MINERALS OF ARIZONA

Their Occurrence And Association

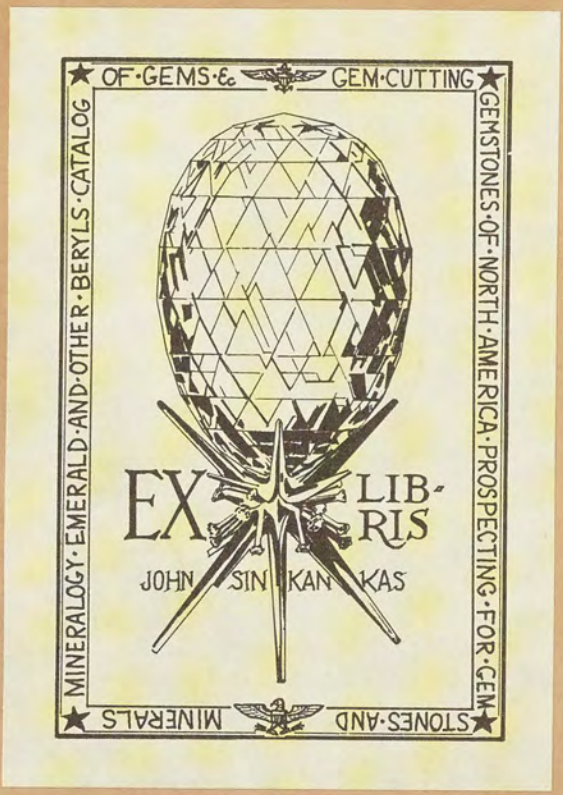
With Notes on Their Composition

A REPORT

To the Hon. J. H. KIBBEY
Governor of Arizona

BY
William P. Blake
Territorial Geologist

TUCSON:
1909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AGATE.

Quartz, Silica, or Silicon Dioxide, Oxygen 53.3, Silicon 46.7.

This, a non-crystalline variety of quartz, occurs in banded layers of different shades of color, the result of deposition in cavites of rocks, usually of basalt; as, for example, in the hills west of Tucson, with chalcedonic crusts and layers. See, also, chalcedony.

ALABANDITE.

Manganese Sulphide; Sulphur 36.9, Manganese 63.1.

In large masses from the 200-foot level of the Lucky Cuss mine, Tombstone, Cochise county, in limestone. For details of occurrence reference is made to the original announcement in the School of Mines Quarterly, XIII. 237.

ALUM.

In Alum Canyon, Santa Cruz county, a few miles west of Patagonia, in crusts and efflorescences, but not in large deposits. The whole mountain through which the arroyo, or canyon, is cut is colored a brilliant red by the abundance of diffused hematite, and a portion of the so-called alum is doubtless in part iron sulphate.

ALUNITE.

Hydrous Sulphate of Aluminum and Potassium, Sulphur trioxide 38.6, Aluminum 37.0, Potash 11.4, Water 13.0.

In the main adit level of the Ryerson mine at Morenci in a narrow seam between shale and porphyry forming a white earthy mass like kaolin.

AMPHIBOLE.

Known also as Hornblende, and as Tremolite. A silicate of calcium and magnesium with alumina and iron.

It occurs with the alteration pro-

ducts of dolomite and limestone in close association with garnet and other silicates. No occurrence of large and well-formed crystals suitable for mineral collections is known in Arizona.

In the form of Tremolite it may be found in the metamorphic dolomitic limestone of Morenci and Metcalf. It there weathers to chloritic and serpentinoid minerals, and sometimes to asbestos.

ARGENTITE.

Silver Sulphide. Silver Glance.

At most of the silver mines of the southwest, notably at the Cerro Colorado, the Heintzelman and the Darwin or Constitution lode when they were first opened and actively worked. (See Silver glance.)

AURICHALCITE.

Basic carbonate of zinc and copper.

On the assumption that the ratio of the zinc and copper is as 5.2 the formula requires: Carbon dioxide 16.1, zinc oxide 53.2, cupric oxide 20.8, water 9.9.

It has been known as **brass ore,** from the fact that the alloy, brass, may be smelted from it without the addition of either copper or zinc. The ore anciently known as **aurichalcum** was regarded by Pliny as the best for brass.

It occurs at the Copper Queen mine, Bisbee, Cochise county, and is reported by Dana to occur also at the Santa Caterina mountains (Catalina) in fine specimens. These specimens were probably from the old Apache camp, now Leatherwood's, in the northern part of the range.

AZURITE.

Basic cupric carbonate; carbon dioxide 25.6, **cupric oxide** 96.2, **water** 5.2.

Occurs in large masses of aggregated crystals in close associatinn with the green carbonate, malachite, native copper and red oxide in the Copper Queen mine at Bisbee, Cochise county. Some of the various complex forms and modifications of the crys-

tals have been drawn by Farrington, figures (7-14) in Dana's Mineralogy.

ANGLESITE.

Lead Sulphate: Sulphur trioxide 26.4, **lead oxide** 73.6.

Not unusual in the lead mines of the territory, but not in good crystals but generally in the amorphous earthy from a direct product of the oxidation of the sulphide, often holding a kernel of unchanged galena.

Mammoth mine, Shultz, Pima county, in the earthy form not crystalized. Also in the Lost Gulch gold mine, near Globe, surrounding nodules of galena, the direct product of the oxidation of the sulphide.

ANTIMONY GLANCE.

Sulphide of Antimony. See Stibnite.

ARGENTITE.

Silver Sulphide; Sulpher 12.9, **silver** 87.1.

The Silver King mine in Pinal county is one of the most interesting and important localities of this species. In fact the presence of rich black lumps of this ore in the soil led to the immediate appreciation and development of this property. These lumps or small nodular masses of the rich sulphide, easily cut with a knife, were picked up along the croppings and were favorite pocket pieces with the prospectors. This **"petanque"** ore continued to be found as the vein was opened from the surface downward to the third and fourth levels of the mine and gave an unusual degree of value to the ore. Is was easily recognized by its malleability, sectility, and its high content in silver; some of the early assays gave as high as 70 per cent of silver. A careful assay of a selected sample of the mineral gave 82.80 per cent of silver; no copper. Specific gravity, 6.828. (Vide Silver King report 1883.)

ASBESTOS.

A fibrous variety of hornblende or actinolite. A silicate of lime without alumina. Well known as a fire-

resisting material. Much of the fine silklike fibrous mineral from Grand Canyon of Arizona and commonly known as asbestos is the mineral **chrysotile** to which reference is made. In the form of matted fibers asbestos is known as "mountain wool" or "mountain leather." Specimens of this nature have been sent to the Terriorial Museum from near Clifton by Colonel Egan and from near Naco by Wm. Hogan.

The metamorphic rocks of the Clifton-Morenci district contain asbestos as a result of hydration according to Lindgren. It is found near the Arizona Copper company's hospital at Morenci and in pieces over a foot long much resembling fossil wood in the Black Hawk No. 3 tunnel at Metcalf.

Black Canyon road, Roberts, Wickenburg.

BARITE.

Sulphate of Barytes. Heavy Spar.

Common as a vein-stone in many Arizona lodes.

At some of the veins in Silver District it is the chief gangue or vein-stone. Yuma county.

At the Silver King mine, Pinal county, it occurred massive and in bunches and, except quartz, was the most abundant vein-stone but not as closely associated with the silver and rich ore as the quartz.

Massive, with red streaks, Salt River Valley east of Phoenix. Austin, Jan. 1905).

In crystalline aggregates like groups of oysters and popularly known as "fossil oysters," from the Cababi country west of Tucson.

BISMUTHENINTE.

Sulphide bismuth, copper and lead.

Reported from near Bisbee, Cochise county. (McGowan.)

BISMUTH.

Bismuth ore has been found at several places in the territory. As carbonate and oxide, it occurs in the Salt River Valley, where the veins have been prospected by a German company. In combination with tel-

lurium ("Tetradymite," which see), at the so-called bismuth claims, Minnehaha flat, Yavapai county.

Ores of bismuth are reported from the Aquarius range in Mohave county.

BOURNONITE.

Known, also, as "Wheel-Ore". Named for Count Bournon, a mineralogist. A sulphide of antimony lead and copper. Occurs in well-formed characteristic brilliant crystals at Murray's claim, Big Bug, Yavapai county, but sparingly, only two good specimens having been obtained by me when the claim was being worked.

BARNHARDITE.

An analysis given by Dana of a specimen from Bill Williams Fork shows: Sulphur 28.96, iron 29.44, copper 50.41. It may be a partly altered chalcopyrite. (See, also Chalcopyrite).

BORNITE.

Known also as Peacock ore, purple copper, variegated copper and as erubesite. It is a sulphide of copper and iron, but the percentages of these metals vary. Analysis shows from 22 to 28 per cent of sulphur, 50 to 70 per cent of copper and from about 7 to 18 of iron. Dana observes that the variation is due in part, at least, to mechanical admixture, chiefly of chalcocite, a view confirmed by Baumhauer's microscopical examination.

This valuable ore of copper occurs at many of the Arizona copper mines, and is closely associated with chalcopyrite, and pyrite. At Leatherwood's claims in the Santa Catalina mountains it constitutes a large part of the ore. It was found at the Silver King in Pinal county; at Austin's mine Santa Cruz county (Balcom); in the Black Hills in the various mines including the United Verde.

BROCHANTITE.

The basic sulphate of copper is comparatively rare in nature, though acting an important part in the formation of secondary copper ores. Being soluble in water it is readily washed downward and out of sight,

till coming un contact with limestone, or calcareous rocks, it is decomposed with the formation of copper carbonate and gypsum.

The investigations of Lindgren and Hillebrand of the copper ore deposits of Metcalf and Morenci showed the presence of this species in a few places in well-developed crystals. This led to a systematic examination of the green colored ores which disclosed the fact that the sulphate is a common associate mostly intergrown with copper carbonate (malachite), which effectively masked its presence. It occurs as lighter or darker emerald-green crusts on limonite or serictized porphyry from the red ore-body in the Shannon mine, from the Metcalf mine and other places.

CALAMINE.

Silicate of Zinc. Silica 25, oxide 6.75, Water 0.75.

Reported by Lindgren from the garnet rock of the Shannon mine just above the lime quarry, Clifton.

CALCITE.

Calcium carbonate. Carbon dioxide 44.0, Lime 56.0.

Usually found as one of the veinstones or gangue in metaliferous veins, and is rarely found in good crystals in Arizona.

At the Silver King it occurred in small obtuse rhombohedral crystals, "nail-head spar", strung, like beads, on silver filaments, or wire silver.

Acute rhombohedra, the form known as "dog-tooth spar," are abundant in the Grand Canyon of the Colorado on the north side of the river, according to W. W. Bass. These crystals are amber-colored and doubly terminated.

At the Copper Queen mine, Bisbee, in the upper workings, calcite was abundant in the form of crystalline aggregates and in stalactites, often beautifully tinted green by the salts of copper.

Calcite at the Ajo mine was the gangue of much native copper.

In the Stonewall Jackson mine, Tombstone.

In nearly all the great copper mines, often in stalactites lining caverns.

In the Naragansett copper claim, in obtuse rhombohedra, Rosemont, as the gangue of copper ore.

CALICHE.

Lime carbonate. Terrigenous travertin.

This term, "caliche," is given in the southwest to the widespread deposition in the soil of a species of travertin which cements sand and boulders into one mass resembling concrete. It appears to originate from the subterraneous flow of water charged with lime-carbonate. Such water rising to the surface by capilarity is concentrated by evaporation and deposits the lime-carbonate.

Chemical analysis, excluding the included sand and insoluble portions, resulted as follows:

Anaylsis of Caliche.

Calcium carbonate	78.28
Magnesium carbonate	2.13
Calcium silicate	5.57
Aluminum silicate	7.17
Ferric oxide	1.88
Moisture	1.20

When properly calcined it makes good caustic lime and a strong mortar with sand which soon hardens.

CERARGYRITE.

"Horn Silver. Silver chloride, chorine 24.7, **silver** 75.3.

Common in the croppings of veins of rich ores of silver in greater or less quantity according to the abundance of the parent minerals.

Found in the croppings of veins in Tyndall district, Santa Cruz county. In the upper workings of the Cerro Colorado. It is cited by Dana as occurring in the veins of El Dorado Canyon, in San Francisco district, and in the Willow Springs district. At the Black Warrior mine and at the Peck mine, Yavapai (Hinton).

CERUSSITE.

Lead Carbonate. Carbon dioxide 16.5, **lead oxide** 83.5.

Occurs in most of the deposits of

galenite which have undergone decomposition by atmospheric agencies. The sulphate is first formed and is then changed to carbonate, as shown in nodules from the Lost Gulch gold mines, near Globe, and in the Mammoth mine at Shultz, Pinal county.

Occurs also at the Castle Dome mines, especially at the water level of the Railroad claim in association with wulfenite and vanadinite.

At the Manila mine, north end of the Huachucas, in a cave-like deposit from which many tons were shipped.

In association with the galenite of Chiricahuas at Hands, and the Outlook and other claims.

At the Alice and adjoining claims at the Seven Cottonwoods, Pinal county.

It occurs in quantity at the Morning lead mine, and at the Flux mine, Santa Cruz county, and in crystals at the Red Cloud mine, Silver district, Yuma county.

CHALCANTHITE.

"Blue stone," "blue vitriol;" hydrous cupric sulphate, sulphuric acid 32.1, **cupric oxide** 31.8, **water** 36.1.

At the United Verde copper mine this mineral occurs in considerable quantity, especially in the neighborhood of the burned-out stopes, where the ore was much enriched by the expulsion of the sulphur and its oxidation. Large masses were presented by the company and secured by Wm. A. A. Johns, of Yavapai, for the mineral exhibit at the Fourth Terriorial Fair, 1908. It was in large but very friable crystalline and stalactitic aggregates of a beautiful blue color, which attracted great attention. But the presence of copperas (melanterite) in portions of the specimens caused a change of color by oxidation.

CHALCEDONY.

Abundant in portions of the Grosvenor Hills in Santa Cruz county; also in amygdular (almond-shaped) nodules in the basaltic rocks of Tumamoc hill west of Tucson.

A variety of chalcedony, colored bluish green and and blue by copper

oxide, has attracted attention as a gem mineral, and has been brought to notice by H. P. Wightman of Globe, Arizona, who sent samples to the United States Geological Survey. The mineral is said to occur in small stringers in the Keystone copper mine in that district. It varies in color from bright to pale blue, bluish-green and nearly apple green, resembling some chrysoprase. It bears some resemblance to the greenish colored chalchuite, but is more brilliant and translucent. It takes a high polish, is hard, and when well cut, **en cabochon,** and mounted forms a pleasing jewel.

CHALCOCITE.

"Copper glance," "vitreous copper," cuprous sulphide; sulphur 20.22, **copper** 79.8.

Common at most of the copper mines in Arizona when opened below the zone of atmospheric oxidation. It is very common in the Clifton district and is the principal copper mineral of value. It occurs chiefly with pyrite in the altered porphyry, in granular or nodular masses or in veinlets traversing the mass. Messrs. Lindgren and Hillebrand write of this occurrence: "It is never crystalized, but has an earthy or sooty appearance and black color; cutting with a knife reveals the semi-sectile character and metallic luster. In a few small, massive veinlets the normal metallic luster and dark gray color appear on fractures. A fibrous or columnar structure of the mineral is known on small seams in shale from the Montezuma mine. The mineral prefers porphyry and the great bodies of ore now worked (1904) all occur in this rock, but it is not entirely unknown from the irregular deposits in limestone generally carrying cuprite and copper carbonates. A partial analysis of massive chalcocite from the Montezuma mine, Morenci, gave 96 per cent copper sulphide, Cu 2 S., and 2.4 per cent Fe S 2 iron sulphide, the latter probably mechanically admixed.

"The chalcocite is everywhere, in

this district, a secondary mineral formed by the replacement of pyrite by means of descending solutions of cupric sulphate. The deposition of the mineral was accompanied by the formation of quartz, chalcedony and kaolin. In the porphyry the chalcocite ore along the veins begins 100 to 200 feet below the surface and continues to a depth of 400 feet, or even more, when it is usually replaced by pyrite, chalcopyrite and zinc blende." (**Am. Jour. Science,** Dec., 1904.)

This mineral is found at various depths in the Copper Queen group of mines at Bisbee, and generally in close association with pyrite. Its distribution through masses of pyrite makes a workable ore.

Chalcocite is found irregularly in the glance conglomerate which extends southward from Gold Hill, but not in sufficient quantity ,or concentration, to be remunerative.

In the old mine, Cornelia shaft, at the Ajo it is an important mineral. Col. Bean presented to the museum at the university, through W. P. Blake, an 80-pound mass.

Occurs in the Cobriza lime, Cababi district, Pima county.

CHALCHUITE.

The Indian name for the gem-stone corresponding to a turquois. It is a hydrous phosphate of aluminum colored by oxide of copper, and varies in color from green to greenish-blue and blue.

Found in Turquois district, Dragoon mountains, near Gleason. In Mohave county, also, where there are extensive prehistoric workings at which Mr. A. B. Frenzel of Colorado found many stone implements of mining scattered through the debris of ancient pits.

This gem-stone was held in high esteem by the aboriginal people of Arizona and New Mexico, and by the tribes of Mexico and South America. It was worn in the form of necklaces of discoid beads or as pendants. It was also used in the form of tesserae for inlaying or for overlaying marine shells. Fragments of the gem may usually be found in the debris of

former villages throughout Arizona. It is highly prized by the Indians of today.

CHALCOPYRITE.

Commonly known, also as "yellow copper," or as "copper pyrites." A sulphide of copper and iron; sulphur 35.0, copper 34.s, iron 30.5. It may also, contain gold and silver, and iron pyrite, mechanically mixed.

A common ore of copper abundantly distributed in the copper mines of Arizona. It may be found in nearly all of the chief copper mines, especially below the zone of atmospheric oxidation and decay, and is generally associated with pyrite by which, and other minerals, the per cent of copper in the ore is much reduced, pyrite often predominating. It may be distinguished from iron pyrites by its softness, being easily cut with a knife. It is represented by 3.5 to 4 in the scale of hardness.

Among numerous copper mines where yellow copper is the chief ore we may mention the mines at Bisbee, at Globe and at Jerome, at the Twin Buttes and at other claims near Tucson. At Leatherwood's in the Catalinas it is closely associated with bornite. We find it in the claims about Dudleyville and the Christmas Gift, and in the lodes of the Bryan group, Harris or Piety groups, and mines near Mineral creek, Ripley mining district, Pinal county.

There are many occurrences in the mountains of the Santa Rita, especially at Helvetia and Rosemont, and at the Total Wreck, Pima county.

The Silver Bell district, west and north of Tucson, is another center of production of chalcopyrite, from the mines of the Old Boot, the Atlas, Imperial company.

In Tyndall district, Santa Cruz county, at the American Boy, at the Tia Juana and other claims.

Yellow copper ore is produced at the mines of the Clara Consolidated Gold & Copper Co., 17 miles northeast of Bouse.

At mines of U. S. Gold & Copper Co., in the Big Horn mountains, 32 miles southwest of Wickenburg.

CHRYSOCOLLA.

A hydrous silicate of copper. Composition variable. Assay of specimen from Bisbee gave about 35 per cent of copper oxide.

This, a common associate of ores of copper, is generally found in the croppings of the copper deposits of the territory.

It occurs in large quantity at the claims of the Black Warrior in Gila county, in close association with a jet-black variety which appears to be different in composition.

It occurs at many of the copper mines of the Clifton and Morenci districts, in Graham county, in seams and coatings; abundantly in the Mammoth mine between the porphyry and limestone; at several places on Chase creek and at the Terrazas vein in porphyry near Metcalf.

A technical analysis of chrysocalla ore from the Terrazas mine by the Arizona Copper company gave

Silica	S:O2	31.65
Copper Oxide	Cu O	34.90
Water	H2 O	26.30
Alumina	Al2 3	3.80
Undetermined		3.35

Lindgren and Hillebrand, commenting on these figures, state that normal chrysocalla should have 34.2 per cent, S:O2 45.2 per cent, Cu O and 20.5 per cent H2 O, but analyses show great differences. Chrysocalla, from the Modoc open-cut, appears as mamillary crusts of bluish green color on copper-pitch ore.

In Canada de Oro, Pima county, in small nodular masses spread through an earthy red-brown gangue, forming very showy specimens. (Burgess.)

At the Ibex, Plomosa mine, Bouse, Yuma county, with malachite and lead bearing minerals.

At Summit, one mile east of Wickenburg; Little Butte, Plomosa district, six miles west of Bouse.

CHRYSOLITE.

An olive-green gem, a silicate of magnesia and iron, occurs in the basaltic rocks of San Carlos Indian Reservation and in the northeastern

portion of the territory, in the country of the Navajo Indians, who collect the stones and sell to the local traders. The gem is also known as **peridot** and locally as **"Job's tears."** The United States Geological Survey report on the production of precious stones for the year 1907, says: Mr. J. L. Hubbell reports a quantity of peridot gathered from the surface of Ziltsusayan Butte, about 20 miles northeast of Ganado, Arizona.

Black and light yellowish-green stones have been obtained at San Carlos.

CHRYSOTILE.

Silky asbestos, amianthus, a variety of serpentine or magnesium silicate.

Mr. W. W. Bass of Bass ranch, Grand Canyon of Arizona, had a fine display of chrysotile at the Territorial Fair, Phoenix, 1908. It is mined on the north side of the Colorado river, but the active working of the deposits is much repressed by the expenses of transportation to a market. The quality is excellent, the fibres extremely firm and silklike, and the color good.

CINNABAR.

Mercuric sulphide sulphur 13.8, **mercury** 86.2.

In Yuma county near Quartzsite (H. Brown) with hematite, in or near Skull Valley west of Prescott. Of high color in calcite veins at Rye, Gila county, reported by T. D. Ridgen, No. 6488.

COAL.

Mineral coal of good quality is reported from the eastern part of the territory adjoining the coal fields of Gallup, New Mexico.

In the Saddle Mountain district, Graham county, between Saddle Peak and the Gila river, beds of coal of Cretaceous age have been partially explored. The coal is friable and seems best adapted to utilization for producing gas. Its proximity to the copper ores of the Christmas Gift company and to smelting plants at

Winkleman give greater value to the deposits.

Similar coal is found in thick beds in the Chiricahua mountains near Bridgers on Wood creek, but the geologic age is uncertain, though nearby croppings are stratified limestones containing encrinites and are believed to be Lower Carboniferous. The coal is graphitic, much broken up, and is mixed with clay.

COPPER-PITCH ORE.

Under this old German name, Lindgren and Hillebrand describe a dark-brown to black substance, sometimes dull but generally with glassy to resinous luster; hardness about 4; streak dark brown. It occurs among the products of oxidation of the copper ore deposits in limetsone, as at the Detroit and Longfellow mines and Medoc open cut at Morenci. It is associated with azurite, malachite and chryoccolla. A rough analysis showed 28.6 of copper oxide, 22.2 of manganous oxide and 22.5 insoluble. See (Am. Jour. Sci., Dec. 1904).

A somewhat similar mineral from Bisbee has been described by Prof. Koenig, as "melanochalcite," which see.

COBALT.

Occurs in the Cababi district, probably as erythrite.

COPIAPITE.

Basic ferric sulphate, sulphuric acid 38.3, **iron serqui oxide** 30.6, **water** 31.1.

From the Azurite mine, Mineral Hill, (Maynard).

COPPER.

Native copper.

A mineral of many localities and wide distribution in Arizona, generally in the upper portions or oxidized zones of copper deposits, a secondary mineral resulting from the oxidation and chemical transformations of sulphide ores. It is usually in close association with cuprite, from which it may have been derived directly by means of de-oxidizing solutions, or

the reverse may take place by the oxidation of the copper.

Of all the occurrences of native copper so far observed in the territory, that at the historic Ajo is the most important, for all the readily accessible masses of the metal have long since been shipped away. It was in close association with the red oxide, cuprite, penetrating its substance, ramifying through it and binding it in solid, heavy masses many pounds in weight. It was, also, found penetrating a gangue of calcite without cuprite, and was an important source of this metal even before the acquisition of the region by the Gadsden purchase.

Dendritic and spongiform masses of copper were abundant in the Copper Queen mine in association with cuprite and malachite and azurite. According to Dr. Douglas it was found at the bottom of the ore-body above the third level in masses which weighed several hundred pounds.

The following from my report to the governor in 1899 gives a general statement introductory to statistics of copper production of the territory:

"The fame of Arizona as a copper producer extends throughout the world. The ores of this most important metal, in their varied forms, are extensively distributed through the territory. The chief and best-known centers of production are Bisbee, in the southern portion of Cochise county; Jerome, in Yavapai county; Morenci and Clifton, in Graham, and Globe, in Pinal county. Large quantities of sulphide ores have also been mined in Pima county, especially at the Imperial, Silver Bell, at Rosemont, Twin Buttes, Helvetia and the Sierritas. In the early days of the territory, even before the construction of the railways, quantities of copper were produced at the Longfellow mines and were sent out by ox teams overland. In those early days,also, the mines of the Ajo produced and shipped large quantities of native copper and of the scarcely less rich and valuable red-oxide to San Francisco, Cal., and the gulf, en route to Swansea, Wales, by way of

Yuma. It would be a great and almost impossible task to enumerate, and much more difficult to describe, all of the localities of copper ores and copper bearing minerals in Arizona. Many localities where they are known to exist are yet lying idle waiting cheaper transportation and for capital to develop them. Many localities are yet to be discovered, for the work of the prospector in Arizona is not yet completed."

On the 1,050-foot level of the Calumet and Arizona mine native copper occurs in branching crystalline masses beautifully encrusted, with crystals of cuprite (Ransome). In other places metallic copper in spongelike masses is filled with crystals of cuprite.

In the Mineral Hill district native copper was taken from the upper workings on the Ray mine.

In the Clifton-Morenci district it is of frequent occurrence in the upper levels of the veins which cut through shale, limestone and associated porphyry dikes (Lindgren). In the Shannon mine in limonite and kaolinitic porphyry in spongy masses. In the Metcalf open-cuts it was found in large, irregular masses, associated with cuprite, malachite, silicates and sulphates. At Morenci with chalcocite and cuprite in the Joy vein. In the Arizona Central mine, 200 feet below the surface, a vein of solid copper was found in decomposed porphyry with some chalcocite. It was, in some places, 8 inches thick and extended downward to the third level, and in places had a remarkable fibrous structure such as is occasionally exhibited by the chalcocite seams, of which it is believed to be a pseudomorphic development. (Lindgren, p. 101).

Table of Copper Production in Arizona.

Year.	Pounds.
1883	23,874,965
1884	26,734,345
1885	22,706,366
1886	15,657,035
1887	17,720,462
1888	31,797,300
1889	31,586,185

1890	34,796,689
1891	39,873,279
1892	38,436,079
1893	43,902,824
1894	44,531,108
1895	48,329,403
1896	73,745,321
1897	81,019,922
1898	110,823,864
1899	133,054,860
1900	118,317,764
1901	126,183,744
1902	119,841,285
1903	153,591,417
1904	191,602,958
1905	222,866,958
1906	263,200,000
1907	254,879,489
1908	252,784,698

CORONADITE.

Manganite of Lead. A new mineral observed, described and named by Lindgren and Hillebrand in 1904. It was obtained from the dump of a small shaft on the west end of the Coronado vein, three-fourths of a of a mile west of Horse Shoe shaft, Clifton-Morenci district. It is a dark colored metallic mineral, intimately intergrown with quartz. Its color is black and its structure fibrous, hardness about 4. Analysis shows the presence of 56.13 per cent of manganous acid, 36.48 of lead oxide, 7.22 per cent of silica and insoluble and small quantities of oxides of various metals, with traces of molybdic acid and vanadic acid.

CUPRITE.

Ruby, Copper, Red oxide, Cuprous oxide; oxygen 11.2, **copper** 88.8.

Familiarly known to the miners of Arizona as **"red oxide of copper"**; occurs in greater or less quantity in most of the croppings of the copper ore deposits of the territory or within the zone of oxidation of the sulphide ores. Some of the more important occurrences are:

The Ajo mines, Pima county, in large masses sub-crystalline, and holding dendritic masses of native copper; both species closely associated with malachite. Specimens can yet

be obtained from the old workings, but the bulk of the ore has long since been shipped away, being in the earlier days carted across the country to Yuma and then sent down the Colorado river to yessels at the head of the gulf by which it was taken to San Francisco, and from thence to Swansea, Wales.

It was an important constituent of the ore of the upper levels in the Copper Queen at Bisbee, where it was closely associated with native copper and the carbonates.

It was found also in the upper levels of the United Verde copper mine at Jerome, Yavapai county.

It occurs disseminated in quartzite in the claims of Jake Schneider, in the southern end of Gila county, near Dudleyville, near croppings of copper glance and granular quartzite, traversed by veinlets of blue and green copper carbonates.

The collection of choice specimens from the Copper Queen made by Mrs. L. Williams contained a remarkably fine single srystal of cuprite about half an inch square, a perfect cube having a rich, ruby-red or cherry-red color, and transparent.

CUPROTUNGSTITE.

Tungstate of Copper.

From the southwestern part of Pima county, exact locality not divulged. Determination was from a sample left at the Arizona School of Mines for assay. W. P. B.

CYANITE.

Silicate of alumina. Analysis by Hillebrand of an Arizona specimen gave silica 36.30, alumina including titani 62.51, ferric iron 0.70, a trace of copper, and loss by ignition 0.40. This was a light green colored variety from Clip in Yuma county, associated with Dumortierite. (Dana's Min. 501).

DERBYSHIRE SPAR.

Fluorite, which see.

DES CLOIZITE.

Vanadate of lead and zinc—Vanadic acid 22.7, **lead oxide** 55.4, **zinc oxide** 19.8, **water** 2.2.

Occurs with wulfenite at the Mam-

moth mine, Shultz, Pinal county; at the old Yuma lead mins near Tucson, Pima coutny; near Tombstone, Cochise county. An analysis by Hillebrand gave only 4.19 per cent of zinc oxide, 57. of lead and 11.21 per cent of copper oxide.

DIAMOND.

Crystallized carbon.

Not known to occur in the usual form in Arizona, but has been detected by Foote in a meteoric-iron from Canyon Diablo. (Foote **Am. Jour. Sci.,** 1891), but not in quantity, or size suitable for use.

DIASPORE.

Reported near Tempe, Maricopa county.

DIATOMITE.

Diatom earth; Infusional earth, chiefly silica of organic origin.

An extensive deposit of diatomaceous earth in horizontal beds many feet in thickness occurs in the valley of the San Pedro, or Rio Quiburi of the aborigines, a few miles south of the mining town of Mammoth, near Redington.

The diatomite beds are horizontal; do not appear to have suffered any disturbance since their deposition; and form the almost vertical walls of the chief lateral canyons, attracting the eye by their snowy whiteness, especially where any recent excavation or falling down of the cliff exposes a fresh surface. Dust and disintegration clouds the surface somewhat; but the beds are always distinct in appearance from the red clays above and below them.

No distinct planes of deposition or stratification appear; and the specimens collected give no evidence to the eye of the existence of layers of stratification. They show a uniform white surface. But when the deposit is seen en masse in the arroyos and bluffs along the canyons, a difference in hardness, and probably in fineness, is shown by the unequal weathering. Evidently some of the beds are softer than others, and yield more readily

to erosion, thus disclosing a straticulate structure otherwise obscure. The lower portions of the deposit appear to be coarser than the upper layers, and to have more distinct partings of thin layers of clay; but these partings are not numerous.

It is not easy to determine the total thickness of the deposit, since there does not appear to be any place where it is exposed in a continuous series from top to bottom. It disappears under the bottom of the canyon; and the upper surface appears to have been considerably worn away. The greatest thickness noted from the floor of the canyon to the top of the beds was estimated at 100 feet. This includes argillaceous beds at the base, and a few feet of superficial wash-gravel at the top. The beds in which the relics of the diatoms most abound are not less than 25 feet thick.

Blocks of seemingly homogeneous snow-white diatomite can be quarried out, though the unweathered beds are somewhat tough. It can be easily cut up into slabs with a saw or knife. It is light and porous. Several blocks cut as nearly as possible into one-inch cubes were found to average 221 grains, or 14.335 grammes in weight, and to absorb as much as 75 per cent of their weight of water. When wet, the material loses its whiteness and assumes a mottled greenish-gray color.

The determinations were made upon specimens from one of the lower coarser layers.

Although to the unaided eye there is no apparent difference in the size of the particles from the different levels, all the specimens being white and soft, yet the touch reveals some coarser grains; and particles of grit are found when a block is cut by a saw, and there is evidently a considerable difference in the degrees of fineness at different levels. By brushing the surface with a soft brush, the finer particles are gradually removed, and the coarser are left standing in relief, palpable to the touch and visible through a pocket lens.

Under the microscope, the material is seen to consist, for the most part, of nearly colorless vitreous particles. It is apparently a volcanic ash or dust—or, rather, a communicated volcanic glass—in minute transparent angular flakes, generally not more than 0.1 mm., but ranging from 0.1 down to 0.005 mm., and averaging, perhaps, about 0.05 mm. in diameter. Here and there in the mass, as spread out in the field of the microscope, appear particles, showing brown or dark-green color by transmitted light. These may be bits of obsidian, or possibly augite or hornblende. Since they can be readily concentrated by levigation, they are clearly heavier than the colorless glass-like particles. There are also small scales, apparently of a silvery mica.

Chemical analysis shows nearly 83 per cent of silica. In the midst of the volcanic dust the higher powers of the microscope bring into view the beautiful forms of the siliceous remains of diatoms.

Fossil bones of some large animal are reported to have been discovered in these beds. (Pool.)

Diatomite and the associated volcanic ash have a variety of economic uses. Diatomite (known also as infusorial earth, or diatomaceous earth, and by the Germans as **kieselguhr**) is usually classed among the abrasives, such as tripoli, rotten-stone, etc. It is largely used as a polishing-powder. The white earth from near Carson, Nevada, sold under the trade name of "Electro-Silicon," is an example. The Arizona earth, if cleaned by elutriation from coarser metals, such as grit and the larger flakes of volcanic glass, makes an excellent polishing powder for metals, including silver.

Its use in the manufacture of dynamite as an absorbent "dope" for nitroglycerine is well known. It has been successfully employed as a non-conductor of heat for coating steam pipes and boilers; and could doubtless be used to advantage in the manufacture of safes. It is applied in coating steam pipes by the California Anti-Caloric Co., and is valued for that market at $9 per ton under-

ground at the mine, and $18 per ton at the works in San Francisco. In 1897, a deposit was opened at Lompoc, Cal., and about 500 tons were shipped from there.

The production of diatomite in the United States ranges in the neighborhood of 3,000 tons annually.

For further information of the earth, and of the new species of diatoms, reference is made to descriptions with illustrations in the **Transactions** of the Wisconsin Academy of Sciences, June, 1902.

DIOPSIDE.

With specular iron, Chiricahua Mts.

DIOPTASE.

Emerald copper, silica 38.2, copper oxide 50.4, water 11.4.

This beautiful gem-like copper silicate has been noted at several localities in Arizona. Its occurrence near Riverside, in Pinal county, was observed by Mr. W. B. Smith (Proceedings of the Colorado Sci. Soc., Vol. II. p. 159, 1887.) It there occurs in seams and crevices of the copper ores at one of the shafts of the Bryan group. The crystals are small but numerous, brilliant and high colored.

Its occurrence was also noted in 1882 at the Bon Ton mines, Chase creek, near Clifton, by R. C. Hills. Lindgren and Hillebrand report its occurrence in good crystalline specimens at an old dump of the Stevens group of mines on the west side of Chase creek near Garfield gulch. These vrystals were from a small chimney of chrysocolla ore in limestone worked out. This is believed to be the same locality observed by Mr. Hills. According to Penfield, to whom some of these crystals were submitted, the crystals, closely grouped together, measured from one millimetre to two millimetres in diameter in cavities in a brown ferruginous gangue impregnated with amorphous green material, probably chryocolla. The habit of the crystals is that most commonly observed and is especially characteristic for dioptase.

A sample of copper ore containing

dioptase was received for the St. Louis exhibition from Mr. Messeger of Glendale, in 1863. It came from the claim of the Illinois Copper Co. about fifteen miles southwest of Wickenburg, and one and one-half miles northwest of the Angel mine.

Dioptase occurs with the pin-head copper, so called at the Ajo, but not in distinct crystals.

DUMORTIERITE.

A basic aluminum silicate; theoretic composition: Silica 30.6, **alumina** 69.4. Color, a bright, smalt-blue to greenish-blue. Hardness 7. Occurs at Clip, Yuma county, about five miles fro mthe Red Cloud silver-lead mine, in a quartzose rock, and associated with cyanite. It is a hard and interesting ornamental stone.

ELECTRUM.

White gold, Oro Blanco.

The Oro Blanco mining district receives the name from the fact that most of the gold produced there is nearly white, or has but a pale yellow color, and is generally not over 0.400 fine.

ENDLICHITE.

Vanadate of lead containing arsenic.

Analyses by Genth of specimens from Lake Valley, New Mexico, gave:

	A.	B.
Vanadic acid	10.98	7.94
Arsenic acid	13.52	10.73
Lead oxide	73.48	79.15
Chlorine	2.45	2.18

From the Railroad mine, Castle Dome, in association with wulfenite, vanadanite and cerussite.

Specimens from Oracle, A. T., (probably from the Mammoth mine) gave Genth and Keller respectively:

	Genth.	Keller.
Vanadic Acid	16.98	17.16
Arsenic acid	3.06	4.30
Phosphoric acid	0.29	trace
Lead oxide	77.49	77.47
Chlorine	2.41	2.46
Sesqui oxide iron	0.48	

EPIDOTE.

Silicate of alumina, lime and iron

of complex composition; pistachio-green or yellowish green in color.

Of common occurrence in the metamorphic rocks of Arizona, especially in the red sandstones and shales. It is frequently mistaken by the inexperienced prospector for an ore of copper of which, like its associate, garnet, it is a frequent associate. Its yellowish-green color is not, however, due to the presence of copper. The metal is often found distributed through the massive epidote in the form of ragged grains or small thread-like masses, as at the epidote veins or croppings in the red shales of Silver Bell district, but not in quantity sufficient to justify mining.

ERYTHRITE.

Cobalt Bloom—A hydrous cobalt arsenate; arsenic pentoxide 38.4, **cobalt protoxide** 37.5, **water** 24.1.

Samples of this mineral were received in January, 1905, from Mr. Herbert Brown of Yuma. (No. 6644.)

In the Cababi region southwest of Tucson, the precise locality unknown; found in samples of ore sent to the School of Mines for assay.

FELSITE.

An extensive stratified deposit of a white felsitic mineral is found on Milk creek, above Walnut Grove, Yavapai.

FLUORITE.

Fluor Spar, Derbyshire Spar. Fluorine 48.9, **Calcium** 51.1.

When massive, an ornamental stone, much used in England for vases and mantel ornaments. It forms an important portion of the vein-filling or gangue of the lodes at Castle Dome, Yuma county, and may be picked up along the croppings, and is usually a delicate pink in color.

It is also found in Pinal county, near the Mammoth mine, beyond Oracle, in a vein or mass several inches wide, green and purple in color.

At Helvetia, Pinal county, green, purple and pink. At Red Rock, Silver Bell district.

At Paradise, green and fluorescent (Mills, 1905), near Ludlow on Santa Fe railway (Broadwell). Useful as a flux in smelting; an ingredient of cement mixtures.

FOOTEITE.

Chlorhydrate of Copper.

A deep blue-colored mineral described by Prof. Koenig in 1891 as occurring in the Copper Queen mine implanted on limonite, but not seen by Ransome in 1892, and evidently rare.

GALENITE.

Lead sulphide, GALENA, sulphur 13.4, **lead** 86.6.

Crystallizes in cubes, or modifications of the cube, but is usually found massive with cubical cleavage. Good crystals are comparatively rare. It is a common associate of silver-bearing minerals and is itself argentiferous, being rarely without a few ounces of silver to the ton of ore.

There are several important lead-bearing districts in Arizona, and galena may be found in the veins of most of the gold and silver-bearing lodes.

Castle Dome in Yuma county, about eleven miles east of Castle Dome Landing on the Colorado river, twenty miles above Yuma, is one of the oldest and most extensively developed lead-yielding districts. It has supplied lead ore continuously since the settlement of the country, and bears evidence of prehistoric working. The mineral veins may be said to have been **re-discovered** in the year 1863, for it is certain that they were opened and worked at a remote period before American occupation, probably by the Spanish explorers, and even by the aborigines, if not for smelting, for the glittering ore obtained by crushing the galena. The ancient excavations extended to a depth of from five to fifteen feet, and followed the croppings of the vein for a hundred feet or more southward toward the banks of the Gila river, where traces of ancient smelting operations may be found.

The veins which yield the lead ore

are good typical examples of the "fissure vein." They traverse fine-grained mica and clay slates and are from one to six and, in places, twelve feet in thickness. They have a general northwest and southeast course and are vertical or but little inclined. The galena occurs in sheet-like masses on one or both walls and also in nodular bunches, spread through a gangue or vein-stone of quartz, gypsum and fluor-spar, this last mentioned mineral being the most abundant and characteristic.

During the first six months of the year 1879, 438 tons shipped to San Francisco averaged 69 per cent of lead and over 26 ounces of silver per ton.

The refined lead produced from Castle Dome ores is remarkable for its purity and softness and its special adaptation to the needs of the manufacturer of white lead. It is superior to lead which has been smelted from arsenical and antimonial ores. This lead is de-silverized with great ease, an advantage, not only of economical importance as respects ease of working and product of silver, but as giving a lead almost free of silver and therefore much better adapted to the manufacture of white lead, and much more valuable for that purpose than if it contained any silver. The presence of an ounce of silver in a ton of lead affects the corrosion of the lead in no slight degree. Lead which corrodes easily and completely is the best for making white lead. Lead holding silver does not corrode so sapidly and completely as pure lead. and white lead containing silver darkens on exposure to sunlight. The Castle Dome galenite is remarkably free from arsenic and antimony. At a depth of 600 feet water is found and the galenite is oxidized with the formation of beautiful crystallizations of carbonates of lead and of wulfenite and of vanadinite.

Silver district is another lead-bearing region adjoining Castle Dome on the north. It has larger veins and the ores are richer in silver but

have not the regularity of occurrence and distribution of galena characterizing the veins of Castle Dome. At the time of the first locations on the veins nodular masses of galenite weighing many pounds could be picked up on the croppings of the Silver Glance claim, having in the course of ages been weathered out from the gangue. Some of the veins are remarkable for the gangue or veinstone of heavy-spar, the sulphate of barytes—barite.

The Mowry mine in Santa Cruz county, about twenty miles south of Patagonia, has long been noted as a producer of lead ore, partly galena and partly carbonate of lead, a mixture favorable to smelting, which was availed of in the early sixties, and before, by the erection of simple adobe furnaces. This is one of the historic mines of Arizona, brought into prominence largely by Sylvester Mowry, the first delegate of the territory to congress, and often styled the "inventor of Arizona."

The Hardschell and Flux mine, also in Santa Cruz county, has been a large producer of low grade lead ore suitable for fluxing other ores. It is largely a carbonate resulting from the oxidation of galena, but carries about 10 ounces of silver to the ton and 10 per cent lead in the large way.

The World's Fair mine yields a considerable quantity of galenite in association with blende and high-grade ores of silver, and native silver.

Very fair crystals of galenite are found in the ore of the Silver Belt claim, Big Bug, Yavapai county, and in the Kasser claim near Globe, where, as in many other localities, it is closely associated with wulfenite, the molybdate of lead indicative of the presence of molybdenum in the galena.

Hand's mines in the Chiricahua mountains, Cochise county, produce not only galena in quantity, but lead carbonate also.

The old Yuma mine, twenty miles northwest of Tucson, has been a large producer of lead ore.

Cerro Colorado and the Liberty mines have also been large producers.

San Xavier mines, Sierritas, south of Tucson, with sphaterite.

Jack Rabbit mine, ten miles east of Vekol.

At Mineral Hill. Pinal county, in the Alice vein.

At the Great American mine, Swishelm mountains.

At the southern end of the Huachuca mountains, not far from the international boundary line, it occurs with zinc blende in limestone.

At Greaterville, in veins near Anderson's. At the Salero in the Eureka, Thunderer and Mabel claims, in a gangue of manganese spar.

The Vekol mines, Pima county, have yielded large masses of lead ore in combination or mixture with high-grade silver ore. Spescimen masses in the museum at the university have yielded by assay as high as 400 ounces of silver to the ton. There is much oxide of lead and carbonate in the ores. Galena has also been mined in quantity from the Liberty mine southwest of Tucson.

In the olive district the Paymaster and other mines have been large producers. Galena mixed with blende is abundant at the San Xavier mine.

Galena is large masses has been extracted wrom the Manila mine at the northern end of the Huachuca mountains. It occurs also in disseminated grains in a quartz of gangue at the croppings.

In Cataract Canyon, a tributary of the Colorado, part way down the Grand Canyon.

In the Mineral Creek country north of Troy and Kelvin.

In the Aztec, Tyndall and Salero districts, Santa Cruz county, there are many localities of massive lead ore, notably at the Trenton.

In quartz with wulfenite, 2½ miles northwest of the Desert gold mine.

It is reported from the Arizona-Pittsburg, in the north end of the Aztec district, in association with copper ore, about nine ounces in silve and a trace of gold. Similar ore is found on the Leek-McDonald property.

Montana mine, Oro Blanco district, Santa Cruz county, with sphalerite.

At Mark Lulley's mine, the "Wandering Jew," in the Santa Ritas, Pima county.

In the gold-bearing quartz vein at Rich Hill, Yavapai county.

Occur at McNeil lead mine 35 miles southwest of Bouse.

The galenite in the ore of the Silver King mine, Pinal county, was not very rich in silver. Tests made by me in 1883, and cited in the report, yielded at the rate of 14.88 ounces per ton. In the large way the ore in which galena preponderated in quantity was found to range in value from $42 to $870 per ton, probably from about 40 to 800 ounces per ton, estimating the value of silver at that date at about $1 an ounce. The galena selected for the assay appeared to be pure. It cleaved with curved cleavage planes.

GARNET.

The association of garnet with ores of copper may be observed on a large scale in Southwestern Arizona, in Southern New Mexico and in Sonora, Old Mexico, especially at El Cananea, and at the Nacosari. It occurs generally at, or near, the plane of contact of an eruptive rock with limestone and may be regarded as the result of contact metamorphism. It also occurs in reefs traversing limestone, like veins of quartz, at some distance from a contact plane, in origin, seemingly the result of siliceous emanations.

Small but dark-red garnets occur abundantly in the gravels and sands of the streams descending from the Catalina mountains north of Tucson in association with heavy black sand.

Garnet, when derived from the pure limestone of the Modoc formation, forms large masses 50 to 100 feet thick, as on the western slope of Modoc Point at Morenci, and on top of Shannon Mountain at Metcalf. (Lindgren.)

Pyrope garnets of fine deep color are obtained in considerable quantity from the Navajo Indians of Northeastern Arizona. The report on the

production of precious stones in the year 1907 published by the United States Geological Survey, says: "A quantity of pyrope garnets was collected from the Indian reservation in Northeastern Arizona and Northwestern New Mexico. Mr. J. L. Hubbell of Ganado, Arizona, mentions a locality about seventy-five miles west of north of Ganado where garnet is found abundantly over a stretch of country about ten miles long. The garnets are picked up from the surface of the ground by the Indians." They occur in sandy soil, and are uncovered by the action of the wind.

The largest of these garnets are transparent and suitable for cutting. They make valuable gems. A black garnet in good rhombic dodecahedrons is reported by Geo. P. Hunstock, 1905, at Superior, and red garnets of similar crystallization from the Graham mountains by Col. Benj. M. Crawford. See also Grossularite).

GLAUBERITE.

Sulphate of soda and lime. Sulphuric acid 57.6, **lime** 20.1, **soda** 22.3.

At the Thenardite and mirabilite beds in the Verde valley, in thin tabular crystals, often changed to calcite.

GERHARDITE.

Basic copper nitrate, Nitric acid 22.5, **cupric oxide** 66.2, **water** 11.3.

A very rare mineral first identified from Arizona by Messrs. Wells and Penfield at the laboratory of the Sheffield Scientific School, among some ores sent to the school by Mr. Thomas from Jerome. Careful search at the locality has since failed to reveal its presence there. And it was sought in vain at the copper mines, until Lindgren and Hillebrand reported finding it in green coatings on the cliffs of granite-porphyry in the deeply eroded Chase Creek canyon at Metcalf. It there appears to be formed by the trickling of atmorspheric waters over and through rocks containing a small percentage of copper. It is locally known as **"green paint"** and is not soluble in water, but chemical examination showed

that the copper minerals consist of a nitrate and a chloride. The authors in conclusion state that "the mixture contains, presumably, the basic nitrate, Gerhardite, and a chloride, which is perhaps atacamite. (Am. Jour Sci., Dec. 1904.)

GOLD.

Oro, Oro nativo, rarely pure; generally alloyed with silver. California gold is mostly 87 to 89 per cent fine. The purest known gold is from Mt. Morgan, Queensland, yielding 99.7 to 99.8 of gold.

In Arizona nearly every mountain range has one or more gold mines or, at least, gold-bearing veins or deposits.

Of all metals gold is the most widely and generally distributed in all parts of Arizona. It occurs either as placer deposits or in veins, or in combination with copper ores, from Yuma on the west to the New Mexican line on the east.

It is not possible to do more in this list than to name some of the more important localities which have been explored and developed.

The Fortuna mine near Yuma has been a large producer of the metal.

North of Yuma, along the Colorado especially, there are several localities where coarse gold has been found in copper ore, notably at the Ellen Gowan claim and in the region of La Paz.

Desert gold mines 2½ miles north of Vicksburg, Yuma county, in veins and in placer deposits (dry washing.)

The King of Arizona has been, and is still, a large producer.

Mack's mine, a few miles north of Parker, wire gold in copper ore.

The Congress mine, in Martinez mining district, Yavapai, is well known for its large production, and for the depth and extent of the workings. The gold is closely associated with pyrite.

Rich Hill, not far east of Congress, is celebrated for the number, size and great aggregate value of the nuggets found there and for the coarse gold in the quartz vein.

Vulture mine, coarse gold in brilliant sheets was often found, associated with galena and wulfenite, jarosite and pyrite.

Southern Belle mine, Old Hat district, Santa Catalinas; Mammoth and Mohawk mines, Shultz, Pinal county; Saddle Mountain district, at Pools mines; Ash Creek Gold Co.

Tombstone mines, especially at the Contention, associated with horn silver and lead carbonate.

In quartz, crystal lode, Big Bug, Yavapai. In quartz veins on Cherry creek, Yavapai.

United Verde, in the quartz vein which adjoins the copper ore.

Bullwhacker mine, near Prescott.

Lynx Creek placer deposits.

Walnut Grove and Hassayampa placers.

Oro Bella, Grey Eagle and other lodes on Hamburg Canyon.

Bradshaw mountains and on eastern slope near Crowned King mine.

Seven Stars group, Hillside.

Weldon mines, Quijotoa region.

Horse Shoe Basin placers, coarse gold.

Greaterville placers and in place, Santa Rita mountains.

Deering's Camp, Box Canyon, Santa Ritas.

South of Casa Grande in quartz veins traversing slates.

Mohave county at Gold Roads, Gold Basin, Golden Sun, Bi-Metals and other properties.

Native with galenite in the Hornmeyer mine, two miles south of Morenci, in limestone; in Gold Gulch and its vicinity; in Morenci Canyon and as placer gold in the gravel banks along the San Francisco river especially near Oroville.

At Crawford's gold mines north of Metcalf.

Native with galenite in the Hon-

GROSSULARITE.

A calcium-aluminum garnet of light color, with much iron oxide. A common associate of copper ores of Arizona and other regions. (See Garnet.) In Arizona it may be noted especially in the Dragoon mountains and in the Santa Rita range south

of Tucson. It is conspicuous as the gangue mineral at the Twin Buttes in the Santa Cruz valley; at Mineral Hill at the Azurite, at the Plumed Knight and at the claims in Olive district and the Sierritas, where much of the copper ore is found in close association with garnet of light color. It occurs similarly in the claims of the Imperial Copper Co. It is particularly evident as dike-like borders of some of the copper ore croppins of the Christmas and neighboring camps.

These and other examples, which might be added, are sufficient to show that in Arizona, as elsewhere, it is the rule with scracely an exception that wherever either a plutonic intrusion traverses limestone or follows a plane of contact of limestone and another rock, and has the conditions required for metamorphic action, garnet and some times other silicates are formed and are found with copper ore. The reef formation of garnet analogous to quartz lodes in form may be seen to an unusual extent at the Twin Buttes property, where there is a series of garnet reefs in parallel lines along and near the contact of the granite and limestone. These garnet reefs are copper-bearing and have the semblance of regular lodes. Both at the Twin Buttes mines and at the Imperial mines, west of Tucson, copper ore in the form of chalcopyrite is disseminated in the midst of the garnet in the form of grains, stringers or nodular masses. Such masses are found in places completely enveloped in the garnet and are apparently of contemporaneous origin. Large blocks of garnet quarried at Twin Buttes often disclose, on being broken up, nodules of copper sulphide so completely enclosed in a dense garnet magma as to be fully protected from atmospheric agencies, and to remain unchanged and unoxidized in croppings exposed to the weather.

It has been noted by Ransome a the Copper Queen mine associated with tremolite and diopside; so, also, in the Calumet and Arizona.

(Sse also garnet.)

HALITE—ROCK SALT.

Sodium chloride, chlorine, 60, **sodium** 39.4.

In large, clear crystalline masses, associated with the sulphate of soda, in hills in the Verde River valley a few miles south of Camp Verde.

In the Upper Salt river, rising in solution—salt springs—the source of the salinity of the Salt river. Reported, also, in beds on Salt river near the mouth of Canyon creek on the Indian reservation, Gila county.

HEMATITE.

Mirror-iron, Specular Iron, Misaceous iron. Sesquie oxide of iron. Iron. Sesqui oxide of iron 30, **iron** 70.

At many localities, chiefly as croppings or hard gossan of pyritous deposits of iron and copper, corresponding in position, and relation to subjacent ore bodies, to the limonitic (hydrous) gossans of less arid regions.

As crest stoi ns, or gossans, of copper ore at Palmer & Wharton's copper claims in the "new copper country," in the northern part of Yuma county.

So also at several lodes or copper deposits in Santa Cruz county, notably at the Pluto claims, the Isbella and at several other claims where copper is found in the red shale formation near Montosa, Santa Rita mountains.

Some loose rolled masses from arroyos have been brought in from the Tucson mountains near Tucson.

In the earthy pulverulent form at Carter in the new copper county, Yuma county.

As "hematite paint" at Uarker, A. T., and according to R. McMahon 1904) in the region known as Bouse's Well, not in very large bodies, but in streaks from three to six inches wide, but of fine quality, such as the Indians use. The specimens sent in to the Arizona School of Mines were superior in quality to any before seen, being extremely fine and smooth, spreading with great ease as paint when mixed with oil. The locality was said to be twenty miles from

Parker, thirty miles northerly from Quartzsite. Since that time the construction of the Arizona and California railroad has brought the locality into further notice and rendered this important pigment commercially accessible.

Specular iron also occurs in crystalline rosetts near Mammoth, Pinal county. (Pool).

The micaceous form is reported from Willcox and from Briggs in Yavapai county. (Long).

In the Clifton-Morenci district, according to Lindgren, it is a somewhat sparing product of contact metamorphism associated with quartz, garnet, epidote and magnetite.

Found also near Quartzsite, Yuma county. Occurs in the magnetite in the massive croppings of the Black Diamond copper mine, Dragoons.

HUBNERITE.

Tungstate of manganese with a little ferrous iron. Analysis of the Dragoon mineral by Prof. F. W. Guild of the Arizona School of Mines in 1904 gave:

Ferrous iron	Fe O	2.66
Tungstic acid	Wo 3	75.36
Manganese oxide	Mn O	19.50
Silica	Si O.3	1.70
Undetermined		.78

This important ore of tungsten occurs abundantly in veins in the northern extension of the Dragoon mountains, north of Dragoon station on the Southern Pacific railway in Cochise county. Sometimes called the Russelville locality. Shipments of the ore have been made from there for several years. About eighty tons of the ore (four car loads) were taken to the School of Mines at the university and were crushed and jigged, yielding very clean concetrates assaying over 70 per cent tungstic acid.

It occurs also sparingly in a vein at Walker's claim, Russellville, with fluorite and some pyrite.

It is reported from Mohave county, seventeen miles east of Yucca, as occurring in schists.

Said to occur at the Tip Top mine in the Bradshaw mountains, Yavapai

county, in needle-like crystals with quartz.

Wtih wulfenite, Gigas region, in quartz veins.

HYALITE.

With semi-opal in the Grosvenor hills near Salero, Santa Cruz county.

ILMENITE.

Titanium 31.6, **iron** 36.8, **but composition variable.**

This hard, black and heavy mineral appears to be widely distributed in the Piedmont region of the mountains of Central Arizona, judging by the many samples sent in to the School of Mines for determination. It is often supposed to be wulframite, or hubnerite.

INFUSORIAL EARTH.

See diatomite.

IODOBROMITE.

Silver with iodine, bromine and chlorine. Silver 60.2, **iodine** 14.1, **bromine** 17.8, **chlorine** 7.9.

This rare mineral occurs in thin seams and crusts in a silver-bearing vein of quartz and calcite near Globe, Pinal county. (Hechman's mine.) Its crystallization is obscure, but the species is known to crystallize in the monometric system. It is soft, like talc., luster vitreous; color light lemon-yellow to sulphur-yellow and canary-yellow. The reactions before the blowpipe are remarkably beautiful and interesting. Heated in a closed tube with bisulphate of potash the mineral quickly changes color to a dark salmon or orange-red; heavy brownish-red fumes of bromine are given off and bromine condenses in the higher portion of the tube; violet vapor of iodine then appears and crystals of iodine form below, or nearer the assay, than the condensed bromine. The fused assay floating in the flux is brilliant cherry-red, at first a very dark red, but as cooling progresses it gradually loses this color passing through various shades of red until the normal yellow color is restored. The fused mass then being

removed from the tube and reheated until all the bromine is expelled and then heated with carbonate of soda on charcoal a button of metallic silver is obtained. The fused carbonate of soda dissolved from the coal reacts for chlorine with silver nitrate. In the final reduction of the assay to metal a slight yellow areola, like that from lead, was observed and referred to probable slight impurity. (W. P. B. Am. Jour. Sci., Vol. XIX., March 1895.)

IODYRITE.

Silver iodide; iodine 54, silver 46.

From the Noon silver claims, Santa Cruz county. Specimens sent by Mr. Edw. E. Noon in 1903 to the School of Mines had a reddish-brown color which rapidly darkened in sunlight to an olive green. So, also, the yellow powder and yellow streak of the mineral rapidly changes color on exposure to the sun's rays. Hardness 2.5 to 3. On charcoal before the blowpipe gives a bluish flame, a yellow areola, and globules of silver and some lead with a yellowish-brown coating near the assay with carbonate of soda. Fuses with great ease and gives off white vapors, yielding a black globule which sinks into the coal and on further smelting the coal becomes sheeted with globules of silver.

Reported to occur also at the Cerro Colorado mine.

IRON.

Native or metallic iron, Meteoric iron.

Although metallic iron is not known occur in the rocks of Arizona, we have several localities of immigrant masses from other worlds, or at least from the regions of space, masses of nearly pure malleable iron with a few per cent of nickel and cobalt, known to mineralogists as meteoric iron or as siderites, which have come to us bearing pyritous nodules and sometimes crystallized carbon in the form of diamonds.

The celebrated "Ring Meteorite," known in the annals of the national museum at Washington as the Irwin-Ainsa meteorite, is known throughout

the science world for its remarkable ring-like form and its history. Found originally near the mouth of the Madera canyon in the Santa Rita range of mountains some twenty-five miles south of Tucson, it was taken to that city and for many years served as an anvil for the local smith, the thinnest part being buried in the earth and the broadest, heaviest part corresponding to the signet portion of a ring, having a nearly flat surface, served as the face of the anvil. Rescued from this position by the joint efforts of Mr. Ainsa and Dr. B. J. D. Irwin, U. S. A., it was taken to Guyamas by a quartermaster's team, shipped from there to San Francisco and thence to Panama and New York, and by rail to the national museum in Washington, where it now rests. A fac-simile in the form of a colored plaster cast is now in the territorial museum at the university, Tucson. The iron weighs 1,400 pounds. It was exhibited in the United States collection of minerals at Philadelphia in 1876 and is noted throughout the world.

The region of Canyon Diablo, Coconino county, is a remarkable one for the number and aggregate weight of siderites found there and distributed to the museums of the world. The wide, circular depression known as the "Crater" is believed by some to have been caused by the impact of an enormous meteor striking the earth at that place, and bursting into fragments.

Nearly all the masses found there contain nodular masses of Troilite, and small diamonds have been found in some of the masses which have been analyzed.

A compact, rounded meteoric iron was found some decades since on Weaver mountain, near Weaver, Yavapai county, and is known as the "Weaver Meteorite." It was secured for the University of Arizona and now rests in its museum. It is remarkable for its density and evenness of grain. Weight originally 85 pounds. Specific gravity % 7.9818. Analysis by W. B. Alexander in 1904 resulted as follows:

Iron	79.60
Nickel	18.80
Cobalt	1.60

Another meteoric mass, chiefly stone, with inclusions of iron, is from Snyder's mountain, west of Tucson, but is not yet described.

The Carleton meteorite in the U. S national museum is from Arizona.

JAROSITE.

A hydrous sulphate of ferric iron. Sulphur trioxide 31.9, iron sesqui-oxide 47.9, potash 9.4, water 10.8.

At the Vulture gold mine, Maricopa county, on quartz.

KAOLIN.

Porcelain clay—Silicate of alumina; composition variable, but theoretically; silica 46.5, alumina 39.5, water 14.

Occurs at nearly all the large copper mines as a result of the alteration of the feldspar in crystalline rocks, granite or porphyry, by acid solutions derived from oxidizing sulphides. It is especially notable at the Copper Queen, at the Longfellow and other mines of Clifton-Morenci, at Globe, and also at the Vekol mines in the southwest corner of Pinal county.

At the copper deposits of the Longfellow and at Morenci and Metcalf. At the Mammoth mine in Garfield canyon and at the Copper Mountain mine.

LIBETHENITE.

Hydrous basic phosphate of copper. Phosphoric acid 29.8, cupric oxide 66.4, water 3.8.

This rare mineral was found by Messrs. Lindgren and Hillebrand thirty feet below the adit level of the Coronado lode in the main chute, in small crystals less than a millimeter in length, deposited in cavities and seams in a quarzite gangue.

LIMONITE.

Hydrous sesqui-oxide of iron.

A common associate of copper ores, and as "gossan." In the Copper Queen

at Bisbee. It is sometimes found in stalactitic and botryoidal forms, but is generally earthy and amorphous.

In cases where copper and iron solutions have attacked limestone so as to form cavities, copper carbonate is deposited in crusts on the limestone while an earthy, porous mass of limonite occupies the central portions.

In the form known as **"gossan"** in the croppings of ore-bodies, and wherever iron pyrites has decomposed with the loss of sulphur by oxidation.

Isolated bunches and fragments occur in the soil of Canyon Diablo, and are believed to be residual masses from the oxidation of the meteoric pyrites.

LINARITE.

Sulphate of lead and copper: Sulphur tri-oxide 20.0, **lead-oxide** 55.7, **cupric oxide** 19.8, **water** 4.6. It is known, also, as cupreous anglesite.

Found in the ores of the Mammoth mine at Shultz, Pinal county, with cerussite, galena and wulfenite in specimens with a beautiful, clear indigo blue color.

MAGNETITE.

Magnetic iron ore. Iron 72.4, **oxygen** 27.6.

As crest-stone and as gangue or veinstone of copper ore at the Black Diamond mine in the Dragoon range, Cochise county.

In the croppings of copper ores at Rosemont and the Narragansett claim.

At the Isabella copper and lead claim near Montoso, Santa Rita mountains large masses were intimately mixed with malachite.

In loose, rounded masses, Tucson mountains.

In dodecahedral crystals five miles south of Queen creek, Pioneer mining district, Pinal county. (Hunstock).

In the Clifton-Morenci district in the contact metamorphic limestones and dolomites, associated with garnet, amphibole, pyroxene and sulphides. It occurs in quantity available for smelting flux in the Manganese Blue and the Arizona Central mines and in the gap where the road to Eagle creek descends into the Gold Gulch valley.

MALACHITE.

Green carbonate of copper—Copper oxide, carbon dioxide.

One of the most common of the copper compounds formed by the decomposition of copper sulphides at or near the surface in copper-bearing deposits. Dark-green or malous green in color it gives beauty to the ores and indicates their nature. While it occurs at nearly all the copper mines in the croppings or upper levels it has been one of the chief ores at the Copper Queen, Bisbee, where it was closely associated with azurite, the blue carbonate, and with oxide of manganese and cuprite.

Fine specimens were found in the upper workings of the Longfellow and other claims, Clifton, Graham county, associated with azurite and native copper in kaolinized porphyry.

It occurs similarly in the upper workings of the Imperial, Silver Belt district.

Of the malachite occurring in the Copper Queen mine Dr. James Douglas says: "The malachite is never found in such large and important masses as to make it commercially valuable for decorative purposes; besides, occurring generally in thin botryoidal masses it is usually streaked with manganese which detracts from its purity. Its most striking mode of occurrence is in geodes which are lined with velvety crystals of the same mineral. These hollow spheres, the walls of which are composed of concentric layers, are rare, but when found are usually in nests imbedded in soft, wet ferruginous or manganiferous clays, such as constitute the gangue or ledge-matter of nearly all the ore, and they occur at no great distance from a limestone wall or partition."

A choice series of beautiful specimens from the Copper Queen was presented to the School of Mines by Dr. Douglas and they may be seen at the university.

MANGANESE ORE.

The various oxides of manganese occur widely distributed in small

quantities, generally as the result of oxidation of manganiferous veinstones, notably from managnese-spar, as at the veins traversing diorite at the Salero, Santa Cruz county.

The occurrence at the Lucky Cuss mine, Tombstone, appears to be primarily from Alabandite (which see).

Samples of hard compact ore contributed to the representation at St. Louis in 1863 by Mr. Barker of Florence were reported as from two parallel veins averaging twelve inches in width of solid ore and extending for about 600 feet in a mica schist formation.

MARBLE.

See building materials—Appendix.

MELANOCHALCITE.

A silico-carbonate of copper.

A lustrous, brittle pitch-black substance described by Koenig as forming a thin envelope about kernels of cuprite in the midst of chrysocolla.

Found on the 850-foot level of the Calumet and Arizona mine, Bisbee.

MELANTERITE.

Iron Vitriol. Hydrous ferrous-iron sulphate; sulphur trioxide 28.8; iron protoxide 25.9; water 45.3.

Occurs in the United Verde mine, Jerome, with copper sulphate (chalcanthite).

In the leachings from Red Mountain, a few miles below Patagonia, Santa Cruz county.

It is found usually wherever iron pyrites is oxidizing and on exposure to the air it changes to ferric sulphate. It is the partial source of the hematite gossans of copper-bearing lodes.

MELANOCHALCITE.

A silico-carbonate of copper. Copper oxide 76.88, silica 7.80, carbon dioxide 7.17, water 7.71.

Described by Prof. G. A. Koenig (Am. Jour Sci., Dec., 1902.)

From the 850-foot level of the Calumet and Arizona mine, in thin shells about nuclei of cuprite, native copper and brochantite.

MIRABILITE—GLAUBER SALT.

Hydrous sodium sulphate. Sulphur trioxide 24.8, **soda** 19.3, **water** 55.9.

Occurs abundantly in beds and rounded hills in the valley of the Verde river, Yavapai county, some three miles southwest of Camp Verde, with thenardite, halite and glauberite. Exposed surfaces soon become covered with a white effloresence which drifts before the wind like dry snow.

It is quarried extensively to obtain "salt" for cattle ranges. More or less rock-salt is found enveloped in it.

MOLYBDENITE.

Sulphuret of molybdenum, sulphur 40.0, **molybdenum** 60.

Valuable as a source of the metal or its salts and for the treatment of steel.

It occurs at several different places in the Santa Rita mountains, notably at McCleary's claims, in a quartz gangue and also in close association with pyrites, from which it is not readily separable. In the quartz vein, however, it occurs in sub-crystalline masses from which it is easily and completely separable by the oil or resin processes. Greasy or resinous compounds adhere to the molybdenite but not to the vitreous quartz, thus permitting a complete separation.

The chief source of molybdenum in Arizona is from the compound of molybdic acid and lead the species wulfenite. (Which see).

Molybdenite occurs also in quartz near Columbia, (samples from Braden, Ft. Thomas, 1903). Reported also from Berkeley in Cedar district. At the Amethyst claim (Walker's), Dragoon, with fluor spar and hubnerite.

Large deposits of molybdenite in granular form, not foliated, are reported in Mohave county, in the Hualapai range, across the valley from the Aquarius . (Smith).

MOLYBDITE.

Molybdic ocher—Molybdenum trioxide; oxygen 33.3, **molybdenum** 66.7.

Accompanies the ore of molybdenite

and results from the oxidation of the sulphide, at McCleary's mines in the Santa Rita mountains.

MORENCITE.

Under this name Messrs. Lindgren and Hillebrand describe a mineral of complex composition which, under the microscope, appeared well individualized and not a mere mixture. It occurs in a lime shale on the intermediate level of the Arizona Central mine at Morenci, 200 feet below the surface, in brown, yellow, silky, fibrous seams in brownish, or greenish, spreading masses.

The fibrous mineral on the seams forms a felted aggregate as seen under the microscope. It appears to be a hydration product of an original meta silicate.

MUSCOVITE.

Mica. Muscovy glass.

From the north side of the Grand Canyon of Arizona, Coconino county, in sheets of two and one-half or three inches square of fair quality and light color. Reported by W. W. Bass.

In the White Horse Tank mountains south and west of Phoenix, in plates of good, merchantable size, but full of internal markings and inclusions which impair its value.

NITRE.

Nitric acid 63.5, **soda** 36.5.

Nitrates, probably with **soda-nitrate** and **potash-nitre,** mixed, are reported at Briggs, Yavapai county, by J. Y. Long, July, 1903. Exploited by the Nitrate of Potash Mining Co., P. W. Dillon, secretary, Redlands, Cal.

Caves and abandoned mine workings are the resort of numberless bats which may be the source of nitrate deposits.

ONXY MARBLE.

Lime onyx. Chiefly lime carbonate. Arragonite.

There are several localities where this ornamental stone occurs. One at Big Bug creek, in Yavapai county,

has been considerably worked and has yielded beautiful material.

Another locality is on Cave creek about forty-five miles north of Phoenix.

A black, white and red variety in layers and stalactite masses deposited upon granite walls and in deep fissures has been opened by Mr. Burson in Kirkland valley. It seems specially well adapted to the manufacture of small objects for decorative purposes.

OPAL.

In the form of semi-opal, hydrous silica, this mineral occurs in the Grosvenor hills near Happy camp, Salero, amber brown in color and associated with chalcedony and hyalite.

Found also at Picket Post, Pinal county, and a thin layer of a greenish color in the upper layers of the diatomite on the San Pedro river.

PERIDOT.

This mineral is described under the head of Chrysolite.

POLYBASITE.

Sulphur 15.0, **antimony** 9.4, **silver** 75.6,. (A part of the silver, maybe, replaced by **antimony**). Silver King mine, Dana, p. 146 (vi.)

PYRITE.

Iron di-sulphide. Sulphur 53.4, **iron** 46.6.

One of the most common and widely distributed of metallic minerals, occurring in nearly every county in the territory, generally in close association with the sulphide ores of copper, especially yellow copper. Cood crystallizations are comparatively rare, but are found in Santa Cruz county near the DuQuesne properties in single, perfect crystals with extremely brilliant faces, generally octahedral and much striated.

PYROSLUSITE.

Manganese di-oxide.

In black, often sooty, masses asso-

ciated with quartz, azurite, malachite, limonite and hematite, in the upper oxidized portions of copper deposits.

PYRRHOTITE.

Magnetic sulphide of iron—See Troilite.

PYROMORPHITE.

Lead phosphate.

In small, dark-green brilliant crystals, and in yellowish-green coatings on the surface of specimens from the Ibex-Plomoso mine, Bouse, Yuma county.

Reported from the early workings of the Constitution, Santa Cruz county, and of the Cerro Colorado, Pima county.

QUARTZ.

In interesting discoid forms resembling buttons and in transparent crystalline rosettes at Picket Post, Pinal county, associated with chalcedony and semi-opal.

As a massive, uncrystallized gangue, or veinstone, it is familiar to prospectors and miners, but is rarely clear and transparent, but is milk-white and opaque. A specimen, however, in the museum at the School of Mines, university, presented by W. Blauvelt, is a good example of a mass of quartz crystals from the side of the vein of the Cash mine near Prescott, Yavapai county.

The white quartz gangue separated from the hubnerite of the Dragoons has the property of phosphorescing when struck or rubbed together.

QUICKSILVER.

Mercury, see Cinnabar.

SALT.

See Halite.

SCHEELITE.

Calcium tungstate. Tungsten trioxide 80.6, **lime** 19.4.

Occurs sparingly with the hubnerite of the Dragoons, observed only when the hubnerite was crushed and jigged in large quantity at the Arizona School of Mines. It was then found

in white and yellowish colored grains with the heavier products of concentration. One or two rudely formed crystals were found.

This mineral, also, occurs sparingly in the veins of pyritic ore (pyrite and chalcopyrite), of the Chiricahuas, near Bowie, in Cochise county.

At the Maudena claims, Old Hat district, Catalina mountains, in considerable quantity, massive and in loose aggregations or friable masses of a light-brown color.

It may probably be found in association with the hubnerite of the Gigas district.

SELENITE.

Sulphate of lime in transparent plates or masses. Known to Mexicans as **"Yeso."**

In the horizontal sediments along the San Pedro river below Mammoth, in thin sheets. Also found on the Ft. Apache Indian reservation in Gila county, about one mile from Cibicu creek and two miles from the buildings of the Indian school.

SERICITE.

An altered muscovite mica in fine scales or masses with silky luster.

It characterizes certain schists, and occurs in the Santa Catalina mountains north of Tucson, and in the mines at Bisbee and Clifton-Morenci.

SIDERITE.

Iron carbonate. Carbonic acid 37.9, **trioxide of iron** 62.10.

At the Dosoris mine in Yavapai county, a part of the veinstone.

SILICIFIED WOOD.

This, though not exactly a mineral species, is one of the interesting mineral productions of Arizona, and in a form at the Petrified Forest which has excited world-wide attention. Chemically considered, it is one of the varied forms of silica.

In the alluvial sands at Parker probably derived from adjacent stratified formations.

In considerable quantity near Yuma

on the Colorado, brown in color and sand-sculptured and polished.

Much of the petrified wood from the Arizona Chalcedony Park was cut and polished at Sioux Falls, South Dakota. The following is clipped from the Sioux Falls Journal:

"The polishing works of this city is now engaged on the stupendous job of getting out $1,000,000 worth of polished chalcedony, or petrified wood, to be taken to the Paris exposition. This petrified wood is hauled from its native heath in Arizona, a distance of sixty-five miles, to a railroad, and then shipped to this city to be cut and polished. It shipped here in great logs and stumps weighing many tons each, just as they have lain for many ages during the process required by nature to turn the wood into beautiful stone. The process of saving the stone up in shape for polishing is most tedious, the huge machinery used for the purpose being able to saw only from an inch to three inches a day into it. After being cut and polished the stone is worked up into every conceivable shape, from cuff buttons to tops for center tables and great columns, which cost a small fortune. All kinds of jewelry is made from it, as well as trinkets and handsome articles for souvenirs."

SILVER.

In ponderous masses near Globe, Gila county.

A fine, large nugget of nearly pure silver was found in the placer deposits about twelve miles north of Globe in 1895. It weighed thirty-one pounds and was 900 fine. It was fully rounded by much attrition, all angles and asperities of surface had been worn away. This mass was figured and described in the governor's report of 1899, p. 37. It was probably derived originally from the deposits of the metal in limestone, associated, as found today in the Stonewall Jackson mine, with horn silver and other silver-bearing minerals.

The Stonewall Jackson is one of the famous old mines of Globe dis-

trict, and is reported to have yielded over a million dollars' worth of silver from the years 1876 to 1883. It is now being reopened, and at the depth of 280 feet a rich vein of silver is reported. (1908.)

The Silver King mine in Pinal county has yielded beautiful specimens of the white metal, massive and in the filamentous form, coarse and fine, very white and striated as if made up of bundles of fine wire, or ranging in size from the size of a pin or knitting needle to masses half an inch through, but solid and much twisted and gnarled. The metal is also finely filiform in long wires, in one instance twenty-four inches long, and in threads as fine as hair, or silk, filling cavities or branching from the coarser wires. It occurs also in sheet-like masses and plates and in thin films forming a regular continuous plating upon the surface of quartz crystals where they are found imbedded in argentite or stromeyerite. It is found similarly on the face and cleavages of black zinc blende. Distinct crystals of the metal were extremely rare in the mine. A few small octahedral crystals were nested in a cavity. The filaments are often subvided toward the extremity and ramify like the tendrils of a vine. They sometimes bear aloft on their ends detached and beautiful crystals of calcite. So also the silver wires penetrated crystals of quartz, or were implanted on them.

This Silver King native silver is remarkably pure. It has been shown by repeated assays to be from .990 to .997 (thousandths) fine. It does not blacken in nitric acid, and does not show a trace of copper or gold by the usual test. It is estimated that one-third of the value of the product of the mine was in the metallic form.

At the Tiger mine, Yavapai county, silver occurs closely associated with blende. At the Eureka-Mabel, Santa Cruz county, with grey copper.

The very large masses of silver found at the celebrated Planchas de Plata in Sonora, near the Arizona line, at Nogales, should be mentioned. The heaviest weighed 108 arrobas (2,700 lbs.)

SILVER GLANCE.

The common name among miners of Arizona for the species of "Argentite," to which reference is made.

At the Silver King mine, Pinal county, in loose masses scattered through the soil of the croppings, partly silver glance and in part stromeyerite, both derived by weathering from the lode, where it occurs in close association with the metal.

Found, also, in the veins of the Tyndall district, Santa Cruz county, at the Eureka-Mabel and at the Constitution lodes, associated with tetrahedrite and manganese spar.

At the Montezuma lode, Empress of India claim, Santa Cruz county, and at the mines of Cerro Colorado.

SMITHSONITE.

Zinc carbonate, the **Dry bone** of the zinc miners of the Mississippi valley.

Occurs sparingly where sphalerite is weathered and decomposed.

SPHALERITE.

Zinc blende, the **sulphide of zinc,** or **"black jack"** of some eastern mining districts, is a comporatively common species occurring under various conditions in the mineral veins of Arizona, but largely in close association with galenite and silver-bearing minerals. It is often of itself largely silver bearing. At the famous Silver King mine, for example, it is in close association with native silver, so close that fractured masses of blende are held together by wire-like threads of very white, pure silver. The blende of this mine is generally light emerald or sea-green in color and transparent, forming very beautiful cabinet specimens, especially when traversed by native silver or closely associated with stromeyerite and silver sulphide.

There are several important occurrences of blende in Santa Cruz county. At the southern end of the Huachucas it is found massive in limestone with galenite and is partly

altered by oxidation to carbonate, "dry-bone" or Smithsonite. The sphalerite of the Silver King presented itself in a variety of forms, sometimes in beautiful transparent, oil-green crystals, and again in black masses without any crystalline facets except by cleavage. The green crystals were so brittle and easily split that it was rare to get one with a single perfect plane. The fragments indicated compound twined dodecahedral crystals. The ore from the lower levels of the mine, or rather, the concentrates, obtained from such ore and shipped in quantity, contained nearly 18 per cent of zinc in the form of blende.

SPANGOLITE.

Basic chloro-sulphate of copper and aluminum.

A rare species discovered and described by the late Prof. S. L. Penfield of Yale university in 1890; from some Arizona locality, the exact place not known.

Lindgren and Hillebrand, in 1904, reported the occurrence of this species on some specimens from the Metcalf mine of the Arizona Copper Mining company taken from the workings in the great open-cut not more than 100 feet below the surpace. The crystals occur on altered porphyry, which is traversed by veinlets and masses of cuprite. This cuprite contains native copper and is covered by crusts of malachite, brochantite and chrysocolla. The crystals are inconspicuous and difficult to obtain free of other minerals. The closed-tube reactions of the mixed copper min-

Hydrous phosphate of aluminum; is given off first. T hen appears suddenly a white sublimate near the assay which seems to form or at once change to minute colorless drops. This deposit can be driven slowly up the tube followed at its lower, sharply defined edge by dark yellow-brown dots which on coating solidify greenish crystalline aggregates, and the part of the tube between them and the assay thus shows under lens delicate, feathery crystallizations like

frost-markings on window panes. Down in the flame the glass becomes colored red Cu 2 o?) and in parts yellow. On charcoal the blowpipe flame is colored azure blue and at the same time green." (Am. Jour. Sci., Dec., 1904.)

SPECULAR IRON.

Mirror Iron, Eisen-glimmer, Hematite.

Of frequent occurrence in Arizona both massive and in small veins and nodular masses interesting to collectors of minerals.

Among other occurrences; in brilliant folia in white quartz, Turkey Creek mining district, Yavapai Co. (Ryan 1903.)

In rosettes, Mammoth (Pool.) From Quartzsite, Yuma Co. (See Hematite.)

Specular iron in large flat folia at the Iron Age, Bouse region, northern part of Yuma county; in large quantity north of the Desert gold mine.

Mineral paint, 12 miles north of Parker.

STIBNITE.

Antimony trisulphide; Sulphur 28.6, **antimony** 71.4.

In veins at Warner's, north of Phoenix, but not worked, and as an associate or constituent of some of the lead ores and silver-bearing ores.

At El Plomo in Sonora in the Altar district. Sparingly in the Tucson mountains, and the Sierritas.

STROMEYERITE.

Sulphide of silver and copper; sulphur 15.8, silver 53.1, copper 31.1.

This somewhat rare and interesting species was discovered in the Silver King mine (vide Silver King report, 1883), Pinal county. It was found in masses of considerable size, in blocks from an inch in thickness to masses weighing four or five pounds. It was more abundant on the third and fourth levels of the mine than below. It was generally penetrated by quartz crystals and was closely associated with the other minerals of the lode.

The fracture was conchoidal and the freshly broken surfaces were brilliantly lustrous, splendent and metallic. Color dark bluish-black, lead-like between that of graphite and anthracite coal. Streaky brown or reddish black. Hardness about 3. Very brittle but packs under the hammer. Specific gravity 6.22. Soluble in hot nitric acid. Contains 51.47 per cent of silver and about 30 per cent of copper. It pures quietly before the blowpipe.

TENORITE.

Black oxide of copper—Cupric oxide.

Oxygen 20.2, **copper** 79.8.

In the surface or oxidized copper ores in small quantity, but generally mixed with iron oxides or manganese oxide as impurities.

In the Copper Queen mine a black mixture of oxide of copper and of manganese oxyd (probably wad(contains 15 per cent of copper.

TETRADYMITE.

Telluride of bismuth, occurs in an auriferous quartz vein at Minnehaha, a timbered valley in Yavapai county, about twelve miles east of Walnut Grove. The locality is more generally known as the Bismuth claims, Montgomery mine, but has not been extensively worked for either bismuth or gold.

TETRAHEDRITE.

Grey copper ore, Fahlerz; sulphur 23.1, **antimony** 24.8, **copper** 52.1.

A common ore of silver in the silver mines of Arizona but varies greatly in the quantity of silver at different localities.

At the famous Silver King mine it was one of the chief silver-bearing minerals, more abundant in the upper levels, than in the lower. It was found not only in the porphyry but in bunches in the midst of the large body of quartz in the third level and above it. Assays have shown as high as 3,000 ounces of silver to the ton, probably, in part, native silver. In the year 1880 this mineral was

regarded as one of the most valuable and important of the mine. It appeared to be replaced in the lower levels by zinc blende, and by Stromeyerite.

At the Eureka mine, Salero, and at the Alta, Tyndall district. At the Heintzelman mine, Cerro Colorado, and at the World's Fair mine, Santa Cruz county.

THENARDITE.

Sodium sulphate. Sulphur trioxide 43.7, **soda** 56.3. Occurs in large beds, worn down by the elements to rounded hills, about three miles southwest of old Camp Verde on the right bank of the Verde river. It is closely associated with halite (rock salt), glauberite and mirabilite, the hydrous sulphate, which constitutes the greater bulk of the deposit.

TOPAZ.

Specimens of this gem were sent to the Arizona School of Mines from Mr. J. Grady of Globe. They were yellowish in tint, but no information regarding their exact locality was obtained.

White, colorless specimens were also received from W. A. Neal, Dec. 1904; locality not disclosed.

TOURMALINE.

A complex silicate, known also as "Schorl."

The common black variety of this mineral occurs in considerable quantity in quartz veins traversing granite in the hills east of Oracle.

TROILITE.

Magnetic iron-sulphide, pyrrhotite, in part. A sulphide of iron often containing a little nickel or cobalt, occurring in the midst of masses of meteoric iron. Theoretic composition nearly sulphur 39.2, iron 60.8. Found in the meteoric irons of Canyon Diablo in nodular masses of various sizes which, by their oxidation, cause exfoliation with formations of scales of limonite, finally leaving pits and cavities on and in the irons, which,

last, may be regarded as residual masses weathered out from much larger masses. From this point of view it is easy to explain the origin of so many fragments of angular iron with confluent pitted surfaces, the original mass probably was chiefly troilite holding irregular masses of iron throughout its mass.

TREMOLITE.

Silicate of calcum and magnesium.

A variety of amphibole. Occurs usually as a result of contact metamorphium.

TRONA.

Carbonate of soda; sodium carbonate, carbon dioxide 38.9, **soda** 412,. **water** 19.9.

Not known to occur in quantity in Arizona, but abundantly in Sonora on the shores of the gulf not far south of the Arizona line.

TUNGSTITE.

Tungstic ocher; tungsten trioxide; oxygen 20.7, **tungsten** 79.3.

A yellow pulverulent and earthy mineral accompanying some of the outcrops of wolframite and hubnerite in the Gigas district, Pima county, as a result of the oxidation of those minerals.

TURQUOIS.

Hydrous phosphate of aluminum; colored by from about 2 to 8 per cent copper oxide in specimens from different localities. An analysis by Clarke (Am. Jour. Sci., 1886), of a dark green stone from New Mexico gave:

Phosphorous pentoxide, P2 O5; 28.63.
Aluminum, Al2 03; 37.88.
Water, H2 O; 18.49.
Copper oxide, Cu O; 6.56.
Ferric iron, Fe2 O3; 4.07.
Silica, Si O2; 4.20.

There are several important localities in Arizona and in the adjoining territory of New Mexico, most of which derive greater interest from the fact that they were worked in prehistoric times by the aboriginal

people, to whom the stone was known as **Chalchuite,** and is so known today by the Indians. See Chalchuite.

It occurs in Mineral Park, Mohave county, and in the Turquois district, Gleason, Cochise county.

Also twelve miles east of Morristown, and about seventy miles southeast from Wickenburg. Not much developed but there are evidences of aboriginal occupation. (Hammer.)

VANADINITE.

Vanadate of lead, vanadium pentoxide 19.4, **lead protoxide** 78.7, **chlorine** 2.5.

Occurs at numerous places in association with galenite and other ores of lead.

In heavy incrusting masses of yellowish brown crystals in a patented claim near the Silver Belt mine, Big Bug, Yavapai county.

Found also in the Black Prince mine, Pioneer mining district, Pinal county, Arizona, in brilliant red and yellow hexagonal crystals.

According to F. H. Blake, who found this occurrence and reported on it in 1864,, (Am. Jour. Sci., Vol. XXVIII.), the crystals occur in the seams of partly decomposed rock resembling trap, covering completely in some cases five square inches of surface. They vary in size from one sixty-fourth to one-eighth of an inch in diameter, sometimes reaching the length of one-quarter of an inch. They are often implanted by the side and are then doubly terminated. The majority of these crystals are of a deep red color; some vary from a red at one end through deepining shades of delicate straw-yellow to orange and red at the other end. Others exhibit a succession of layers of deep red and light yellow parallel to the basal plane. Many of the crystals are cavernous, and fibrous, resembling in their cavernous structure the prisms of pyromorphite. The prismatic planes "I" are straiated vertically, which in this rspect is just the opposite to what occurs in pyromorphite.

The simple hexagonal prism, without modifications, predominates as the crystalline form; although in some

groups of crystals is found the combination of the two prisms "I" and i-2, with the basal edges replaced by planes of the pyramid of the first series. These planes are very minute. He was unable to find planes between "O" and i-2.

Wulfenite is also found in this mine but not in very perfect crystals.

Vanadinite occurs also near Fairbanks, Cochise county. (McGee 1903.)

Massive or in a confused aggregation of crystals in limestone near Globe.

In large crystals at the Old Yuma mine, with wulfenite, cerussite and galena.

In massively aggregated crystals at Lockwood's claim, near Globe.

Also at the Clark and Stewart claims near the Old Dominion property. (Cook, 1905.)

Royal Dane claim, seven miles southwest of Oracle.

VERMILLION.

A finely divided powdery form of cinnabar of brilliant color, occurring with cinnabar, or prepared artificially. See Cinnabar.

WILLEMITE.

Silicate of zinc.

A rare species in Arizona, but common in quantity at the zinc mines of Franklin, New Jersey, has been noted by Mr. Boutwell as very small, greyish crystals on a fragment of garnet rock in the Modoc open-cut on the north side of Modoc mountain, Clifton, Morenci district. These crystals were identified by Pirsson and Penfield of Yale university as resembling the stout hexagonal prisms of the original locality at Moresnet.

WOLFRAMITE.

Tungstate of iron; approximate composition. Tungstic acid 75.0, **ferrous iron** 25.0.

A part of the iron oxide may be replaced by manganous oxide. If there is more manganous oxide than ferrous oxide the species is known as **"hubnerite,"** the tungstate of manganese.

The color of wolframite is darker and blacker than the brown of hubnerite.

It occurs with the Gigas deposits of hubnerite, and sparingly with those of the dragoons. Also in a quartz vein on the southeast side of San Cayetano mountain, about seven miles north of Nogales. (Walsh, 1904.) In the Old Hat district, Santa Catalina mountains.

At or near Bisbee. (Barnaby).

Columbia, Yavapai county.

Near Owens, Mohave county.

Near Benson, Whetstone mountains, Cochise county, in granite.

In the Aquarius range of mountains, Mohave county, wolfram occurs in promising quantity. Shipments have been made to eastern works.

WULFENITE.

Molybdate of lead; molybdenum trioxide 39.3, lead oxide 60.7.

A common associate of the oxidized lead ores of Arizona often confounded, in name at least, with the species of wolframite with which it has no affiliation. Its close association with galenite at so many different localities leads to the belief that molybdenum occurs in the form of sulphide in the galenite, either enfolded in the crystalline or cleavage planes, or in such close combination as not to be recognizable except by the products of oxidation with the formation of the highly-colored molybdate of lead.

In this form it occurs at Castle Dome in beautifuly honey-yellow crystals at the water level in the Railroad claim implanted on white crystals and crystalline aggregates of Cerussite, the carbonate of lead.

Some of the finest specimens yet obtained of wulfenite were taken from the Mammoth mine in Silver district in tabular crystals over an inch in width and deep, rich red color. Another mine in the same district, the Hamburg, has yielded crystals remarkable for their dark color and octahedral habit, sprinkled upon slabs of black limestone.

The Old Yuma mine near Tucson has yielded some tabular red crystals

of large size and good color, closely associated with vanadinite.

The Mammoth gold mine at Shultz, Pinal county, has yielded probably the finest crystallized groups of this mineral and in a massive form in the greatest profusion, for though great care was taken to separate the masses of galenite and of wulfenite from the auriferous quartz before crushing and milling, it appeared in quantity in the tailings, which afterward became an available source of the mineral. Two or three car loads were washed out of these tailings by sluicing.

Found also near Schneider's mine, Dripping Springs range.

ZINC.

For ores of zinc, see Blende, calamine and Smithsonite.

ZINKENITE.

Sulphide of lead and antimony.

Sulphur 22.3, antimony 41.8, lead 35.9. From near Prescott, Yavapai county.

PART II.

Materials of Construction

Arizona is fortunate in the possession of building stones and other materials of construction in great variety and wide distribution. There are granites of various grades and tints of color, porphyries, andesites and diorites, basalts, tufas and sandstones. Limestones abound suitable for burning for lime or for buildings.

GRANITE.

Quarries furnishing granite of superior quality have been opened at Prescott and have supplied the large cut stones for the banks and other buildings.

It may be quarried at numerous other places in the Bradshaw mountains and further south in the Catalina mountains, and the Santa Ritas.

At Oracle a coarse-grained, gray

granite weathers out into large boulders of disintegration.

Near Phoenix a very fine granite rock of a dark-grey color is specially suitable for monumental work.

In the Catalina mountains, near Tucson, the peculiar gneiss which has been so elongated that it weathers out in long, prismatic blocks, or post-like masses, was much ultizized by the prehistoric peopie in the construction of their houses. Such posts remaining deeply planted in the soil mark in a very distinct way the forms and groupings of the foundations of their buildings.

A beautiful grey granite is found in Peeple's Valley, Yavapai, at Yuma and near Tombstone.

RED SANDSTONE—FREESTONE.

Quarries near Flagstaff yield excellent building stone. For analysis see Report of 1899, and Bulletin U. S. Geological Survey, No. 78.

TUFA.

The tufas are consolidated volcanic muds and rank high amongst the materials of construction. The capital building at Phoenix is in large part of tufa, with foundations of granite.

The tufas of the vicinity of Tucson are quarried extensively for building. The men's dormitory and other buildings at the university are constructed of it. It is a firm, hard stone, conchoidal in fracture, and without any decided rift or cleavage. It occurs both white or grayish white in color and also in one quarry of a pink color.

Tufa also occurs in quantity at Nogales and is used for building.

In the Grosvenor Hills, north of Patagonia, it occurs in thinly bedded strata from which broad and thin slabs, useful for building or paving, may be quarried.

A good quality of tufa for building purposes occurs at Kingman, Mohave county, and at many other points in the territory.

LITHOGRAPHIC STONE.

Occurs in a remarkable series of

horizontal sediments perched upon the summit of Black Range, at the north fork of Cherry creek, about thirty-two miles east of Prescott. There are many different layers, varying in thickness from a fraction of an inch to six and eight inches and more, and all clearly sedimentary. Calcareous beds alternate with highly siliceous layers. These all weather white in color but have interiorly the peculiar drab or mouse-colored tone characteristic of the Solenhofen stone. Experimental trials upon small samples compare in results favorably with those upon imported stone. The Arizona stone takes in well and is slightly absorbent, so that it is easily and uniformly wetted by the sponge.

POTTERY AND BRICK CLAY.

Clays for fine pottery, or for the manufacture of brick and tile, are abundant and obtainable along and near the railway between Tucson and Benson.

A good, strong, plastic clay containing carbon or graphite, and black in color, is obtained in quantity near the northern end of the Whetstone mountains in Cochise county, about seven miles from Benson. It contains diffused carbon and has been found very useful about the Copper Queen smelters at Bisbee. Farther details may be found in the report of the governor of Arizona, 1899.

The alluvial clays of the Santa Cruz river at Tucson make a soft red-brick and haxe been extensively utilized.

Black clay at Bridger's in the Chiricahuas appears to be a fair quality of fire clay and resembles that obtained near Benson.

A good clay is reported from Columbia, Yavapai county, eight miles from Hot Springs, Castle creek. (North, 1907.)

A superior shale, suitable for the manufacture of brick, has recently been discovered near Tucson, and is to be the basis of a brick industry of large magnitude. Sharp, strong brick of various pleasing colors are readily made from this material.

LIMESTONE.

Limestones suitable for making lime for mortar are abundant and accessible at nearly all points where they are needed. Good lime is burned in the Tucson mountains a few miles west of Tucson. At Tempe, in the Salt River valley, a limestone is well adapted to hydraulic lime mortar. Caliche makes a good, strong mortar if properly calcined and mixed with sand. The materials for the manufacture of cement are obtainable near Tucson and other points.

MARBLE.

Marble of fair quality is quarried at many places in Arizona, and is utilized for monuments at the chief centers of population.

A white marble is found in the foothills of the Chiricahua mountains near the old military post. Both black and white marble are reported to exist there in large deposits and of superior quality.

White statuary marble occurs at the north end of the Catalina mountains near the Condon copper property. It is very white and has an even crystalline grain.

Black and variegated marble exists near the Total Wreck mine, west of Tucson, but has not been explored.

A fair grade of black marble can be quarried in the Tucson mountains a few miles west of Tucson.

Marble of various shades has been quarried at various places in the Santa Rita mountains along the wagon road leading from Vail's station to the copper mines at Helvetia.

MINERAL PAINT.

See, also, Hematite, Ferric Iron oxide.

Excellent native pigments consisting of hematite occur at several different localities, but particularly in Monumental Park mining district, eight miles from the Colorado river on the California side, but tributary to the Arizona town of Parker. It is reported that the quantity is large and that the place was worked by the aboriginal people.