syenite groups. Also in gneisses and schists and the chief mineral of the amphibolites.

*Cochise County*.—Tombstone district, as long prismatic crystals in the Schieffelin granodiorite.

*Gila and Pinal counties*.—The principal constituent of the greenstone facies of the Pinal schist. In intrusive bodies in the vicinity of Picket Post Mountain, near Superior.

*Greenlee County*.—Abundant in diorite porphyry, Clifton-Morenci district.

*Pima County*.—At Ajo, as bodies of hornblendite, the largest 2,000 by 1,000 feet, in the Cardigan gneiss. Empire Mountains, as phenocrysts in a diorite porphyry dike at the Prince mine.

*Yavapai County*.—Lenticular beds composed largely of hornblende are found at many places in Yavapai schist.

*Yuma County*.—Harcuvar Mountains, as crystals more than an inch long near dikes in pre-Cambrian granite.

#### BERYL

$\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$ . Emerald-green, pale green, light blue, yellow, white. Luster vitreous. Transparent to subtranslucent. Streak white. H. = 7.5-8. G. = 2.63-2.8. Hexagonal. Crystals generally long prismatic. Imperfect basal cleavage. Coarse columnar, granular, or compact. Pure mineral 14% BeO.

Most common in cavities in granite or pegmatite, also in tin ores and mica schists.

*Cochise County*.—Dragoon Mountains, as small colorless crystals with fluorite at the Boericke tungsten property.

*Mohave County*.—Aquarius Range, as crystals in pegmatite. Wright Creek, 15 miles south of Peach Springs, in pegmatite.

*Yavapai County*.—Eureka district, Bagdad vicinity.

#### GARNET

Essentially a silicate of calcium, magnesium, iron, or manganese, the composition varying with different varieties. Red, brown, yellow, white, green, or black. Luster vitreous to resinous. Transparent to opaque. Streak white. H. = 6.5-7.5. G. = 3.15-4.3. Isometric. Characteristically in dodecahedral or trapezohedral crystals. Also in tough compact masses or granular aggregates.

Generally of metamorphic origin. Most abundant in rocks derived from contact metamorphism of limestone; also in schists and gneisses. Several subspecies are based upon composition.

#### Grossularite

$\text{Ca}_3\text{Al}_2(\text{SiO}_4)_3$ . G. = 3.53. White to colorless, pale green, yellowish, brownish yellow, cinnamon brown, and red.

*Cochise County*.—Bisbee district, as rounded crystals in unoxidized pyritic ores. Tombstone district, of cinnamon-brown color in contact-metamorphic zones; forms massive beds on Comstock Hill. Little Dragoon Mountains, a gangue of copper ores, Johnson district.

#### Pyrope

$\text{Mg}_3\text{Al}_2(\text{SiO}_4)_3$ . G. = 3.51. Deep red to nearly black. Transparent varieties are prized as gems.

*Apache County*.—Navajo reservation, just south of the Utah line, as pebbles of gem quality on Garnet Ridge.

**Almandite**

$\text{Fe}_3\text{Al}_2(\text{SiO}_4)_3$ . G. = 4.25. Deep red to brownish red. Transparent varieties used as gems.

*Coconino County*.—Grand Canyon, in Archean rocks of the Inner Gorge. As crystals over an inch in diameter on Phantom Creek.

*Mohave County*.—Aquarius Range, as crystals in light-colored volcanic rocks at the south end of the range.

**Andradite**

$\text{Ca}_3\text{Al}_2(\text{SiO}_4)_3$ . G. = 3.75. Various shades of yellow, green, brown, or black. The most common variety of garnet, particularly abundant in contact-metamorphic zones.

*Cochise County*.—Dragoon Mountains, common in wall rocks of pyritic ores in Abrigo limestone, Turquoise district.

*Gila County*.—Dripping Spring Mountains, Banner district, Christmas mine, in large massive bodies.

*Graham County*.—Aravaipa and Stanley districts, as gangue in contact-metamorphic ores.

*Greenlee County*.—Clifton-Morenci district, in altered limestones, forming masses from 50 to 100 feet thick.

*Pima County*.—Empire Mountains, as zones of massive material at the contact of Paleozoic limestone and quartz monzonite. Sierrita Mountains, as zones up to 200 feet wide at Twin Buttes, and containing chalcopyrite ore. Santa Rita Mountains, the commonest metamorphic product of limestones, Rosemont camp.

*Santa Cruz County*.—Patagonia Mountains, as crystals up to 2 inches in diameter in metamorphosed limestone, Westinghouse property.

**OLIVINE**

$(\text{Mg,Fe})_2\text{SiO}_4$ . Luster vitreous. Transparent to translucent. Streak uncolored. H. = 6.5-7. G. = 3.27-3.37. Orthorhombic. Granular massive or as disseminated grains.

Most abundant in basic igneous rocks such as gabbro, basalt, peridotite, and diabase, formed by crystallization of magmas rich in magnesia and low in silica. The clear green gem varieties of olivine are known as *peridot*.

*Apache County*.—As clear green to brown stones of gem quality 10 miles north of Ft. Defiance, and at Garnet Ridge, just south of the state line.

*Cochise County*.—Tombstone district, in contact zone of Comstock Hill and in the Lucky Cuss mine.

*Coconino County*.—In basalts of the San Francisco Mountains.

*Gila County*.—In basaltic rocks and stream gravels of the San Carlos Indian Reservation near Peridot and Tolikai. A cut stone from this locality weighed 25.75 carats.

*Pinal County*.—An accessory mineral in diabase sills which intrude the Apache group in this and adjoining counties. Dripping Spring Mountains, with augite and iddingsite in Tertiary basalts. Galiuro Mountains, in the contact zone between granodiorite and Cretaceous sediments.

*Santa Cruz County*.—Sparingly in gabbro, diabase, and younger andesite of the Patagonia and Santa Rita mountains.

**MONTICELLITE**

$\text{CaMgSiO}_4$ . Colorless to gray. H. = 5. G. = 3.2. In small prismatic crystals or grains.

A rare member of the olivine group.

*Cochise County*.—Tombstone district, as narrow bands in contact silicates on the fourth level of the Lucky Cuss mine.

**FAYALITE**

$\text{Fe}_2\text{SiO}_4$ . Light greenish yellow, but brown to black after exposure. Luster vitreous to somewhat greasy. Transparent to translucent. Streak uncolored. H. = 6.5. G. = 4.1. Orthorhombic. Crystals like those of olivine. Commonly massive.

An end member of the olivine series. Same origin and occurrence as olivine, but comparatively rare.

*Gila County*.—A minor constituent of volcanic bombs and stream gravel in the vicinity of Peridot and Tolikai.

#### WILLEMITE

$Zn_2SiO_4$ . Green, yellow, brown, reddish brown, flesh-pink, or white. Luster somewhat resinous and weak. Transparent to opaque. Streak uncolored.  $H. = 5.5$ .  $G. = 3.89-4.18$ . Tri-rhombohedral. Crystals generally hexagonal prisms. Basal cleavage. Cleavable to granular massive or in disseminated grains.

A relatively rare mineral formed by alteration of primary zinc sulfides.

*Cochise County*.—Chiricahua Mountains, at Hilltop, as small white to rose-colored prisms in cavernous rock.

*Greenlee County*.—Clifton-Morenci district, as small grayish crystals on garnet rock on the north side of Modoc Mountain.

*Pima County*.—Tucson Mountains, as crystals on dump of prospect 1 mile south of Old Yuma mine.

*Pinal County*.—Mammoth mine, as small colorless rhombs on wulfenite and vanadinite.

#### DIOPTASE

$H_2CuSiO_4$ . Emerald-green. Luster vitreous. Transparent. Streak uncolored.  $H. = 5$ .  $G. = 3.28-3.35$ . Tri-rhombohedral. Perfect pyramidal cleavage. In prismatic crystals or crystal aggregates.

A rare mineral of secondary origin found with oxidized copper minerals.

*Greenlee County*.—Clifton-Morenci district, Bon Ton mine, as crystals in cavities in chrysocolla (6:05).

*Gila County*.—Payson district, as small prismatic crystals, Ox Bow mine.

*Pinal County*.—Mammoth mine, as deep emerald-green aggregates of small crystals. Diopside of identical character was found on a mine dump near Riverside, on the Gila River.

*Yuma County*.—Buckskin Mountains, in small quantities, Chicago property.

#### IDOCRASE—Vesuvianite

$Ca_{10}Al_2(Mg,Fe)_2Si_8O_{21}(OH)_4$ . Yellow green to brown, rarely pale blue. Luster vitreous. Subtransparent to translucent. Streak white.  $H. = 6.5$ .  $G. = 3.35-3.45$ . Tetragonal. Crystals prismatic or pyramidal. Commonly massive.

Formed by contact metamorphism of impure limestones. Generally associated with grossularite, diopside, and wollastonite.

*Cochise County*.—Tombstone district, in the contact zone of Comstock Hill; Lucky Cuss mine, with monticellite, hillebrandite, and thaumasite. Little Dragoon Mountains, as small pale green crystals in metamorphosed limestone, Johnson district.

*Gila County*.—Dripping Spring Mountains, Christmas mine.

*Yuma County*.—Abundant in metamorphosed limestones.

#### ZIRCON

$ZrSiO_4$ . Colorless, pale yellowish, grayish, yellowish green, brownish yellow, reddish brown. Luster adamantine. Transparent to translucent and opaque.  $H. = 7.5$ .  $G. = 4.68-4.7$ . Tetragonal. Commonly in square prismatic crystals. Also in irregular forms and grains. Pure mineral 67.2%  $ZrO_2$ .

A common accessory mineral of igneous rocks, generally present as minute crystals, but commonly of large size in pegmatites. Also in crystalline limestones and schists, and in sands.

*Cochise County*.—Bisbee district, as small crystals in Pinal schist with tourmaline, and in granite northwest of Bisbee. Tombstone, as microscopic grains in light-colored intrusive rocks.

*Gila County*.—In Pinal schist, Madera diorite, and Ruin granite.

*Greenlee County*.—Clifton-Morenci district, in granite.

*Pima County*.—Santa Rita Mountains, in granite porphyry.

*Pinal County*.—Sparingly in Pinal schist.

*Santa Cruz County.*—Patagonia Mountains, in granite.

*Yavapai County.*—Bradshaw Mountains, sparingly in Bradshaw granite.

#### ANDALUSITE

$\text{Al}_2\text{SiO}_5$ . Whitish, rose-red, flesh-red, violet, pearl-gray, reddish brown, olive-green. Luster vitreous. Transparent to opaque. Streak uncolored.  $H. = 7.5$ .  $G. = 3.16-3.2$ . Orthorhombic. Crystals nearly square prismatic. Good prismatic cleavage near  $90^\circ$ . Commonly massive, with granular or columnar structure.

Of either regional or contact-metamorphic origin, most commonly in slates, but also in gneiss, mica schists, and other altered rocks. Generally associated with sillimanite or kyanite, the mixture commonly known as "spark plug ore."

*Gila and Pinal counties.*—Locally abundant in Pinal schist near post-Cambrian granitic rocks.

*Mohave County.*—Cedar mining district, 11 miles east of Yucca, in quartz veins in schist.

*Yavapai County.*—Bradshaw Mountains, as scattered lenses and disseminations in schist. Near Granite Mountain in extensive veins. Santa Maria Mountains, near Camp Wood, as flakes and nodules in schist.

*Yuma County.*—Near Quartzsite, with kyanite and dumortierite in schist.

#### SILLIMANITE

$\text{Al}_2\text{SiO}_5$ . Brown, grayish brown, grayish white, grayish green, olive-green. Luster vitreous. Transparent to translucent. Streak uncolored.  $H. = 6.7$ .  $G. = 3.23-3.24$ . Orthorhombic. Crystals long, slender, and not distinctly terminated. Perfect brachypinacoidal cleavage. In closely parallel groups, passing into fibrous and columnar forms.

Of metamorphic origin, like andalusite with which it is commonly associated. Generally in gneisses and schists, less commonly in contact-metamorphic deposits.

*Coconino County.*—Grand Canyon, abundant in the Inner Gorge  $\frac{1}{2}$  mile downstream from Monument Creek.

*Gila and Pinal counties.*—In Pinal schist near post-Cambrian granite contacts.

*Yavapai County.*—Santa Maria Mountains, near Camp Wood, as veins, flakes, and nodules in schist. Eureka district, Bagdad vicinity.

#### KYANITE—Cyanite

$\text{Al}_2\text{SiO}_5$ . Blue, white, gray, green, black; commonly blue along the center of the blades or crystals and white along the margins. Luster vitreous to pearly. Transparent to translucent. Streak uncolored.  $H. = 5-7$ , 5 on the cleavage parallel to the c axis, 6-7 on the cleavage normal to the c axis.  $G. = 3.56-3.67$ . Triclinic. Crystals long bladed and rarely terminated. Perfect macropinacoidal cleavage. In columnar or coarse granular masses.

Of metamorphic origin, like andalusite and sillimanite with which it is commonly associated in schists and gneisses.

*Yuma County.*—Near Quartzsite, with dumortierite and andalusite in schist. Gila Mountains, 8 miles west of Wellton, on the east side of the range.

*Maricopa County.*—Phoenix Mountains.

#### GADOLINITE

$\text{Y}_2\text{Fe}^*\text{Be}_2(\text{SiO}_4)_2\text{O}_2$ . May contain cerium oxide. Black, greenish black, brown. Luster vitreous to greasy. Transparent to translucent.  $H. = 6.5-7$ .  $G. = 4-4.5$ . Crystals prismatic with rough faces. More commonly massive.

A rare mineral, principally from pegmatites.

*Mohave County.*—In pegmatite veins of the Aquarius Range, 30 miles south of Hackberry, from which several tons of the mineral have been mined. Near Kingman and in the northern part of the county, in sand dunes. Partial analysis by Chase Palmer as follows:

$\text{SiO}_2$	Yttria earths	Ceria earths	BeO	FeO	Total
24.21	38.86	11.50	11.50	11.56	95.83

## ZOISITE

$\text{Ca}_2\text{Al}_2(\text{SiO}_4)_2(\text{OH})$ . Grayish white, gray, greenish gray, yellowish brown, apple-green; rarely peach-red to rose-red. Luster vitreous. Transparent to subtranslucent. Streak uncolored.  $H. = 6-6.5$ .  $G. = 3.25-3.37$ . Orthorhombic. Crystals prismatic, deeply striated vertically. Perfect brachypinacoidal cleavage. In columnar to compact masses.

Most commonly in crystalline schists from metamorphism by basic igneous rocks. Also from alteration of plagioclase feldspar.

*Cochise County*.—Tombstone district, microscopically in igneous rocks.

*Yavapai County*.—Bradshaw Mountains, in scattered lenses in schist. Eureka district, as an accessory mineral in bodies of titaniferous magnetite and in gangue of copper deposits at Bagdad.

*Yuma County*.—Dome Rock Mountains, in wall rocks of cinnabar veins.

## CLINOZOISITE

$\text{Ca}_2\text{Al}_2(\text{SiO}_4)_2(\text{OH})$ . Colorless, light yellow, green, pink. Luster vitreous. Transparent to opaque.  $H. = 6-7$ .  $G. = 3.25-3.5$ . Monoclinic. Crystals prismatic. Perfect basal cleavage. Also fibrous and granular.

Dimorphous with zoisite, for which it is commonly mistaken.

*Cochise County*.—Tombstone district, as small vitreous green grains with idocrase, monticellite, and thaumasite, Lucky Cuss mine.

## EPIDOTE

$\text{Ca}_2(\text{Al,Fe})_2(\text{SiO}_4)_2(\text{OH})$ . Pistachio-green to dark green, also colorless to yellow. Luster vitreous to dull. Transparent to opaque, generally subtranslucent. Streak uncolored or grayish.  $H. = 6.7$ .  $G. = 3.25-3.5$ . Monoclinic. Crystals prismatic, commonly deeply striated. Perfect basal cleavage. In granular, fibrous, or columnar masses, or as disseminated grains.

A common contact-metamorphic mineral in limestone, with garnet and idocrase, and as gangue in contact-metamorphic copper deposits. Also in crystalline schist and gneiss, and an alteration product of such minerals as garnet, augite, hornblende, biotite, and scapolite.

*Cochise County*.—Tombstone district, in shale and quartzite. Chiricahua Mountains, common; in the California mining district, a copper-bearing epidote vein up to 5 feet wide extends for over a mile. Turquoise district, in wall rocks of pyritic deposits in Abrigo limestone.

*Gila County*.—Payson district, with chalcocopyrite, Harrington claims. Dripping Spring Mountains, Christmas mine, Banner district.

*Graham County*.—Turnbull Mountains, with chalcocopyrite, sphene, apatite, and chlorite in micropegmatite, Fisher prospect. Widely distributed in contact copper deposits, Aravaipa and Stanley districts.

*Greenlee County*.—Clifton-Morenci district, principally in metamorphic rocks, rarely as well-defined crystals.

*Pima County*.—Santa Rita Mountains, widespread in metamorphosed limestones and wall rocks of copper deposits. Sierrita Mountains, common as a metamorphic product and as an alteration product of dikes. Santa Catalina Mountains, in contact copper deposits near Marble Peak, in places as splendid crystals.

*Santa Cruz County*.—Abundant in metamorphosed limestones, Santa Rita and Patagonia mountains.

*Yavapai County*.—Bradshaw Mountains, in lenses in the schist; Weaver district, in dikes, Rich Hill.

*Yuma County*.—Abundant in metamorphosed limestones. Dome Rock Mountains, in the wall rock of cinnabar veins.

## PIEDMONTITE

$\text{Ca}_2(\text{Al,Mn})_2(\text{SiO}_4)_2(\text{OH})$ . Pink, rose-red, reddish brown, and reddish black.  $H. = 6.5$ .  $G. = 3.404$ . Monoclinic. Crystals like those of epidote in habit. Commonly in rock masses.

The rare manganese member of the epidote group. In some crystalline schists, rhyolites, and closely related volcanics.

*Cochise County*.—In andesitic rock of Pat Hills, northeast of Pearce.

*Pima County*.—In rhyolite and adjacent sandstone, Tucson Mountains. Also in the Santa Rita Mountains, near Madera Canyon. Analysis by Paul H. M. P. Brinton as follows:

SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	Mn <sub>2</sub> O <sub>3</sub>	TiO <sub>2</sub>	H <sub>2</sub> O	Total
37.43	21.27	3.80	24.75	11.80	0.10	0.96	100.11

#### ALLANITE—Orthite

A basic silicate of calcium, iron, aluminum, and the metals of the cerium and yttrium groups. Brown to black. Luster submetallic, pitchy, or resinous. Subtranslucent to opaque. H. = 5.5-6. G. = 3-4.2. Monoclinic. In tabular or acicular prismatic crystals. More commonly massive or as disseminated grains.

An accessory mineral in granite, syenite, diorite, or pegmatite, or in metamorphic rocks derived from these. Commonly associated with bodies of magnetite.

*Cochise County*.—Tombstone district, microscopic in granodiorite.

*Mohave County*.—Aquarius Range, in pegmatite with gadolinite. Cerbat Range, as small masses in pegmatite at the Feldspar mine.

*Yavapai County*.—Eureka district, in pegmatite knots on the 7 U 7 ranch, near Bagdad, with triplite and bermanite.

#### HEMIMORPHITE—Calamine

Zn<sub>2</sub>Si<sub>2</sub>O<sub>7</sub>(OH)<sub>2</sub>·H<sub>2</sub>O. Colorless, white, yellowish, brownish; also blue or green. Luster vitreous. Transparent or translucent to opaque. H. = 4.5-5. G. = 3.4-3.5. Orthorhombic-hemimorphic. Commonly in tabular or prismatic crystals arranged in bunches, or grouped in sheaflike aggregates. Also in cavernous masses or layers. Pure mineral 54.4% Zn.

A mineral of oxidized zinc ores, generally with zinc carbonate, which the massive varieties closely resemble.

*Cochise County*.—Tombstone district, sparingly as radiating aggregates in oxidized ore, Empire and Toughnut mines. Turquoise district, as in-crustations and druses, Mystery and Silver Bill mines.

*Greenlee County*.—Clifton-Morenci district, as small transparent crystals on decomposed garnet rock, Shannon mine.

*Pima County*.—Empire Mountains, as small colorless crystals in smithsonite, Hilton mines. Sierrita Mountains, in small quantity in the San Xavier district.

*Pinal County*.—Mammoth mine, as porous to compact granular masses and as slender needles bristling from quartz crystals on the walls of open cavities.

#### TOURMALINE

A complex silicate of boron and aluminum. Most commonly black or brown, also blue, green, red, rarely white or colorless. Luster vitreous. Transparent to opaque. Streak uncolored. H. = 7-7.5. G. = 2.98-3.2. Rhombohedral-hemimorphic. Crystals prismatic, rarely flattened. Also in columnar, coarsely fibrous, or compact masses.

Common in granitic crystalline rocks, particularly pegmatites, generally with quartz, albite, microcline, and muscovite. Transparent colored varieties are prized as gems.

*Cochise County*.—As microscopic prismatic crystals with zircon in Pinal schist. As nests of small prismatic crystals in muscovite in granite northwest of Bisbee.

*Coconino County*.—Grand Canyon, as black crystals in pegmatites, Hermit Creek.

*Maricopa County*.—Mazatzal Mountains, in cinnabar veins.

*Pima County*.—Santa Rita Mountains, with magnetite and siderite, Iron Mask mine, Old Baldy district. Sierrita Mountains, as veinlike masses with quartz in soda-granite, Papago district.

*Pinal County*.—In vein quartz in Pinal schist near post-Cambrian granite contacts. Santa Catalina Mountains, in pegmatites of the Oracle granite. Galiuro Mountains, Copper Creek district, as radiating groups of slender prismatic crystals.

*Yavapai County*.—Bradshaw Mountains, in pegmatites of the Bradshaw granite, in lenses in schist and scattered through the schist near granite

contacts. In veins of the Prescott district, and as blue gray prisms in quartz and dolomite, Iron King mine, Big Bug district. Eureka district, in pegmatites of the Bagdad area.

*Yuma County*.—Dome Rock Mountains, with magnetite and siderite in gangue of cinnabar veins.

#### DUMORTIERITE

$\text{Al}_2\text{BSi}_2\text{O}_{10}(\text{OH})$ . Lilac, blue, bluish green, rose, pink. Luster vitreous. Transparent to translucent. Streak uncolored.  $H. = 7$ .  $G. = 3.26-3.36$ . Orthorhombic. Distinct pinacoidal cleavage. Generally in fibrous to columnar aggregates.

Most common as a metamorphic mineral in schist and gneiss, and generally associated with sillimanite or kyanite. Used in manufacture of refractory porcelain.

*Yuma County*.—As fine fibrous material in boulders along the Colorado River between Ehrenburg and Yuma, and in schist near Quartzsite. Associated with kyanite and altered to pyrophyllite. Average analysis by W. E. Ford as follows:

$\text{SiO}_2$	$\text{Al}_2\text{O}_3$	$\text{Fe}_2\text{O}_3$	$\text{B}_2\text{O}_3$	$\text{H}_2\text{O}$
29.86	63.56	0.23	5.26	1.41

#### SPHENE—Titanite

$\text{CaTiSiO}_5$ . Brown, gray, yellow, green, and black. Luster adamantine to resinous. Transparent to opaque. Streak white.  $H. = 5-5.5$ .  $G. = 3.4-3.56$ . Monoclinic. Crystals wedge-shaped and flattened. Distinct prismatic cleavage. Cleavable to compact massive.

An accessory mineral in intrusive rocks of intermediate composition, in gneiss and schist, and in granular limestone. Commonly associated with pyroxene, amphibole, chlorite, and scapolite.

*Cochise County*.—Tombstone district, microscopic in granodiorite and porphyries.

*Graham County*.—Aravaipa district, Turnbull Mountains, in micropegmatite, Fisher prospect.

*Yavapai County*.—Bradshaw Mountains, in schist, Butternut mine, Big Bug district; as large crystals in granodiorite, Springfield group, Pine Grove district.

#### STAUROLITE

$\text{Fe}^+\text{Al}_2\text{Si}_2\text{O}_{12}(\text{OH})$ . Dark reddish brown to brownish black. Luster subvitreous to resinous. Streak uncolored to grayish. Translucent to opaque.  $H. = 7-7.5$ .  $G. = 3.65-3.77$ . Orthorhombic. Generally in twinned prismatic crystals having the form of a cross.

In crystalline schist as a result of regional or contact metamorphism, generally with garnet, sillimanite, andalusite, kyanite, or tourmaline.

*Coconino County*.—Grand Canyon, as brownish red stout prismatic crystals with garnet in metamorphic rocks of Lone Tree Canyon.

*Yavapai County*.—Bradshaw Mountains, in schist near contacts with granite bodies.

#### HILLEBRANDITE

$\text{Ca}_2\text{SiO}_4\text{H}_2\text{O}$ . White.  $H. = 5.5$ .  $G. = 2.7$ . Orthorhombic. In radiating fibrous masses.

Exceedingly rare, formed by contact metamorphism of limestone.

*Cochise County*.—Tombstone district, Lucky Cuss mine, with monticellite and idocrase.

#### PTILOLITE

Essentially a hydrous aluminum silicate. Colorless to white.  $H. = 5$ .  $G. = 2.1$ . Orthorhombic. In short capillary needles aggregated in delicate tufts.

A rare zeolite formed in cavities in basic lavas.

*Pinal County*.—Galiuro Mountains, as delicate cottonlike aggregates of white to colorless capillary needles in basalt flows, Copper Creek district.

## ANALCIME—Analcite

$\text{NaAlSi}_2\text{O}_6 \cdot \text{H}_2\text{O}$ . Colorless to white, also grayish, greenish, yellowish, or reddish. Luster vitreous. Transparent to nearly opaque.  $H. = 5-5.5$ .  $G. = 2.22-2.29$ . Isometric. Generally in trapezohedral crystals. Also granular to compact massive.

One of the more common zeolites, formed in cavities in basic lavas. Also a component of some basic igneous rocks.

*Pima County*.—Santa Rita Mountains, in microscopic cavities of amygdaloidal basalts, Rosemont camp.

*Yavapai County*.—As small crystal grains making up the bulk of granular beds in the Big Sandy Valley a few miles east of Wikieup.

## THOMSONITE

$(\text{Ca}, \text{Na}_2)\text{Al}_2\text{SiO}_8 \cdot 2\frac{1}{2}\text{H}_2\text{O}$ . Snow-white to reddish green; impure varieties brown. Luster vitreous to pearly. Transparent to translucent.  $H. = 5-5.5$ .  $G. = 2.4$ . Orthorhombic. Commonly in radiating fibrous spherical concretions; also compact.

Most common in cavities in amygdaloidal lavas, locally with nepheline as an alteration product.

*Pinal County*.—As radiating fibrous amygdules in basalts just east of the highway about midway between Tucson and Florence.

## MUSCOVITE—White Mica

$\text{KAl}_2\text{Si}_2\text{O}_{10}(\text{OH})_2$ . Colorless, gray, brown, pale green, yellow. Luster vitreous to pearly or silky. Transparent to translucent. Streak uncolored.  $H. = 2-2.25$ .  $G. = 2.76-3$ . Monoclinic. Crystals tabular with rhombic or hexagonal outline. Perfect basal cleavage, yielding thin plates which are flexible and elastic. In scales or scaly masses, cryptocrystalline and compact forms. *Sericite* is a finely divided, soft variety.

Most abundant in granitic pegmatite, gneiss, and schist, in places making up a large proportion of the rocks. As sericite, an abundant alteration product in the wall rocks of many ore deposits and widely distributed in sediments and sedimentary rocks. In granite pegmatite muscovite may occur in large plates. An abundant and widely distributed mineral in Arizona.

## Mariposite

A green chromium mica. Exact composition and properties in doubt. Is placed here as a variety of muscovite only for convenience.

*Yuma County*.—Trigo Mountains, Eureka district, disseminated in schist and accompanied by chromite.

## LEPIDOLITE—Lithia Mica

$\text{K}_2\text{Li}_2\text{Al}_2\text{Si}_2\text{O}_{21}(\text{OH}, \text{F})_3$ . Rose-red, violet-gray, lilac, yellowish, grayish, white. Luster pearly. Translucent.  $H. = 2.5-4$ .  $G. = 2.8-3.3$ . Generally in cleavable plates, also coarse to fine granular.

A mineral of lithia-bearing granite pegmatite, generally associated with lithia tourmaline, amblygonite, and spodumene.

*Yavapai County*.—Eureka district, from pegmatites of the Bagdad area.

## ZINNWALDITE

An iron-lithia mica in form near biotite. Pale violet, yellow, brown, and dark gray.

Most commonly in tin- and topaz-bearing pegmatite or in granite.

*Santa Cruz County*.—Patagonia Mountains, from the Line Boy mine, Duquesne.

## BIOTITE—Black Mica

$\text{K}(\text{Mg}, \text{Fe})_3\text{AlSi}_3\text{O}_{10}(\text{OH})_2$ . Deep black or brown to green. Luster splendid, pearly on cleavage surfaces. Transparent to opaque. Streak uncolored.  $H. = 2.5-3$ .  $G. = 2.7-3.1$ . Monoclinic. Crystals tabular or short prismatic. Perfect basal cleavage. In disseminated scales or massive scaly aggregates.

The commonest of the micas. An important constituent of many igneous rocks, gneisses, schists, and contact-metamorphic zones. Widespread in the rocks of the state.

## CHLORITE

Essentially  $(\text{Mg,Fe})_5(\text{Al,Fe}^{++})_2\text{Si}_3\text{O}_{10}(\text{OH})_8$ . Includes several minerals with similar chemical, crystallographic, and physical properties. Generally some shade of green. Luster vitreous to pearly. Transparent to translucent. H. = 2-2.5. G. = 2.6-2.9. Monoclinic. Crystals tabular and pseudo-hexagonal. Perfect basal cleavage, yielding flexible but nonelastic plates. Commonly foliated massive, as scaly aggregates or disseminated particles.

Most common in crystalline schist, in places making up a considerable proportion of the rock. Also resulting from alteration of ferromagnesian silicates such as biotite, pyroxene, or amphibole. Widely distributed in the state.

## VERMICULITE

Includes several hydrated silicates, in part related to the chlorites. Composition varies widely. White to yellow and brown, with pearly or bronzelike luster. Generally soft with micaceous cleavage, occurring in flaky or scaly masses. Exfoliates when heated, swelling to several times the original thickness or opening into long wormlike threads.

An alteration product, chiefly of the micas, found in highly altered rocks.

*Maricopa County.*—Reported from near Aguila and between Wickenburg and the Vulture Mountains.

*Mohave County.*—In northeastern part of Hualpai Mountains.

## SERPENTINE

$\text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_4$ . Green, brownish, and yellowish to white. Luster resinous, greasy, silky to earthy. Translucent to opaque. H. = 2.5-4, may be harder. G. = 2.5-2.65. Fibrous varieties may be less. Monoclinic. *Antigorite* is platy, granular or massive; *chrysotile* is a fibrous variety.

Of secondary origin, from alteration of nonaluminous magnesian silicates, particularly olivine, amphibole, or pyroxene, in places in large rock masses derived from peridotite or other basic igneous rocks. Also a common product of contact metamorphism of magnesian limestones. Chrysotile is the chief source of asbestos.

*Cochise County.*—Tombstone district, in altered limestone, Lucky Cuss mine. Chiricahua Mountains, as chrysotile with contact-metamorphic ores. Dos Cabezas Mountains, in metamorphosed limestone.

*Coconino County.*—Grand Canyon, as chrysotile, Bass and Hance properties, where the pre-Cambrian Bass limestone has been altered by diabase sills.

*Gila County.*—The most extensive deposits of chrysotile in the state are north and northeast of Globe along the Salt River in the vicinity of Chrysotile and along Cherry Creek. The deposits originated through metamorphic action of diabase intrusives upon pre-Cambrian Mescal limestone. Analyses by R. E. Zimmerman as follows:

	MgO	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	FeO	CaO	H <sub>2</sub> O	Total
(1)	42.05	41.56	1.27	0.64	0.00	14.31	99.83
(2)	41.85	41.35	0.91	0.69	0.07	13.34	98.21

Other deposits occur in the Pinal and Mescal mountains and in the Pinto Creek region.

*Greenlee County.*—Clifton-Morenci district, as yellow transparent material on the ridge just west of Morenci, and at the Thompson mine as green, banded material with magnetite.

*Pinal County.*—Globe district, Old Dominion mine, as massive yellow to green material in diabase and Mescal limestone.

## TALC

$\text{Mg}_3\text{Si}_4\text{O}_{10}(\text{OH})_2$ . Green to white; brownish or reddish if impure. Luster pearly to dull. Subtransparent to translucent. Streak white. H. = 1-1.5. Feels greasy. G. = 2.7-2.8. Monoclinic. Perfect basal cleavage yielding thin flexible plates. Generally foliated, also granular to compact massive. Rocklike material is also known as *soapstone* or *steatite*.

Formed by alteration of nonaluminous magnesian silicates. Commonly associated with serpentine.

Abundant in the mining regions of the state where metamorphism has occurred.

## SEPIOLITE—Meerschaum

$Mg_2Si_2O_5 \cdot 2H_2O$ . White, grayish white, or faintly yellowish. Luster dull and earthy. Streak white. H. = 2-2.5. G. = 2. In compact masses with smooth feel and earthy texture, a mixture of fine fibrous material and an amorphous substance apparently of the same composition.

An alteration product of magnesian rocks and generally associated with serpentine or magnesite.

*Maricopa County*.—Reported from a locality 42 miles north of Phoenix and 2 miles east of Highway 69.

## IDDINGSITE

$H_5MgFe_2Si_3O_{14}$  (?). Brown; reddish by transmitted light. Bronzeliike luster. H. = 3. G. = 2.5-3.8. Orthorhombic. Pinacoidal cleavage. As small disseminated flakes or foliated masses.

A relatively uncommon mineral formed by alteration of olivine in basic rocks.

*Cochise County*.—Tombstone district, as microscopic particles in basaltic rocks.

*Gila and Pinal counties*.—Pinal Mountains, as small reddish plates in the basalt flow above the Mescal limestone. Dripping Spring Mountains, as pseudomorphs of olivine in Tertiary basalt.

## GLAUCONITE

$K_2(Mg,Fe)_2Al_6(Si_4O_{10})_3(OH)_{12}$ . Dull green. Soft. Generally amorphous and resembles earthy chlorite.

Abundant only in rocks known as "greensands," and in ocean sediments near continental shores. Believed to have been formed by alteration of such minerals as augite, hornblende, and biotite. Surface oxidation of glauconitic sediments has in some places formed iron ores.

*Mohave County*.—Big Sandy Valley, east of Wickieup, as extensive glauconitic sand beds.

*Greenlee County*.—In Clifton-Morenci district, glauconite (?) occurs in shale of the Morenci formation and in green shales above the Coronado quartzite.

## KAOLINITE—NACRITE—DICKITE

$Al_2Si_2O_5(OH)_4$ . White, grayish, yellowish, also brownish, bluish, or reddish. Luster pearly to dull and earthy. H. = 2-2.5. G. = 2.6-2.63. Monoclinic. Perfect basal cleavage. In thin scales or plates constituting claylike masses.

Kaolinite, nacrite, and dickite are properly termed *kaolin*, and are ordinarily formed from decomposition of feldspars. The term commonly is extended to include other clay minerals of similar composition and origin. Kaolin is abundant in clays, extensive deposits of which occur in the state. Only occurrences of relatively pure material are listed.

*Cochise County*.—Bisbee district, as nearly pure kaolinite in snow-white, waxy masses, from the second level of the Copper Queen mine. Tombstone district, Toughnut mine. Silver Bill mine, Turquoise district.

*Gila County*.—Globe district, in chalcocite and oxidized zones, Old Dominion mine.

*Greenlee County*.—Clifton-Morenci district, in large masses at the Long-fellow mine, and in snow-white mammillary masses with azurite and malachite at the Copper Mountain and Mammoth mines.

*Pima County*.—Silver Bell Mountains, as large masses in wall rock on the upper levels of the El Tiro mine.

## ANAUXITE

$Al_2Si_2O_5 \cdot 2H_2O$ . White. Luster pearly. H. = 2.5. G. = 2.524. Monoclinic. Perfect basal cleavage. In crystal plates with hexagonal outline.

A kaolinlike mineral believed to be of wide occurrence in clays.

*Pima County*.—Roskrige Range, as minute pale brown tabular crystals with tridymite and cristobalite in cavities in andesite.

## MONTMORILLONITE

$(Al,Mg)_8(Si_2O_5)_3(OH)_{10} \cdot 12H_2O$ . White or grayish to rose-red, brownish, bluish, or greenish. Luster feeble. H. = 1-1.5. G. = 2. Massive and claylike. Gives X-ray pattern of kaolinite and may be composed of that mineral enclosing colloidal particles within the structure.

An alteration product of some aluminous mineral. Probably often identified as kaolin. *Bentonite*, an alteration product of volcanic ash or tuff, widely distributed throughout the western United States, is largely composed of montmorillonite.

*Apache, Navajo, and Coconino counties.*—Lenticular beds of bentonite occur in the lower part of the Chinle formation.

*Cochise County.*—East of Elgin.

*Maricopa County.*—Bentonite occurs 2 miles northeast of Wickenburg, and has been reported from the vicinity of Phoenix.

*Mohave County.*—Reported as bentonite from the southern part of the county and east of the Big Sandy River.

*Yavapai County.*—In Thompson Valley, between Kirkland and Yava, in bentonite.

*Yuma County.*—Bentonite occurs near Wellton and Bouse.

## PYROPHYLLITE

$Al_2Si_2O_{10}(OH)_2$ . White, greenish, yellowish. Luster pearly to dull. Subtransparent to opaque. Streak white. H. = 1-2. Feels greasy. G. = 2.8-2.9. Orthorhombic. Good basal cleavage. In radiating, lamellar, or fibrous rosettes, or in foliated, granular compact, or cryptocrystalline masses.

In schistose rocks, largely of metamorphic origin, but may also form as an alteration product. Commonly associated with kyanite. Massive varieties closely resemble talc.

*Mohave County.*—Williams River, near Alamo, Cactus Queen mine.

*Yuma County.*—Near Quartzsite, with dumortierite and kyanite. Also reported from Bouse vicinity.

## NONTRONITE—Chloropal

Perhaps  $H_2Fe_2Si_2O_8$ . Some shade of green or yellow. Luster dull to waxy. Opaque to subtranslucent. H. = 2.5-4.5. G. = 1.727-2.105. Generally compact massive to earthy.

An iron-rich clay mineral, analogous to kaolin and sometimes included as a member of the kaolin group. Commonly mixed with opal. A secondary mineral of uncertain origin. *Morencite* is identical with nontronite.

*Greenlee County.*—Clifton-Morenci district, as silky seams in limy shale, Arizona Central mine.

*Pima County.*—Santa Rita Mountains, in metamorphosed wall rock, Pauline mine, Helvetia district.

*Yavapai County.*—Black Hills, in limonite of the gossan, United Verde mine.

## CHRYSOCOLLA

$CuSiO_3 \cdot 2H_2O$ . Green to bluish green, sky-blue, and turquoise-blue. Luster vitreous to earthy. Translucent to opaque. Streak white. H. = 2.4. G. = 2-2.24. Cryptocrystalline. Generally enamellike in texture, also earthy. Pure mineral 35.8% Cu.

Of secondary origin, formed in practically all oxidized copper deposits. Generally mixed with tenorite and malachite. Only the more important or interesting localities are listed.

*Cochise County.*—Bisbee district, a minor constituent of oxidized ores.

*Gila County.*—Globe district, an important ore mineral, particularly at the Old Dominion mine. Miami district, in the Bulldog tunnel of the Inspiration mine, with malachite, chalcedony, and quartz in aggregates of great beauty; Van Dyke property, with tenorite and azurite.

*Greenlee County.*—Clifton-Morenci district, in places as fine glassy-green specimens.

*Mohave County.*—Near Kingman, as specimen material of fine color, Emerald Isle mine.

*Navajo County.*—White Mesa district, as cementing material in beds of sandstone.

*Pima County.*—Silver Bell Mountains, Silver Bell district. As clear emerald-green material, El Tiro mine. Sierrita Mountains, San Xavier and Mineral Hill districts.

*Pinal County.*—Mammoth mine, in places of gem quality.

*Yavapai County.*—Black Hills, as a mammillary filling in Tertiary conglomerate, Arizona-Dundee property. Bradshaw Mountains, bright blue material, Copperopolis and Whipsaw properties, Castle Creek district.

*Yuma County.*—Buckskin Mountains, Planet mine.

## SHATTUCKITE

$2\text{CuSiO}_3 \cdot \text{H}_2\text{O}$ . Color blue. G. = 3.8. Monoclinic. In compact, granular, or fibrous masses.

An alteration product of other secondary copper minerals.

*Cochise County.*—Bisbee district, Shattuck mine.

*Pima County.*—Ajo, in veins, New Cornelia mine.

## BISBEEITE

$\text{CuSiO}_3 \cdot \text{H}_2\text{O}$ . Color pale blue to nearly white. Orthorhombic. In massive aggregates of fibers or thin laths.

Formed by hydration of shattuckite, with which it is associated.

*Cochise County.*—Bisbee district, Shattuck mine.

*Pima County.*—Ajo, in veins, New Cornelia mine.

## THAUMASITE

$\text{Ca}_3\text{SiO}_3(\text{CO}_3)(\text{SO}_4) \cdot 15\text{H}_2\text{O}$ . White. Luster somewhat greasy to silky. H. = 3.5. G. = 1.877. Hexagonal. Generally in compact masses, commonly with a delicately fibrous structure.

*Cochise County.*—Tombstone district, Lucky Cuss mine.

TITANATES, NIOBATES, TANTALATES

Arizonite	$\text{Fe}_2\text{Ti}_3\text{O}_9$	Tapiolite	$(\text{Fe},\text{Mn})(\text{Nb},\text{Ta})_2\text{O}_6$
Fergusonite	$\text{R}''(\text{Cb},\text{Ta})\text{O}_4$	Euxenite	Complex
Samarskite	$\text{R}_2\text{R}_2''(\text{Nb},\text{Ta})_6\text{O}_{21}$		

ARIZONITE

$\text{Fe}_2\text{Ti}_3\text{O}_9$ . Dark steel-gray. Streak brown. H. = 5.5. G. = 4.25. Monoclinic (?). In crystals with rough faces.

Only known occurrence in Mohave County, with gadolinite in pegmatite of the Aquarius Range, 25 miles south of Hackberry. Analysis by Chase Palmer as follows:

$\text{TiO}_2$	$\text{SiO}_2$	FeO	$\text{Fe}_2\text{O}_3$	$\text{H}_2\text{O}$	Total
58.82	1.02	0.70	38.38	1.10	100.12

FERGUSONITE

$\text{R}''(\text{Cb},\text{Ta})\text{O}_4$ . R mostly yttrium. Brownish black. Luster dull to vitreous and submetallic. Opaque. Streak pale brown. H. = 5.5-6. G. = 5.8. Tetragonal-pyramidal. In pyramidal or prismatic crystals. Also massive.

Of uncommon occurrence, generally in acid pegmatite with other rare-earth minerals.

*Yavapai County*.—Specimens have been received by the Arizona Bureau of Mines from the vicinity of Yarnell Hill.

SAMARSKITE

A niobate and tantalate of iron, calcium, uranium, and the cerium and yttrium metals. Velvet-black. Luster vitreous to resinous. Streak dark reddish brown. H. = 5-6. G. = 5.6-5.8. Orthorhombic. Crystals rectangular prisms with rough faces. Imperfect brachypinacoidal cleavage. Commonly massive and in flattened disseminated grains.

Generally in small amounts in pegmatite with other rare-earth minerals.

*Mohave County*.—Aquarius Range, with allanite in pegmatite.

*Yavapai County*.—Black Hills, reported from near Jerome.

TAPIOLITE

$(\text{Fe},\text{Mn})(\text{Nb},\text{Ta})_2\text{O}_6$ . Black. H. = 6. G. = 7.3-7.8. Tetragonal. In square pyramidal crystals.

An uncommon mineral generally found in pegmatite.

*Yavapai County*.—Bradshaw Mountains, in stream gravels on Castle Creek.

EUXENITE

A niobate and titanate of yttrium, erbium, cerium, and uranium. Color brownish black. H. = 6.5. G. = 4.7-5. Pseudo-orthorhombic. Massive.

Found only in pegmatite. Rare in the United States.

*Mohave County*.—Cerbat Range, as scattered masses up to 50 pounds weight in pegmatite, Kingman Feldspar mine. Similarly east of the Big Sandy River, south of Burro Creek.

PHOSPHATES, ARSENATES, VANADATES, ANTIMONATES

Monazite	(Ce,La,Di)PO <sub>4</sub>	Hewettite	Ca(VO <sub>4</sub> ) <sub>2</sub> ·9H <sub>2</sub> O
Apatite	Ca <sub>5</sub> (F,Cl)(PO <sub>4</sub> ) <sub>3</sub>	Conichalcite	(Cu,Ca) <sub>2</sub> AsO <sub>4</sub> (OH)·½H <sub>2</sub> O (?)
Pyromorphite	Pb <sub>5</sub> Cl(PO <sub>4</sub> ) <sub>3</sub>	Volborthite	Vanadate of Cu, Ba, and Ca
Mimetite	Pb <sub>5</sub> Cl(AsO <sub>4</sub> ) <sub>3</sub>	Bermanite	(Mn <sup>++</sup> ,Mg) <sub>5</sub> Mn <sub>2</sub> (PO <sub>4</sub> ) <sub>8</sub> ·(OH) <sub>10</sub> ·15H <sub>2</sub> O
Vanadinite	Pb <sub>5</sub> Cl(VO <sub>4</sub> ) <sub>3</sub>	Chalcophyllite	Cu <sub>20</sub> Al <sub>2</sub> (AsO <sub>4</sub> ) <sub>4</sub> (SO <sub>4</sub> ) <sub>2</sub> ·(OH) <sub>14</sub> ·11H <sub>2</sub> O (?)
Triplite	(Fe,Mn) <sub>3</sub> F <sub>2</sub> (PO <sub>4</sub> ) <sub>2</sub> (?)	Turquoise	Al <sub>2</sub> (OH) <sub>3</sub> PO <sub>4</sub> ·H <sub>2</sub> O+xCu
Olivinite	Cu <sub>2</sub> AsO <sub>4</sub> (OH)	Chalcosiderite	CuFe <sub>6</sub> (OH) <sub>3</sub> (PO <sub>4</sub> ) <sub>4</sub> ·10H <sub>2</sub> O (?)
Higginsite	CuCa(AsO <sub>4</sub> ) <sub>2</sub> (OH) <sub>2</sub>	Torbernite	Cu(UO <sub>2</sub> ) <sub>2</sub> (PO <sub>4</sub> ) <sub>2</sub>
Libethenite	Cu <sub>2</sub> (PO <sub>4</sub> )(OH)	Carnotite	K <sub>2</sub> (UO <sub>2</sub> ) <sub>2</sub> (VO <sub>4</sub> ) <sub>2</sub> ·8H <sub>2</sub> O
Brackebuschite	(Pb,Mn,Fe) <sub>3</sub> (VO <sub>4</sub> ) <sub>2</sub> (?)	Tyuyamunite	Ca(UO <sub>2</sub> ) <sub>2</sub> (VO <sub>4</sub> ) <sub>2</sub> ·H <sub>2</sub> O (?)
Calciovolborthite	(Cu,Ca) <sub>2</sub> VO <sub>4</sub> (OH) (?)	Bindheimite	Lead antimonate
Descloizite	PbZnVO <sub>4</sub> (OH)	Ecdemite	Pb <sub>3</sub> Cl <sub>2</sub> AsO <sub>4</sub> (?)
Cuprodescloizite	Pb(Cu,Zn)VO <sub>4</sub> (OH)	Beudantite	PbFe <sub>2</sub> (SO <sub>4</sub> )(AsO <sub>4</sub> ) <sub>6</sub> ·6H <sub>2</sub> O (?)
Mottramite	PbCuVO <sub>4</sub> (OH)		
Erythrite	Co <sub>3</sub> (AsO <sub>4</sub> ) <sub>2</sub> ·8H <sub>2</sub> O		

MONAZITE

(Ce,La,Di)PO<sub>4</sub>, with thorium oxide up to 20%. Reddish, brownish, yellowish. Luster resinous. Subtransparent to subtranslucent. H. = 5-5.5. G. = 4.9-5.3. Monoclinic. Crystals small and flattened. Perfect basal cleavage. In masses yielding angular fragments and in rolled grains. The chief source of thorium oxide.

An accessory mineral in granite, gneiss, aplite, and pegmatite. Commercial quantities only in placers.

*Mohave County*.—Mohave Mountains, Chemehuevis district, 20 miles southeast of Topock, sparingly in stream gravels.

APATITE

Ca<sub>5</sub>(F,Cl)(PO<sub>4</sub>)<sub>3</sub>. White or a light shade of green or blue, less commonly yellow, gray, red, or brown. Luster vitreous to resinous. Transparent to opaque. H. = 5. G. = 3.17-3.23. Hexagonal-pyramidal. Crystals prismatic. Imperfect basal cleavage. In granular masses.

An accessory mineral, generally as minute crystals. More abundant in metamorphic rocks, particularly granular limestone. In places as beds in sedimentary rocks. A source of mineral fertilizers.

*Graham County*.—Aravaipa district, in micropegmatite, Fisher prospect, Turnbull Mountain.

*Pinal County*.—Galiuro Mountains, as crystals up to several inches long, Childs-Aldwinkle and Old Reliable mines, Copper Creek district.

*Yavapai County*.—As large crystals in granodiorite, Springfield group, Pine Grove district. Eureka district, as an accessory in titaniferous magnetite ores near Bagdad.

PYROMORPHITE

Pb<sub>5</sub>Cl(PO<sub>4</sub>)<sub>3</sub>. Most commonly green, yellow, or brown. Luster resinous. Subtransparent to translucent. Streak white or yellowish. H. = 3.5-4. G. = 6.5-7.1. Hexagonal-pyramidal. Crystals prismatic. In globular, reniform, or botryoidal masses or incrustations. Pure mineral 76.4% Pb.

Common in oxidized lead deposits, generally in small quantity. Formed through action of phosphoric acid upon galena and cerussite.

*Cochise County*.—Tombstone district, as tiny crystals.

*Pima County*.—Cerro Colorado Mountains, Cerro Colorado mine.

*Pinal County*.—Mammoth mine as olive-green prisms on mottramite.

*Santa Cruz County*.—Patagonia Mountains, as incrustations, Trench mine, Harshaw district; Javelina prospect, Patagonia district.

MIMETITE

Pb<sub>5</sub>Cl(AsO<sub>4</sub>)<sub>3</sub>. White, yellow, brown. Luster resinous. Subtransparent to translucent. Streak white. H. = 3.5. G. = 7-7.25. Hexagonal-pyramidal. Crystals like pyromorphite in habit. In mammillary crusts. *Endlichite* is intermediate between mimetite and vanadinite.

Of uncommon occurrence. Formed by alteration of lead ores.

*Cochise County*.—Gallagher Vanadium property, near Charleston. Also at Bisbee.

*Pinal County*.—Mammoth mine, as bright orange or canary-yellow crusts or as coatings of tiny prismatic crystals. Galiuro Mountains, with wulfenite, vanadinite, and quartz, Table Mountain mine.

*Yavapai County*.—Vulture district, in considerable masses, Domingo mine, Castle Creek.

*Yuma County*.—Castle Dome Mountains, Castle Dome district.

#### VANADINITE

$\text{Pb}_2\text{Cl}(\text{VO}_3)_2$ . Red, orange, or yellow. Luster resinous. Subtranslucent to opaque. Streak white or yellowish.  $H. = 2.75-3$ .  $G. = 6.66-7.1$ . Hexagonal-pyramidal. Crystals prismatic, commonly with hollow basal pinacoid. Also as globular incrustations. Pure mineral 19.3%  $\text{V}_2\text{O}_5$ , 73.1% Pb.

A comparatively rare mineral of some oxidized lead deposits, with wulfenite, descloizite, and cerussite.

*Cochise County*.—Tombstone district, on calcite, Tribute and Tombstone Extension mines. Gallagher Vanadium property, near Charleston. Huachuca Mountains.

*Gila County*.—Globe district, as splendid crystal specimens, Apache Vanadium property, 8 miles north of Globe. Dripping Spring Mountains, "79," McHur, Premier, and C and B (International) properties, Banner district.

*Maricopa County*.—Vulture Mountains, Collateral, Phoenix, Montezuma, and Frenchman mines. Hieroglyphic Mountains, with wulfenite in veins, White Peak district.

*Mohave County*.—Cerberat Range, El Dorado and Climax mines, Gold Basin district.

*Pima County*.—Tucson Mountains, Old Yuma mine, magnificent crystal specimens. Empire Mountains, Total Wreck mine.

*Pinal County*.—Mammoth mine, as splendid groups of crystals with wulfenite and descloizite. Dripping Spring Mountains, 4 miles east of Kelvin. Superior district, Black Prince mine, as doubly terminated crystals.

*Yuma County*.—Trigo Mountains, as fine crystal aggregates, Silver Clip and Princess mines, and as brilliant deep red crystals, Red Cloud mine. Also reported from the Chocolate Mountains.

#### TRIPLITE

$(\text{Fe}, \text{Mn})_5\text{F}_2(\text{PO}_3)_2$  (?). Brown or blackish brown. Luster resinous. Subtranslucent to opaque. Streak yellowish, gray, or brown.  $H. = 4-5.5$ .  $G. = 3.44-3.8$ . Monoclinic. Cleavage in two directions. Massive.

An unusual mineral found in pegmatite.

*Yavapai County*.—Eureka district, as a spherical segregation about 2 feet in diameter, in a small pegmatite knot on the 7 U 7 ranch. Analysis by F. A. Gonyer as follows:

FeO	MnO	MgO	CaO	Na <sub>2</sub> O	H <sub>2</sub> O	P <sub>2</sub> O <sub>5</sub>	F	Total
11.68	34.55	11.87	2.48	0.52	0.75	33.32	8.02	99.81

Also at other localities in the same general area.

#### OLIVENITE

$\text{Cu}_2\text{AsO}_4(\text{OH})$ . Various shades of green to yellowish. Luster adamantine to vitreous. Subtransparent to opaque. Streak olive-green to brown.  $H. = 3$ .  $G. = 4.1-4.4$ . Orthorhombic. Generally in crystals. Also globular, reniform, fibrous, and granular.

A rare secondary mineral of copper deposits.

*Pinal County*.—Galiuro Mountains, Copper Creek district, as small olive-green crystals, Old Reliable mine.

#### HIGGINSITE

$\text{CuCa}(\text{AsO}_4)_2(\text{OH})_2$ . Deep green to yellowish green. Transparent.  $H. = 4.5$ .  $G. = 4.33$ . Orthorhombic. In small prismatic crystal incrustations.

A secondary mineral in seams and cavities of copper ore bodies.

*Cochise County*.—Bisbee district, originally described from the Higgins mine, as crystals and small masses in manganese oxides. Analysis by E. V. Shannon as follows:

CuO	CaO	V <sub>2</sub> O <sub>5</sub>	As <sub>2</sub> O <sub>5</sub>	H <sub>2</sub> O	Fe <sub>2</sub> O <sub>3</sub>	MnO	Insol.	Total
28.27	20.83	1.97	41.23	3.49	0.48	2.84	0.86	100.37

## LIBETHENITE

$\text{Cu}_2(\text{PO}_4)(\text{OH})$ . Dark olive-green. Luster resinous. Translucent to subtranslucent. Streak olive-green. H. = 4. G. = 3.6-3.8. Orthorhombic. Crystals short prismatic. In globular, reniform, or compact masses.

A rare mineral found in a few copper deposits of the world.

*Greenlee County*.—Morenci district, as small crystals in cavities, Coronado mine.

## BRACKEBUSCHITE

$(\text{Pb}, \text{Mn}, \text{Fe})_3(\text{VO}_4)_2$  (?). Black. Monoclinic (?). In prismatic crystals.

A secondary mineral, in small quantities with other vanadium minerals.

*Cochise County*.—Reported in minute amounts from the Gallagher Vanadium property, near Tombstone.

## CALCIOVOLBORTHITE

$(\text{Cu}, \text{Ca})_2\text{VO}_4(\text{OH})$  (?). Yellow green. H. = 3.5. G. = 3.5. Monoclinic (?). In pseudohexagonal scales, rosettes, and as fine granular masses.

A secondary mineral, in small quantities accompanying other vanadium minerals.

*Cochise County*.—Reported from the Gallagher Vanadium property, near Tombstone.

## DESCLOIZITE—CUPRODESCLOIZITE—MOTTRAMITE

$\text{PbZnVO}_4(\text{OH})$  to  $\text{PbCuVO}_4(\text{OH})$ , and forming a continuous series. Red, brownish red, brown, black. Translucent. Streak orange to brownish red or yellowish gray. H. = 3.5. G. = 5.9-6.2. Orthorhombic. Generally in drusy aggregates of small crystals. *Psittacinite* is synonymous with mottramite. Pure mineral about 40% V<sub>2</sub>O<sub>5</sub>.

Of secondary origin, in small amounts in some oxidized lead-zinc or copper deposits.

*Cochise County*.—Bisbee district, mottramite, as crystals from the Higgins mine, and as reniform masses from the Shattuck mine. Tombstone district, mottramite, as brilliant black crystals, Lucky Cuss and Toughnut mines. As descloizite, Tombstone Extension and Toughnut mines. Pat Hills, as mottramite.

*Gila County*.—Payson district, as cuprodescloizite in small amounts, Ox Bow and Zulu mines. Globe district, 2 miles north of the Old Dominion mine, as descloizite.

*Pima County*.—Tucson Mountains, as cuprodescloizite, Old Yuma mine. Analysis by F. N. Guild as follows:

V <sub>2</sub> O <sub>5</sub>	PbO	CuO	ZnO	MnO	H <sub>2</sub> O	Total
23.02	52.26	11.64	6.71	2.16	2.52	98.31

*Pinal County*.—Mammoth mine, as descloizite and mottramite, forming crusts of small pointed crystals. Dripping Spring Mountains, 4 miles east of Kelvin.

*Mohave County*.—Grand Wash Cliffs, as descloizite, Grand Gulch mine, Bentley district.

*Santa Cruz County*.—Near Nogales, locality unknown, as reddish fibrous layers of cuprodescloizite up to an inch thick.

## ERYTHRITE—Cobalt Bloom

$\text{Co}_3(\text{AsO}_4)_2 \cdot 8\text{H}_2\text{O}$ . Crimson to peach-red. Luster adamantine, vitreous, or pearly to dull and earthy. Transparent to subtranslucent. Streak paler than the color. H. = 1.5-2.5. G. = 2.95. Monoclinic. Crystals prismatic and vertically striated. Perfect pinacoidal cleavage. Globular, reniform, or earthy.

Of secondary origin, characteristic of outcrops of cobalt ores.

*Gila County*.—Reported from ½ mile northeast of the Oxbow Bend of the Salt River.

*Yavapai County*.—Black Hills, as powdery incrustations from alteration of cobaltite near claims of the old Prudential Copper Mining Co.

## HEWETTITE

$\text{Ca}(\text{VO}_3)_2 \cdot 9\text{H}_2\text{O}$ . Deep red.  $G. = 2.5\text{-}2.6$ . Orthorhombic. In needles or fibrous incrustations.

A rare secondary product found with other vanadium minerals.

*Apache County*.—Carrizo Mountains, as hairlike crystals and fibrous incrustations in sandstone with carnotite.

## CONICHALCITE

Perhaps  $(\text{Cu,Ca})_2\text{AsO}_4(\text{OH}) \cdot \frac{1}{2}\text{H}_2\text{O}$ . Pistachio-green to emerald-green.  $H. = 4.5$ .  $G. = 4.1$ . Orthorhombic. Fibrous. Resembles malachite.

An uncommon secondary mineral of oxidized copper deposits.

*Gila County*.—Globe Hills, Copper Hill mine.

## VOLBORTHITE

A hydrous vanadate of copper, barium, and calcium. Olive-green to citron-yellow. Pearly to vitreous luster. Streak yellowish green.  $H. = 3$ .  $G. = 3.5$ . Monoclinic (?). In small six-sided tablets or globular forms.

A rare mineral of uncertain origin. Reported from copper and lead ores of the state (1:17) but no specific localities were given.

## BERMANITE

$(\text{Mn}^{\prime},\text{Mg})_3\text{Mn}_3(\text{PO}_4)_8(\text{OH})_{10} \cdot 15\text{H}_2\text{O}$ . Reddish brown.  $H. = 3.5$ .  $G. = 2.84$ . Orthorhombic. Perfect basal, imperfect prismatic cleavage. Crystals of pronounced tabular habit. Also cleavable massive.

A new species discovered in 1936 in a pegmatite knot on the 7 U 7 ranch near the Bagdad mine, Yavapai County, as narrow veinlets and small crystals in triplite. Accompanied by torbernite and other phosphates. Analysis by F. A. Gonyer as follows:

$\text{Fe}_2\text{O}_3$	$\text{Mn}_2\text{O}_3$	MnO	MgO	CaO	$\text{Na}_2\text{O}$	$\text{H}_2\text{O}$	$\text{P}_2\text{O}_5$	Total
3.03	26.76	13.79	2.39	0.72	0.32	19.33	31.39	99.73

## CHALCOPHYLLITE

$\text{Cu}_{20}\text{Al}_2(\text{AsO}_4)_4(\text{SO}_4)_2(\text{OH})_{14} \cdot 11\text{H}_2\text{O}$  (?). Emerald-green to grass-green. Luster vitreous. Transparent to translucent. Streak paler than the color.  $H. = 2$ .  $G. = 2.4\text{-}2.66$ . Rhombohedral. Crystals tabular. Perfect basal cleavage. As foliated masses or in druses.

A comparatively rare secondary mineral of oxidized copper deposits.

*Cochise County*.—Bisbee district, in irregular crystal plates imbedded in connellite, Calumet and Arizona mine.

## TURQUOISE

$\text{Al}_2(\text{OH})_2\text{PO}_4 \cdot \text{H}_2\text{O} + x\text{Cu}$ . Sky-blue, bluish green to apple-green. Luster waxy. Streak white or greenish.  $H. = 5\text{-}6$ .  $G. = 2.6\text{-}2.83$ . Triclinic. Massive, with amorphous or cryptocrystalline structure. In thin seams, disseminated grains, or incrustations.

An uncommon mineral of secondary origin, found in altered rocks.

*Cochise County*.—Turquoise district, as stringers up to a few inches wide and small nuggetlike masses in granite and quartzite. Bisbee, as minute stringers in massive pyrite, 1,200-foot level, Cole shaft. Also reported from Pearce vicinity.

*Gila County*.—Globe district, in small amount with copper ores. Miami district, Castle Dome mine, with chrysocolla.

*Maricopa County*.—Reported 12 miles east of Morristown.

*Mohave County*.—Cerbat Range, Ithaca Peak, Mineral Park district, as gem material in porphyry cutting schist and gneiss.

*Pinal County*.—Reported 2 miles south of Kelvin.

## CHALCOSIDERITE

$\text{CuFe}_2(\text{OH})_3(\text{PO}_4)_4 \cdot 10\text{H}_2\text{O}$  (?). Light siskin-green.  $H. = 4.5$ .  $G. = 3.1$ . Triclinic. As incrustations of sheaflike crystal groups.

A rare secondary mineral, found in oxidized copper deposits.  
*Cochise County*.—Bisbee district, in small quantity.

## TORBERNITE

$\text{Cu}(\text{UO}_2)_2(\text{PO}_4)_2$ . Various shades of green. Luster subadamantine to pearly. Transparent to subtranslucent. Streak paler than the color. Orthorhombic, pseudotetragonal. Crystals have square outlines. Perfect basal cleavage. Foliated, micaceous.

A rare mineral generally associated with other uranium minerals.  
*Yavapai County*.—Eureka district, in small amounts with bermanite and triplite in a pegmatite knot on the 7 U 7 ranch.

## CARNOTITE

$\text{K}_2(\text{UO}_2)_2(\text{VO}_4)_2 \cdot 8\text{H}_2\text{O}$ . As yellow crystalline powder, or in loosely cohering masses, intimately mixed with sandy rock. Pure mineral 64.5%  $\text{U}_3\text{O}_8$ , 21.2%  $\text{V}_2\text{O}_5$ .

*Apache County*.—West of Carrizo Mountains, in Morrison (McElmo) sandstone.

*Navajo County*.—Monument Valley, with fossil wood in Shinarump sandstone.

*Maricopa County*.—Vulture Mountains, southeast of Aguila, in tuff.

## TYUYAMUNITE—Calciocarnotite

$\text{Ca}(\text{UO}_2)_2(\text{VO}_4)_2 \cdot \text{H}_2\text{O}$  (?). Soft.  $G. = 3.7-4.3$ . Orthorhombic. One perfect and two distinct pinacoidal cleavages. As scales, or cryptocrystalline and earthy.

A rare mineral in places accompanying carnotite.  
*Cochise County*.—Bisbee district, in small amount from an unknown locality.

## BINDHEIMITE

A hydrous antimonate of lead. Color and streak gray, brownish, or yellowish. Resinous luster. Amorphous. As reniform or earthy masses or incrustations.

A secondary mineral, generally in small quantities in oxidized antimonial lead ores.

*Cochise County*.—Tombstone district, as yellowish gray spots in siliceous ores.

*Santa Cruz County*.—Patagonia Mountains, in small amounts, Mowry mine.

## ECDEMITTE

$\text{Pb}_2\text{Cl}_2\text{AsO}_4$  (?). Bright yellow to green.  $H. = 2.5$ .  $G. = 6.9-7.1$ . Tetragonal. As incrustations of tiny prismatic crystals. Also massive.

A rare secondary mineral found in some oxidized lead ores.

*Pinal County*.—Mammoth mine, as bright orange incrustations on wulfenite crystals.

## BEUDANTITE

$\text{PbFe}_3(\text{SO}_4)(\text{AsO}_4)_6 \cdot 6\text{H}_2\text{O}$  (?). Green to brown and black.  $H. = 4$ .  $G. = 4.1$ . Rhombohedral crystals with basal cleavage.

A rare mineral generally found in limonitic ores.

*Pinal County*.—Mammoth, on the upper levels of the Collins mine, as tufts of yellowish green fibers.

SULFATES, CHROMATES, TELLURITES

Thenardite	$\text{Na}_2\text{SO}_4$	Kornelite	$\text{Fe}_2(\text{SO}_4)_3 \cdot 7\text{H}_2\text{O}$
Glauberite	$\text{Na}_2\text{Ca}(\text{SO}_4)_2$	Coquimbite	$\text{Fe}_2(\text{SO}_4)_3 \cdot 9\text{H}_2\text{O}$
Barite	$\text{BaSO}_4$	Alumogen	$\text{Al}_2(\text{SO}_4)_3 \cdot 16\text{H}_2\text{O}$
Celestite	$\text{SrSO}_4$	Ransomite	$\text{Cu}(\text{Fe}, \text{Al})_2(\text{SO}_4)_4 \cdot 7\text{H}_2\text{O}$ (?)
Anglesite	$\text{PbSO}_4$	Guildite	$(\text{Cu}, \text{Fe}''')(\text{Fe}''', \text{Al})_2(\text{SO}_4)_2 \cdot 9\text{H}_2\text{O}$ (?)
Crocoite	$\text{PbCrO}_4$	Louderbackite	$\text{Fe}''(\text{Fe}''', \text{Al})_3(\text{SO}_4)_5 \cdot 17\text{H}_2\text{O}$ (?)
Phoenicochroite	$\text{Pb}_3\text{Cr}_2\text{O}_8$	Voltaite	$(\text{K}_3, \text{Fe}'')(\text{Al}, \text{Fe}''')_3(\text{SO}_4)_3 \cdot 9\text{H}_2\text{O}$ (?)
Vauquelinite	$(\text{Pb}, \text{Cu})_5(\text{PO}_4)_2(\text{CrO}_4)_2$ (?)	Roemerite	$\text{Fe}''\text{Fe}_2''(\text{SO}_4)_4 \cdot 14\text{H}_2\text{O}$
Leadhillite	$\text{Pb}(\text{CO}_3)_3\text{SO}_4 \cdot \text{H}_2\text{O}$	Cyanotrichite	$\text{Cu}_4\text{Al}_2\text{SO}_4 \cdot 8\text{H}_2\text{O}$
Connellite	$\text{Cu}_{22}\text{Cl}_4(\text{OH})_{32}\text{SO}_4 \cdot \text{H}_2\text{O}$ (?)	Beaverite	$\text{CuPbFe}_2(\text{SO}_4)_3 \cdot 4\text{H}_2\text{O}$
Spangolite	$\text{Cu}_{10}\text{AlCl}_2\text{SO}_{10} \cdot 9\text{H}_2\text{O}$	Copiapite	$\text{Fe}_4(\text{OH})_2(\text{SO}_4)_5 \cdot 18\text{H}_2\text{O}$ (?)
Brochantite	$\text{Cu}_2(\text{OH})_6\text{SO}_4$	Rhombochase	$\text{Fe}_2(\text{SO}_4)_4 \cdot 9\text{H}_2\text{O}$
Antlerite	$\text{Cu}_3(\text{OH})_4\text{SO}_4$	Lausenite	$\text{Fe}_2(\text{SO}_4)_3 \cdot 6\text{H}_2\text{O}$ (?)
Caledonite	$(\text{Cu}, \text{Pb})(\text{OH})\text{SO}_4 + \text{CO}_2$ (?)	Butlerite	$(\text{Fe}, \text{Al})_2(\text{SO}_4)_2 \cdot 5\text{H}_2\text{O}$
Linarite	$(\text{Pb}, \text{Cu})_2(\text{OH})_2\text{SO}_4$	Alunite	$\text{KAl}_3(\text{OH})_6(\text{SO}_4)_2$
Mirabilite	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$	Jarosite	$\text{KFe}_3(\text{OH})_6(\text{SO}_4)_2$
Gypsum	$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$	Plumbojarosite	$\text{PbFe}_3(\text{OH})_{12}(\text{SO}_4)_4$
Epsomite	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	Chalcoalumite	$\text{CuAl}_3\text{SO}_4 \cdot 9\text{H}_2\text{O}$
Goslarite	$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$	Emmonsite	Ferric tellurite (?)
Melanterite	$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$		
Pisanite	$(\text{Fe}, \text{Cu})\text{SO}_4 \cdot 7\text{H}_2\text{O}$		
Chalcanthite	$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$		
Halotrichite	$\text{FeAl}_2(\text{SO}_4)_4 \cdot 22\text{H}_2\text{O}$		

THENARDITE

$\text{Na}_2\text{SO}_4$ . White, grayish, or brownish. Luster vitreous. Translucent to opaque. Streak white. Water soluble.  $H. = 2.7$ .  $G. = 2.68$ . Orthorhombic. Crystals pyramidal, short prismatic, or tabular. Good basal cleavage. In cleavable masses.

Formed by evaporation of salt lakes, commonly along the shores.

*Pinal County*.—Near Maricopa.

*Yavapai County*.—Verde Valley, as extensive beds in the salt deposits 3 miles southwest of Camp Verde.

GLAUBERITE

$\text{Na}_2\text{Ca}(\text{SO}_4)_2$ . Pale yellow to gray; also brick-red. Luster vitreous. Transparent to translucent. Streak white. Taste saline.  $H. = 2.5-3$ .  $G. = 2.7-2.85$ . Monoclinic. Crystals tabular or prismatic in habit. Perfect basal cleavage.

Found in small quantities in salt beds.

*Yavapai County*.—In salt deposits of the Verde Valley, 3 miles southwest of Camp Verde.

BARITE

$\text{BaSO}_4$ . White, yellow, gray, blue, red, or brown. Luster vitreous. Transparent to opaque. Streak white.  $H. = 2.5-3.5$ .  $G. = 4.3-4.6$ . Orthorhombic. Crystals tabular or prismatic. Perfect basal and prismatic cleavage. Granular massive, lamellar, or concretionary. Pure mineral 65.7% BaO.

As a gangue mineral with sulfide ores. Also in veins or massive beds. Only the more important occurrences are listed.

*Cochise County*.—Tombstone district, Ground Hog mine, as a vein, and near the Lucky Cuss mine as white crystals. Dragoon Mountains, as veins, Middle Pass.

*Coconino County*.—Grand Canyon, as crystal masses in caves, Kaibab Trail.

*Gila County*.—Richmond Basin, abundant in veins.

*Graham County*.—Stanley district, abundant in several veins near Stanley Butte. Reported south of Klondike.

*Maricopa County*.—Goldfield Mountains, as veins.

*Mohave County*.—Reported 20 miles from Boulder Dam. Aquarius Range, as veins. Near Alamo crossing, as veins.

*Pima County*.—Comobabi Mountains, Cobabi district, with galena in veins.

*Pinal County*.—Galiuro Mountains, as tabular crystals and crystal groups, Old Reliable mine, Copper Creek district. Mammoth mine, as groups of large tabular crystals.

*Yavapai County.*—Bradshaw Mountains, gangue in several mines. Eureka district, Bagdad mine.

*Yuma County.*—Trigo Mountains, Mandeville claims, in veins. Castle Dome Mountains, in many veins, and as large, clear crystals with wulfenite and fluorite, Castle Dome mines. Mohawk Mountains, Barite mine, as white to pink radiating crystals in calcite veins.

## CELESTITE

$\text{SrSO}_4$ . White or bluish; reddish. Luster vitreous to pearly. Transparent to sub-translucent.  $H. = 3-3.5$ .  $G. = 3.95-3.97$ . Orthorhombic. Crystals like barite. Perfect basal, nearly perfect prismatic cleavage. Fibrous, columnar, and granular massive. Pure mineral 56.4%  $\text{SrO}$ .

In veins, beds, or lenticular masses in limestone or sandstone. Also with gypsum and halite, and in gangue of lead-zinc ores.

*Maricopa County.*—With gypsum in sandstone and conglomerate 15 miles south of Gila Bend. In fanglomerate, northeast slope of the Vulture Mountains, 15 miles southeast of Aguila.

## ANGLESITE

$\text{PbSO}_4$ . White; also yellow, brown, or gray. Luster adamantine to dull. Transparent to opaque. Streak uncolored.  $H. = 2.75-3$ .  $G. = 6.3-6.39$ . Orthorhombic. Crystals prismatic or tabular. Distinct basal and prismatic cleavage. Granular to compact massive. Pure mineral 68.3%  $\text{Pb}$ .

Abundant in oxidized lead deposits, most commonly as masses surrounding galena and cerussite.

*Cochise County.*—Tombstone district, with galena, Tombstone Extension mine. Dragoon Mountains, as crystals in cavities, Silver Bill mine.

*Gila County.*—Dripping Spring Mountains, in large quantity with cerussite, wulfenite, and vanadinite, "79" mine, Banner district. Globe district, Lost Gulch mine.

*Graham County.*—Aravaipa and Stanley districts.

*Mohave County.*—Cerbat Range, at the Tennessee-Schuykill mine, Wallapai district; in several mines of the Mineral Park district.

*Pima County.*—Empire Mountains, in the mines of the Hilton group. Sierrita Mountains, abundant at the Paymaster mine, Olive camp. Quijotoa Mountains, at the Morgan mine.

*Pinal County.*—Galiuro Mountains, at the Saddle Mountain group. At the Mammoth mine.

*Santa Cruz County.*—Patagonia Mountains, at the Westinghouse and Mowry mines.

*Yavapai County.*—Bradshaw Mountains, in the Copperopolis mine, Castle Creek district.

*Yuma County.*—Castle Dome Mountains, Castle Dome district.

## CROCOITE

$\text{PbCrO}_4$ . Bright red. Luster adamantine to vitreous. Translucent. Streak orange-yellow.  $H. = 2.5-3$ .  $G. = 5.9-6.1$ . Monoclinic. Crystals prismatic. Distinct prismatic cleavage. Columnar and granular massive.

An unusual secondary mineral of oxidized lead deposits, formed by action of chromic acid.

*Maricopa County.*—Vulture Mountains, Collateral, Chromate, Blue Jay, and Phoenix mines.

*Pinal County.*—Mammoth mine, in small amounts with vanadinite and wulfenite.

*Yuma County.*—Reported from the Castle Dome Mountains (1:17).

## PHOENICOCHROITE

$\text{Pb}_3\text{Cr}_2\text{O}_6$ . Cochineal- to hyacinth-red.  $H. = 3$ .  $G. = 5.75$ . Orthorhombic. One perfect cleavage. As crystals and massive material.

A rare secondary mineral accompanying crocoite in oxidized lead deposits.

*Maricopa County.*—Vulture Mountains, Collateral, Chromate, Blue Jay, and Phoenix mines.

## VAUQUELINITE

$(\text{Pb,Cu})_2(\text{PO}_4)_2(\text{CrO}_4)_2$  (?). Green to brown. H. = 2.5-3. G. = 6. Monoclinic. In crystals, mammillary, and reniform masses.

A rare secondary mineral of oxidized lead deposits.

*Maricopa County*.—Vulture Mountains, Collateral, Chromate, Blue Jay, and Phoenix mines.

## LEADHILLITE

$\text{Pb}(\text{CO}_3)_2\text{SO}_4\cdot\text{H}_2\text{O}$ . White, yellow, green, blue, or gray. Luster adamantine, resinous, and pearly. Transparent to translucent. Streak uncolored. H. = 2.5. G. = 6.26-6.44. Monoclinic. Perfect basal cleavage. In tabular crystals or cleavable masses.

A rare secondary mineral of oxidized lead deposits. Closely resembles cerussite.

*Cochise County*.—Bisbee district, locality unknown.

*Pinal County*.—Mammoth mine, with other rare minerals, 400-foot level of the Collins vein, in pseudorhomboidal crystals with brilliant basal cleavage.

## CONNELLITE

$\text{Cu}_2\text{Cl}(\text{OH})_2\text{SO}_4\cdot\text{H}_2\text{O}$  (?). Deep blue. Translucent. H. = 3. G. = 3.4. Hexagonal. As slender, prismatic crystal aggregates. *Footite* is identical with connellite.

A secondary mineral of considerable rarity from oxidized copper deposits, generally in small cavities in cuprite.

*Cochise County*.—Bisbee district, Copper Queen, Calumet and Arizona, and Czar mines, as small radiating aggregates of slender crystals. Analysis by W. M. Bradley as follows:

CuO	Cl	SO <sub>3</sub>	N <sub>2</sub> O <sub>5</sub>	H <sub>2</sub> O	Total
73.38	6.82	3.15	0.72	17.13	101.20

Tombstone district, as small clusters of crystals in cuprite, Toughnut mine.

*Pima County*.—At Ajo, in a vug lined with cuprite crystals.

## SPANGOLITE

$\text{Cu}_2\text{AlClSO}_4\cdot 9\text{H}_2\text{O}$ . Dark green. H. = 2.5. G. = 3.1. Hexagonal. In small tabular or short hemimorphic crystals with basal cleavage.

A rare mineral, originally described from an unknown locality thought to be in Pinal County, near Globe. As crystals on a rounded mass of impure cuprite.

*Greenlee County*.—Clifton-Morenci district, as a scaly coating on chrysocolla from Metcalf.

## BROCHANTITE

$\text{Cu}_2(\text{OH})_2\text{SO}_4$ . Emerald-green to dark green. Luster vitreous. Transparent to translucent. Streak green. H. = 3.4-4. G. = 3.9. Orthorhombic. Crystals prismatic or flattened. Perfect brachypinacoidal cleavage. Massive, with reniform structure. Pure mineral 56.2% Cu.

A common secondary mineral in oxidized copper deposits. Generally confused with malachite, with which it is commonly associated.

*Cochise County*.—Bisbee district, widely distributed as an intergrowth with malachite; in crystalline masses at the Shattuck mine. Tombstone district, as needlelike crystals lining vugs in cuprite.

*Greenlee County*.—Clifton-Morenci district, abundant as an intergrowth with malachite, less commonly as crystals.

*Mohave County*.—Grand Wash Cliffs, Grand Gulch mine, Bentley district.

*Pima County*.—Silver Bell district.

*Pinal County*.—Galiuro Mountains, Copper Creek district.

*Yavapai County*.—Black Hills, United Verde mine.

*Yuma County*.—Buckskin Mountains, Mineral Hill property.

## ANTLERITE

$\text{Cu}_2(\text{OH})_2\text{SO}_4$ . Light green. H. = 3. G. = 3.9. Orthorhombic, with crystallographic and optical similarity to brochantite. Crystals slender prismatic. In parallel aggregates, reniform, or massive.

A secondary mineral, generally mistaken for brochantite.

*Cochise County*.—Bisbee district, with brochantite.

*Mohave County*.—Hualpai Mountains, in soft green lumps, Antler mine, from which it was first described.

#### CALEDONITE

A basic sulfate-carbonate of lead and copper. Deep bluish green to pale blue. Luster vitreous to adamantine. H. = 2.5-3. G. = 5.64-6.4. Orthorhombic. Perfect basal, distinct pinacoidal, cleavage. In prismatic crystals striated vertically, or in confused crystal masses.

A secondary mineral of rare occurrence.

*Pinal County*.—Mammoth mine, as excellent crystals, 400-foot level, Collins vein. Forms: (100), (120), (010), (101), (111), (131), (011).

#### LINARITE

$(\text{Pb,Cu})_2(\text{OH})_2\text{SO}_4$ . Deep azure-blue. Luster vitreous. Subtranslucent. Streak pale blue. H. = 2.5. G. = 5.4. Monoclinic. Perfect orthopinacoidal cleavage. Most commonly as columnar or platy masses.

An uncommon secondary mineral generally mistaken for azurite.

*Graham County*.—Aravaipa district, in the Tenstrike group.

*Pinal County*.—Mammoth mine, with cerussite and wulfenite. In places as perfect crystals with the forms (110), (101), ( $\bar{1}01$ ), (001), (111), (201), ( $\bar{2}12$ ).

#### MIRABILITE

$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ . White. Luster vitreous. Transparent to opaque. Streak white. Taste cool, then saline and bitter. Water soluble. H. = 1.5-2. G. = 1.481. Monoclinic. Crystals like pyroxene in habit and angle. Generally in efflorescent crusts.

Formed most commonly by evaporation of salt lakes, but also found in old mine workings.

*Yavapai County*.—In salt deposits of the Verde Valley, with halite, thenardite, and glauberite.

#### GYPSUM

$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ . White; also gray, reddish, yellowish, brown, or black. Luster vitreous to satiny. Transparent to opaque. H. = 1.5-2. G. = 2.31-2.32. Monoclinic. Crystals flattened or prismatic. Perfect clinopinacoidal cleavage, yielding thin plates. Massive to earthy. *Alabaster* is fine-grained, *selenite* clear and lustrous.

The commonest sulfate mineral. Most abundant in beds in sedimentary rocks, formed by evaporation of salt waters or by alteration of anhydrite. Also found in oxidized sulfide ores.

*Cochise County*.—Near Douglas, mined for plaster and other gypsum products. Analysis by Arizona Gypsum Plaster Co. as follows:

CaO	SO <sub>3</sub>	(CaSO <sub>4</sub> )	Fe <sub>2</sub> O <sub>3</sub> +Mn <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	H <sub>2</sub> O
31.00	44.17	(79.05)	1.00	1.60	21.86

Sulphur Spring Valley, as beds in recent lake sediments. San Pedro Valley, deposits reported both north and south of Benson.

*Greenlee County*.—Clifton-Morenci district, common in oxidized deposits in limestone.

*Maricopa County*.—Fifteen miles south of Gila Bend, as beds in sandstone and conglomerate, with celestite. Reported from the Superstition Mountains (1:17).

*Mohave County*.—Abundant in the Virgin Valley badlands, as thick beds in South Mountain and Quail Canyon. Williams River, in beds northeast of the Planet mine. As satin spar, Mammoth claim, 60 miles southeast of Kingman.

*Navajo County*.—Near Winslow, mined for several years. As large plates of selenite, Fort Apache Indian Reservation.

*Pima County*.—Empire, Santa Rita, and Sierrita mountains, as beds up to 50 feet thick below the Snyder Hill limestone. Santa Catalina Mountains, foothills north of Tucson. In recent sediments near Vail.

*Pinal County*.—As thick beds in lake deposits near Feldman and Redding-

ton. Galiuro Mountains, Copper Creek district, as layers in Gila Conglomerate.

*Yavapai County.*—In salt deposits of the Verde Valley.

*Yuma County.*—Plomosa Mountains, at Mudersbach camp, as a bed several feet thick. Eastern foot of Harquahala Mountains, as beds.

#### EPSOMITE—Epsom Salt

$MgSO_4 \cdot 7H_2O$ . White. Luster vitreous to earthy. Transparent to translucent. Streak white.  $H. = 2-2.5$ .  $G. = 1.751$ . Taste bitter and salty. Orthorhombic. Cleavage perfect brachypinacoidal. As long slender fibers, fibrous crusts, or botryoidal masses.

Generally as efflorescence in old mine workings or natural caves.

*Greenlee County.*—Clifton-Morenci district, as delicate efflorescence on the walls of tunnels.

*Pima County.*—Silver Bell Mountains, as capillary hairs, El Tiro mine.

#### GOSLARITE

$ZnSO_4 \cdot 7H_2O$ . White, reddish, yellowish.  $H. = 2$ .  $G. = 2$ . Orthorhombic-sphenoidal. Crystals acicular or hairlike. Perfect brachypinacoidal cleavage. Massive or as incrustations. *Cuprogoslarite* is a blue variety containing copper.

Formed by decomposition of sphalerite, or by action of sulfate waters upon smithsonite. Most common on walls of old mine workings.

*Gila County.*—Globe district, as efflorescence, Continental and Old Dominion mines.

*Greenlee County.*—Clifton-Morenci district, as efflorescence, Arizona Central mine.

*Pima County.*—As cuprogoslarite in old workings, Silver Bell district.

#### MELANTERITE

$FeSO_4 \cdot 7H_2O$ . Green to white; becomes yellowish on exposure. Luster vitreous. Subtransparent to translucent. Streak uncolored.  $H. = 2$ .  $G. = 1.89-1.90$ . Monoclinic. Perfect basal, less perfect prismatic cleavage. Fibrous, massive, or earthy.

Formed from oxidation of iron sulfides.

*Greenlee County.*—Clifton-Morenci district, sparingly in the upper mine levels.

*Pima County.*—Sierrita Mountains, as efflorescence on walls of old workings, Mineral Hill district.

#### PISANITE

$(Fe,Cu)SO_4 \cdot 7H_2O$ . Blue. Luster vitreous.  $H. = 1-2$ . Monoclinic. Basal cleavage. In long slender prisms and concretionary or stalactitic forms.

A secondary mineral formed from oxidation of iron and copper sulfides. Generally of recent formation.

*Gila County.*—Globe district, 15th level, Old Dominion mine.

*Pima County.*—Silver Bell Mountains, in small amounts, El Tiro mine.

#### CHALCANTHITE

$CuSO_4 \cdot 5H_2O$ . Berlin-blue to sky-blue. Luster vitreous. Subtransparent to translucent. Streak uncolored.  $H. = 2.5$ .  $G. = 2.12-2.3$ . Triclinic. In cleavable, stalactitic and reniform masses, or as crusts.

Generally deposited from mine waters in cavities in the oxidized zones.

*Gila County.*—Globe district, as stalactites or as a coating on floors of old openings, Old Dominion mine.

*Greenlee County.*—Clifton-Morenci district, as small bodies in the oxidized ores of Copper Mountain and as stalactites nearly filling one of the upper drifts, Jay shaft.

*Pima County.*—Silver Bell Mountains, as thick coatings in old workings, Silver Bell district. Santa Rita Mountains, Rosemont camp, as fibrous veins.

*Pinal County.*—Galiuro Mountains, as coatings on walls of drifts and in fractures, Old Reliable and Copper Giant mines.

*Yavapai County.*—United Verde mine, as stalactites up to 2 feet long.

## HALOTRICHITE

$\text{FeAl}_2(\text{SO}_4)_4 \cdot 22\text{H}_2\text{O}$ . Yellowish. H. = 2. G. = 1.9. Monoclinic. In silky fibrous forms.

Commonly formed from weathering of rocks containing disseminated pyrite, but also by action of sulfate waters upon rocks containing potassium and aluminum silicates.

*Cochise County*.—Tombstone district, as material previously identified as ettringite.

## KORNELITE

$\text{Fe}_2(\text{SO}_4)_3 \cdot 7\text{H}_2\text{O}$ . Pale rose or violet. Silky luster. G. = 2.306. Orthorhombic. Prismatic and pinacoidal cleavage. As prismatic or fibrous tufts.

A rare mineral formed by evaporation in old mine workings.

*Cochise County*.—Bisbee district, in irregular porous crusts, Copper Queen mine.

## COQUIMBITE

$\text{Fe}_2(\text{SO}_4)_3 \cdot 9\text{H}_2\text{O}$ . White, yellowish, brownish. H. = 2-3. G. = 2.1. Rhombohedral or trigonal. Perfect prismatic cleavage. As granular masses or crusts.

An uncommon mineral formed in oxidized sulfide ores, in old mine workings, or under fumarolic conditions.

*Cochise County*.—Bisbee district, as porous crusts in the Copper Queen mine.

*Yavapai County*.—At the United Verde mine, as a result of burning of pyritic ore.

## ALUNOGEN

$\text{Al}_2(\text{SO}_4)_3 \cdot 16\text{H}_2\text{O}$ . White, yellow, or red. H. = 1.5-2. G. = 1.65. Monoclinic or triclinic. As rosettes of thin crystals; also as fibrous masses or crusts.

Formed under fumarolic conditions or by decomposition of pyrite.

*Yavapai County*.—United Verde mine, as small crystal aggregates formed from burning of pyritic ore.

## RANSOMITE

$\text{Cu}(\text{Fe}, \text{Al})_2(\text{SO}_4)_4 \cdot 7\text{H}_2\text{O}$  (?). Sky-blue. H. = 2.5. G. = 2.632. Orthorhombic. Perfect cleavage. In slender prisms.

*Yavapai County*.—United Verde mine, as crusts and small tufts of crystals formed as a result of burning of pyritic ore.

## GUILDITE

$(\text{Cu}, \text{Fe}''')(\text{Fe}''', \text{Al})_2(\text{SO}_4)_2 \cdot 9\text{H}_2\text{O}$  (?). Deep chestnut-brown. H. = 2.5. G. = 2.725. Monoclinic. Perfect basal and orthopinacoidal cleavage. In crystals with a cubic habit.

*Yavapai County*.—Black Hills, United Verde mine, under fumarolic conditions as a result of burning of pyritic ore. Relatively rare. Crystals up to  $\frac{1}{2}$  centimeter in width.

## LOUDERBACKITE

$\text{Fe}''(\text{Fe}''', \text{Al})_3(\text{SO}_4)_3 \cdot 17\text{H}_2\text{O}$  (?). Pale chestnut-brown. H. = 2.5-3. G. = 2.185. Orthorhombic. Two good cleavages. As thin crystalline crusts coating pyrite.

*Yavapai County*.—Black Hills, United Verde mine, formed under fumarolic conditions as a result of burning of pyritic ore. Relatively rare. As thin crusts on pyrite.

## VOLTAITE

$(\text{K}_2, \text{Fe}'')(\text{Al}, \text{Fe}'')_3(\text{SO}_4)_3 \cdot 9\text{H}_2\text{O}$  (?). Dull oil-green to brown or black. H. = 3-4. G. = 2.8. Isometric (?). Generally in octahedral crystals.

An uncommon mineral formed in oxidized sulfide ore bodies, on walls of old mine workings, and under fumarolic conditions.

*Cochise County*.—Bisbee district, in irregular porous crusts several inches thick in the Copper Queen mine, with coquimbite, roemerite, copiapite, kernelite, and rhomboclase.

*Yavapai County*.—Black Hills, United Verde mine, as black resinous cubo-octahedral crystals up to 5 millimeters in length, formed as a result of burning of pyritic ore.

## ROEMERITE

$\text{Fe}^{\text{II}}\text{Fe}_2^{\text{III}}(\text{SO}_4)_4 \cdot 14\text{H}_2\text{O}$ . Chestnut-brown. Taste saline, astringent.  $H. = 3-3.5$ .  $G. = 2.15$ . Triclinic. Crystals tabular. Granular, massive, or as crusts.

An uncommon mineral found on walls of old mine workings.

*Cochise County*.—Bisbee district, in porous crusts, Copper Queen mine.

## CYANOTRICHITE—Lettsomite

$\text{Cu}_3\text{Al}_2\text{SO}_4 \cdot 8\text{H}_2\text{O}$ . Bright blue.  $G. = 2.74$ . Orthorhombic. In velvetlike druses or spherical forms.

A rare secondary mineral of some oxidized copper ores.

*Coconino County*.—Grand Canyon, Grandview mine, in methyl-blue capillary crystals.

*Greenlee County*.—Clifton-Morenci district.

## BEAVERITE

$\text{CuPbFe}_2(\text{SO}_4)_3 \cdot 4\text{H}_2\text{O}$ . Canary-yellow. Hexagonal. In microscopic plates.

Rare. Formed in oxidized lead-copper deposits.

*Cochise County*.—Tombstone district, in small quantities with cerussite, Empire and Toughnut mines.

## COPIAPITE

$\text{Fe}_2(\text{OH})_2(\text{SO}_4)_2 \cdot 18\text{H}_2\text{O}$  (?). Sulfur-yellow to citron-yellow. Luster pearly. Translucent.  $H. = 2.5$ .  $G. = 2.1$ . Orthorhombic. Basal cleavage. In loose aggregates of crystalline scales, granular masses, or incrustations.

The most common ferric sulfate, formed under a variety of conditions. Probably more widely distributed in the state than the localities listed indicate.

*Cochise County*.—Bisbee district, in porous crusts, Copper Queen mine.

*Pima County*.—Sierrita Mountains, as silky fibers and foliated masses, Mineral Hill district.

*Yavapai County*.—United Verde mine, as incrustations, crystals, or crystalline masses formed by burning of pyritic ore.

## RHOMBOCLASE

$\text{Fe}_2(\text{SO}_4)_4 \cdot 9\text{H}_2\text{O}$ . Clear and colorless to gray and opaque.  $H. = 2$ . Orthorhombic (?). Basal cleavage. Most commonly in rhombic plates.

A rare secondary mineral formed from highly acid sulfate solutions.

*Cochise County*.—Bisbee district, in porous crusts, Copper Queen mine.

## LAUSENITE

$\text{Fe}_2(\text{SO}_4)_3 \cdot 6\text{H}_2\text{O}$  (?). White. Monoclinic. In aggregates of minute, silky fibers.

*Yavapai County*.—United Verde mine, formed as a result of burning of pyritic ore.

## BUTLERITE

$(\text{Fe,Al})_2(\text{SO}_4)_2 \cdot 5\text{H}_2\text{O}$ . Deep orange. Orthorhombic. Brachypinacoidal cleavage. In minute pyramidal crystals.

*Yavapai County*.—United Verde mine, as a thin crystalline coating formed as a result of burning of pyritic ore.

## ALUNITE

$\text{KAl}_3(\text{OH})_6(\text{SO}_4)_2$ . White, grayish, or reddish. Luster vitreous to earthy. Transparent to subtranslucent. Streak white.  $H. = 3.5-4$ .  $G. = 2.58-2.752$ . Rhombohedral. Crystals high-angle rhombs. Distinct basal cleavage. Massive, with granular or impalpable texture.

Most abundant in wall rocks of sulfide ore bodies, formed by solutions under high pressure and temperature.

*Gila County.*—Globe district, as veins in diabase, Old Dominion mine. Dripping Spring Mountains, Apex mine, Banner district.

*Greenlee County.*—Clifton-Morenci district, Ryerson mine as grains, irregular masses, and fibrous aggregates in altered porphyry.

*Santa Cruz County.*—Patagonia Mountains, as alunitization of wall rock, 3R mine.

*Yuma County.*—Sugarloaf Butte, near Quartzsite, as irregular veins in dacite. Partial analysis by F. S. Wartman as follows:

Al <sub>2</sub> O <sub>3</sub>	SO <sub>3</sub>	K <sub>2</sub> O	Na <sub>2</sub> O	SiO <sub>2</sub>
36.5	38.1	4.85	4.3	1.2

#### JAROSITE

$\text{KFe}_3(\text{OH})_6(\text{SO}_4)_2$ . Yellow to brown. Luster vitreous, silky, dull. Streak yellow. H. = 2.5-3.5. G. = 3.15-3.26. Rhombohedral. Distinct basal cleavage, yielding micaceous flakes. Most commonly in scaly masses or crusts.

A secondary mineral of common occurrence in oxidized sulfide bodies.

*Cochise County.*—Tombstone district, abundant in the Toughnut and Empire mines. Turquoise district, as small flaky bunches. Commonwealth mine, Pearce, with cerargyrite and native silver.

*Maricopa County.*—Vulture Mountains, as minute transparent crystals, Vulture mine. Analysis by S. F. Penfield as follows:

SO <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	K <sub>2</sub> O	Na <sub>2</sub> O	H <sub>2</sub> O	Total
30.42	48.27	8.53	0.28	12.91	100.41

*Pima County.*—Empire Mountains, Total Wreck mine with wulfenite, vanadinite, and cerargyrite; in the Hilton mines with cerussite and smithsonite.

#### PLUMBOJAROSITE

$\text{PbFe}_6(\text{OH})_{12}(\text{SO}_4)_4$ . Dark brown. G. = 3.7. Rhombohedral. Crystals small and tabular. Rhombohedral cleavage. Compact to earthy. Pure mineral 18.3% Pb.

Similar to jarosite in origin and occurrence, but less abundant.

*Cochise County.*—Tombstone district, abundant in brown oxide ore of the Holderness "roll." Material from the Empire mine assayed 58.92 ounces of silver, from the Toughnut mine up to 200 ounces.

*Pima County.*—Empire Mountains, as earthy masses, Hilton mines. Sierrita Mountains, San Xavier district.

*Mohave County.*—Cerbat Range, Tennessee-Schuykill mine.

#### CHALCOALUMITE

$\text{CuAl}_2\text{SO}_4 \cdot 9\text{H}_2\text{O}$ . Turquoise-green. H. = 2.5. G. = 2.29. Probably triclinic. Several perfect cleavages. In matted fibrous crusts.

A rare secondary mineral found in a few oxidized copper deposits.

*Cochise County.*—Bisbee district, from which it was described in 1925, as delicate crusts on brown limonitic material.

#### EMMONSITE

Probably a hydrated ferric tellurite. Yellow green. H. = 5. Monoclinic. In thin scales.

A rare alteration product of other telluride minerals.

*Cochise County.*—Tombstone district (Hillebrand, 86).

## TUNGSTATES AND MOLYBDATES

Ferberite	FeWO <sub>6</sub>	Powellite	Ca(Mo,W)O <sub>4</sub>
Wolframite	(Fe,Mn)WO <sub>6</sub>	Stolzite	PbWO <sub>4</sub>
Huebnerite	MnWO <sub>6</sub>	Wulfenite	PbMoO <sub>4</sub>
Scheelite	CaWO <sub>4</sub>	Ferrimolybdite	Fe <sub>2</sub> Mo <sub>3</sub> O <sub>12</sub> ·8H <sub>2</sub> O
Cuprotungstite	CuWO <sub>4</sub>		

### FERBERITE—WOLFRAMITE—HUEBNERITE

FeWO<sub>6</sub> to MnWO<sub>6</sub>, forming a continuous series. Dark gray or brownish black. Luster submetallic. Opaque. Streak dark brown to nearly black. H. = 5-5.5. G. = 7-7.5. Monoclinic. Crystals commonly tabular. Perfect clinopinacoidal cleavage. In bladed, lamellar, or granular masses or as disseminated grains. Pure mineral 76.5% WO<sub>3</sub>.

Most abundant in quartz veins in granite and schist that have been invaded by pegmatite. Commonly the only metallic minerals present, but in places accompanied by scheelite or sulfides. Detailed descriptions of occurrences in the state are given in Arizona Bureau of Mines Bulletin No. 148.

*Cochise County.*—Whetstone Mountains, in veins and replacements with scheelite, eastern slope of the range. Little Dragoon Mountains, in quartz veins and placer gravels.

*Gila County.*—Pinal Mountains, at several places south of Globe. West of Miami, on Pinto Creek. Spring Creek, southwest of Young. Mazatzal Mountains, northwest of Four Peaks.

*Maricopa County.*—Cave Creek district, as ferberite. Mazatzal Mountains, northwest of Four Peaks.

*Mohave County.*—Hualpai Mountains, in quartz veins of the Borianna, Telluride Chief, Laxton, and Moon properties. Aquarius Range, in quartz veins in the Williams and other mines in the vicinity of Boner Canyon. Also west of Cottonwood Cliffs and west of Greenwood Peak. White Hills, O. K. mine, Gold Basin district.

*Pima County.*—Las Guijas Mountains. Baboquivari and Comobabi mountains.

*Pinal County.*—Tarr property, northwest of Mammoth, with scheelite.

*Santa Cruz County.*—Southeast of Calabasas. Patagonia Mountains, Red Mountain property.

*Yavapai County.*—Bradshaw Mountains, Tip Top and Tule Creek areas. Eureka district, in quartz veins, Black Pearl and Joy properties, south of Camp Wood. Silver Mountain district.

### SCHEELITE

CaWO<sub>4</sub>. White, yellow, brown. Luster vitreous to adamantine. Transparent to translucent. Streak white. H. = 4.5-5. G. = 5.9-6.1. Tetragonal-pyramidal. Distinct pyramidal cleavage. Crystals of octahedral habit. Granular massive or as disseminated grains. Pure mineral 80.5% WO<sub>3</sub>.

Generally in quartz veins associated with pegmatite or granitic intrusives; in contact zones; and as replacements. Commonly associated with wolframite.

*Cochise County.*—Little Dragoon Mountains, in quartz veins, contact zones, and placers. Whetstone Mountains, in quartz veins and replacements in granite, eastern slope of the range. Huachuca Mountains, Tungsten Reef, James, Harper, and other properties.

*Maricopa County.*—Mazatzal Mountains, northwest of Four Peaks.

*Mohave County.*—Hualpai Mountains, with wolframite in quartz veins, Borianna, Telluride Chief, and Laxton properties. Aquarius Range, sparingly at the Williams mine, Boner Canyon. In small amounts with wolframite, Cottonwood and Greenwood areas. Mohave Mountains, Dutch Flat.

*Pima County.*—Las Guijas Mountains, sparingly present. Santa Rita Mountains, in contact-metamorphic zone, Helvetia district. Sierrita Mountains, in contact zones, Twin Buttes. Gunsight Hills.

*Pinal County.*—Campo Bonito area, Maudina and other properties. North-west of Mammoth, Tarr and Antelope Peak areas.

*Santa Cruz County.*—Near Calabasas, with wolframite. Patagonia Mountains, with molybdenite 4 miles south of Duquesne.

*Yavapai County.*—Bradshaw Mountains, Tip Top district. Wickenburg Mountains, disseminated in garnet-epidote schist on upper San Domingo and Little San Domingo washes. Silver Mountain area.

*Yuma County.*—Trigo Mountains, in a sheared quartz vein, Gold Reef claims, Silver district.

#### CUPROTUNGSTITE

$\text{CuWO}_4$ . Green. Luster vitreous to waxy. H. = 4.5. Cryptocrystalline or fibrous. *Cuproscheelite* is a variety with both copper and calcium.

Formed by replacement of the calcium in scheelite by copper; generally in concentric layers about scheelite.

*Maricopa County.*—Cave Creek district. Recalculated analyses by W. T. Schaller as follows:

$\text{WO}_3$	CuO	CaO	MgO	$\text{H}_2\text{O}$	Total
55.36	32.66	4.12	0.67	7.19	100.00
59.04	32.68	2.98	0.45	4.94	100.00

#### POWELLITE

$\text{Ca}(\text{Mo,W})\text{O}_4$ . Grayish to greenish yellow. Resinous luster. H. = 3.5. G. = 4.35. Tetragonal. In minute pyramidal crystals or as fine massive material.

An uncommon secondary mineral generally found in small quantities in tungsten ores.

*Mohave County.*—Reported from Cerbat Range.

*Pima County.*—Helvetia district, disseminated with scheelite in contact zone near the Black Horse shaft.

#### STOLZITE

$\text{PbWO}_4$ . Green to gray or brown. H. = 3. G. = 7.87-8.13. Tetragonal. In pyramidal crystals.

A rare secondary mineral found in some oxidized lead deposits.

*Maricopa County.*—Vulture Mountains, reported as sparingly present in mines containing crocoite and vanadinite.

#### WULFENITE

$\text{PbMoO}_4$ . Orange to bright red; also grayish or yellowish. Luster resinous to adamantine. Transparent to subtranslucent. Streak white. H. = 2.75-3. G. = 6.7-7. Tetragonal-pyramidal, hemimorphic. Generally as thin, square, tabular crystals. Pure mineral 26.2% Mo, 56.4% Pb.

An uncommon mineral generally considered to be secondary (11:38).

*Cochise County.*—Tombstone district, as clusters and rosettes of crystals. Turquoise district, in cavities, Mystery, Silver Bill, and Tom Scott workings. Chiricahua Mountains, Hilltop mine, as groups of deep yellow crystals.

*Gila County.*—Dripping Spring Mountains, Banner district, "79," McHur, Premier, C and B, and London Range properties.

*Graham County.*—Aravaipa district, Silver Coin and Dogwater mines.

*Maricopa County.*—White Peak district, 12 miles north of Beardsley.

*Mohave County.*—Artillery Mountains, near Artillery Peak.

*Pima County.*—Tucson Mountains, Old Yuma mine, as deep orange-red crystal groups. Empire Mountains, Total Wreck and Hilton mines.

*Pinal County.*—Mammoth mine, in light yellow to bright red crystals containing tungsten. Black Prince mine, Superior district. Dripping Spring Mountains, 4 miles east of Kelvin.

*Santa Cruz County.*—Santa Rita Mountains, Gringo mine, Wrightson district, with native gold. Patagonia Mountains, Domino mine, Palmetto district, as beautifully crystallized specimens with galena, cerussite, and native silver.

*Yuma County*.—Trigo Mountains, as crystals, Red Cloud, Hamburg, and other properties.

FERRIMOLYBDITE—Molybdate

$\text{Fe}_2\text{Mo}_3\text{O}_{12}\cdot 8\text{H}_2\text{O}$ . Sulfur- to canary-yellow. H. = 1.5. G. = 4.5. Orthorhombic. In aggregates of crystal fibers.

Formed in small quantity by oxidation of molybdenite.

*Pima County*.—Santa Rita Mountains, as hairlike crystals and tufts near Madera Canyon. Average analysis by F. N. Guild as follows:

MoO <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	H <sub>2</sub> O	Total
60.805	21.835	17.355	99.995

*Pinal County*.—Galiuro Mountains, as yellow powder and radiating crystal aggregates, Childs-Aldwinkle mine, Copper Creek district.

*Santa Cruz County*.—Patagonia Mountains, Red Mountain mine.

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