ONE HUNDRED ARIZONA MINERALS

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ARIZONA BUREAU OF MINES
MINERAL TECHNOLOGY SERIES No. 49
BULLETIN No. 165

PRICE THIRTY CENTS
(Free to Residents of Arizona)

PUBLISHED BY
University of Arizona
TUCSON, ARIZONA
PART I. THE STUDY OF MINERALS

INTRODUCTION

Great mineral wealth has been paramount in the development of Arizona. It has attracted attention since the first Spanish explorations of the Southwest. The lure of precious metals brought many of the early American settlers to the Territory, and mining has been responsible for the establishment of many Arizona cities and towns. Ajo, Bisbee, Clarkdale, Clifton, Douglas, Globe, Hayden, Jerome, Miami, Morenci, Superior, Tombstone, Ray, and numerous other centers of population have owed their existence to mining, milling, or smelting. Several agricultural communities were started and grew as a direct result of the requirements for adequate food supplies of the booming mining camps.

In addition to the professional prospectors and miners who are seeking minerals for their commercial value, an increasingly large number of persons collect minerals solely for their beauty and rarity.

Arizona is a wealthy hunting ground for such collectors because the crustal rocks here have been subjected to extensive deformation, and great masses of igneous material have been intruded into zones of weakness that resulted. Large quantities of mineral-bearing solutions, called hydrothermal solutions, accompanied much of the intrusive activity and formed mineral deposits. Erosion and continued deformation, especially faulting, later exposed many of the deposits.

The arid climate prevailing in the Southwest has played an important part in Arizona’s fame with mineral collectors. Several minerals which are not stable in humid climates, and therefore rare, have been found here in relative abundance. Another feature of our arid climate favorable for mineral collecting is the prevalence of good rock exposures, relatively free from the thick soil and dense vegetation so common to humid regions.

Because of the increasing interest of Arizona residents and visitors in mineral collecting, there has been considerable demand for a non-technical publication regarding descriptive mineralogy.

To meet this demand, Arizona Bureau of Mines Circular No. 14, “Fifty Common Arizona Minerals,” was prepared by F. W. Galbraith and J. W. Anthony in 1949. The Circular No. 14 was so popular that a somewhat more comprehensive coverage of the subject seems desirable.

This Bulletin has been prepared to help the beginners, or those who have had no formal training in the subject, to become familiar with approximately one hundred of the minerals which are either common in Arizona or are found in few other localities. Wherever possible, non-technical language has been used, but the reader should remember that mineralogy is a science, and therefore some technical terms are unavoidable. Those technical terms used, however, are explained.
The writer wishes to express his appreciation to Mr. Jackson L. Clark for his aid in the selection of the minerals described and to Dr. Eldred D. Wilson for his helpful criticism during the preparation of the manuscript.

For those interested in more advanced studies a list of suggested references follows Part II.

ROCKS AND MINERALS

A mineral is defined as any naturally occurring inorganic substance having a definite chemical composition capable of being expressed by a chemical formula. A mineral has more or less constant physical properties, and if formed under favorable conditions, a characteristic crystalline form. Moreover, a mineral must be a homogeneous substance, even when minutely examined with the aid of a microscope.

From the point of view of a mineralogist, coal is not a mineral. It is formed from plant remains and is therefore organic in origin. Obsidian, for example, is a rock but is not a mineral; although a homogeneous substance, it has no crystalline form and is not of constant chemical composition. On the other hand, ice and snow can be considered minerals, for they fulfill all the conditions of the definition of a mineral.

A rock is defined as the solid material which comprises an essential part of the earth's crust. Rocks range greatly in composition, and geologists have established several classifications of them. Some rocks are large masses of a single mineral; marble, for example, is pure calcite, and some very pure sandstones and quartzites are composed entirely of quartz. Other rocks are composed of a mixture of minerals, for example, granite and related igneous rocks, conglomerates, and metamorphic rocks such as gneiss and schist.

Aside from rock types based on differences in composition, there are three main classifications, based on origin. They are igneous, sedimentary, and metamorphic.

Igneous rocks are more apt to be found in one class of rocks than in another, mineral collectors should have some knowledge of rock types and be able to recognize the more common examples of each.

Igneous rocks result from the cooling and solidification of magma, a molten mixture of the elements of which the igneous rocks are eventually composed. This magma originates deep within the earth. If, for one reason or another, a magma starts moving toward the surface of the earth, it will eventually reach a point where the pressure and temperature have decreased sufficiently for the material to crystallize or solidify.

Two subclassifications are based on where the solidification takes place. If the molten material reaches the surface and flows out, it is called a volcanic or extrusive rock. Two examples of extrusive rocks are basalt and rhyolite. If, on the other hand, the magma comes to rest at some point beneath the surface and there solidifies, it is called an intrusive igneous rock. Granite is one example of this type.

In general, volcanic rocks, because they cool rapidly, are very fine grained. When this is the case it may be very difficult or even impossible to identify the individual minerals of which the rock is composed. In fact, some are composed almost entirely of a glass, obsidian, having no crystal structure whatever.

Most deep-seated intrusive igneous rocks, because they are completely enveloped by other rocks, cool more slowly and retain more of the volatile material contained in the original magma. Hence they tend to be more coarsely crystalline than their volcanic equivalents, and their individual mineral grains are generally large enough to be identified.

Of course, as with all things in nature, there are gradations between the two classes, and some intrusive igneous rocks, particularly those intruded very near the surface of the earth, have more of the characteristics of volcanic rock types. On the other hand, the central portions of some very thick flows, where cooling was slower, look very much like intrusive rocks.

Intrusive igneous rocks occur in various shapes and sizes, and special names are given to some of them. Dikes and sills are tabular sheets in which one dimension is small compared with the other two. If they are intruded along fractures cutting across the bedding of the enclosing rocks, they are called dikes, and if they are intruded along weaknesses parallel to the bedding, they are called sills. If the enclosing rock is not bedded or stratified, as in the case of granite, steeply dipping or vertical rock sheets are called dikes, and the term sill denotes a horizontal or gently dipping body.

Stocks and batholiths are massive intrusive bodies. Both are more or less circular or elliptical in plan view, but differ mainly in size. Stocks range from a few hundred square feet to several tens of square miles in areal extent of outcrop. Intrusive masses exceeding 40 or 50 square miles in known area are usually classed as batholiths. Of course some batholiths are much larger than this arbitrary figure; for example the Coast Range batholith in British Columbia and southeastern Alaska extends over an area of approximately 100,000 square miles.

Many other terms are encountered in descriptions of intrusive igneous rocks, but they are of little importance to the amateur mineral collector.

Sedimentary rocks are those rocks formed by the accumulation or deposition of debris resulting from the erosion and weathering of all rock types. Two main subclassifications are the clastic sediments and the chemical precipitates.

Clastic sediments are those composed of fragments of pre-existing rocks and include, for example, sandstones, shales, and conglomerates.

All rocks exposed at the surface of the earth are, to a greater or lesser degree, being worn away. Wind, rain, running water,
blowing sand, freezing, thawing, and glacial action are some of the agents which accomplish this erosion. The fragmental material resulting is carried away by gravity, running water, and wind and is deposited, sometimes far away, as a loosely consolidated layer of material. As more debris is added, the material becomes compacted from the added weight, forming a rock. The deltas forming at the mouths of rivers are good examples of this process. By careful examination of the fragments comprising a clastic rock, it is sometimes possible to tell where the eroded material was derived and thereby learn about the geologic history of the area.

The sedimentary rocks formed by chemical precipitation are of two types. In the formation of both types the chemicals of which they are composed are dissolved out of the pre-existing rocks by surface waters and carried to lakes and oceans, in solution, by streams and rivers. In one type the chemicals accumulate in these large bodies of water until their concentrations eventually become sufficient to induce their precipitation at the bottom in layers. It is just such precipitation, continued over periods of millions of years, which deposited the thick beds of potash salts found near Carlsbad, New Mexico. The thenardite deposits of the Verde River, Arizona were also formed in this way.

In the second type of sedimentary rock formed by chemical precipitation the concentration of the chemicals in solution, material was derived from the pre-existing rocks through solution for use in their body parts, such as shells, or by the secretion of chemical compounds resulting from their life-processes. This type of precipitation accounts for the large formations of limestone which were deposited in Arizona.

The third genetic classification is the metamorphic group of rocks. As might be surmised from their name, they are rocks which have undergone change or have been metamorphosed. This change can be brought about in several ways, and different metamorphic rocks result, depending upon the nature of the original rock and upon what agencies affected it.

The principal agents of metamorphism are shearing and compressional stresses, liquids and gases which bring about chemical reactions, pressure, and heat. When subjected to shearing forces and high pressure, the minerals comprising a rock are reoriented or turned, so that they offer the least resistance to the forces acting upon the rock. In this way long thin crystals may be turned so that they are nearly parallel to the direction in which the forces are acting. In some cases, the forces may be so great that a mineral crystallized with no one direction particularly longer than the others, becomes unstable, and another mineral of similar composition is formed in which the crystals are of a shape that can adjust to the forces. Rocks formed in this way include gneiss, schist, and slate.

Commonly a zone of metamorphism occurs around intrusive bodies. This type, called contact metamorphism, results from a combination of heat, pressure, and chemical reaction with the gases and liquids expelled by the intrusive. Contact metamorphic rocks are of importance to both the mineral collector and the miner because many valuable mineral deposits are found in such rocks.

**Geologic Occurrence**

In studying and collecting minerals, a knowledge of the associations and modes of occurrence can be very helpful. Some minerals are formed by replacement of other minerals, some occur as deposits in veins, and still others, the rock-forming minerals, are most commonly found as the original constituents making up rocks.

In a contact-metamorphic zone, calcite, the principal mineral in limestone, may be replaced, and such minerals as wollastonite, garnet, and scheelite deposited in its place.

Veins are formed when the mineral-bearing gases and liquids, emanating from an igneous intrusive, escape along faults or fissures and deposit material in them. Minerals such as galena, chalcopyrite, quartz, calcite, and many others can be deposited in this way. Not all veins, of course, contain valuable minerals. Many contain nothing but quartz.

Some minerals are found most commonly in pegmatites which are tabular bodies composed principally of quartz, feldspar, and mica, with the individual crystals fairly well developed and much larger than in normal igneous rocks. Tourmaline, beryl, spodumene, feldspar, sapphire, and tantalite are among the minerals formed in pegmatites.

Some of the very heavy minerals, such as gold and various "blacksands," are found as placer deposits. Placers are formed when the minerals are eroded out of veins or rocks, and concentrated by running water.

**Physical Properties of Minerals**

Because minerals are definite chemical compounds with more or less constant physical properties and crystal form, a knowledge of these properties affords a convenient method of identifying many of the more common minerals. Several diagnostic features often can be determined by merely looking at the specimen, and others can be determined by a few simple tests.

**Color:** The color of a mineral is an important property in its recognition. However, many minerals exhibit a wide variety of colors; the variance is due to the presence of impurities or a change in chemical composition. With practice, however, one may become familiar with the most typical color of minerals.

Color is especially useful in identifying minerals having a metallic luster, as they are fairly constant in color. Galena, for
example, has a characteristic lead-gray color, and magnetite is invariably black.

A freshly broken surface always should be used when determining the color of minerals, as surface alteration may tarnish their normal color, just as the green tarnish on copper or the rust of iron are not the true colors of the fresh metals.

**Streak:** The color of powder obtained by scratching or rubbing the mineral on a porous porcelain plate is known as its streak. Although the color of individual specimens of a mineral may differ widely, the color of their streaks is generally fairly constant, so that streak is an important property to aid in identification. The color of the streak may be lighter, darker, or the same shade as the color of the mineral, or it may be entirely different.

**Hardness:** The resistance of a mineral to scratching is its hardness. The Moh's hardness scale, listed below, is used in mineralogy to represent the relative hardnesses of minerals.

1. Talc
2. Gypsum
3. Calcite
4. Fluorite
5. Apatite
6. Feldspar
7. Quartz
8. Topaz or beryl
9. Corundum
10. Diamond

As the minerals in this scale are not usually on hand, the following hardnesses of common materials are given for quick determination:

- Fingernail—up to 2 plus
- Copper coin—up to 3 plus
- Knife blade—up to 5½
- Window glass—up to 6 minus
- Steel file—up to 6½

Since most minerals have a hardness of less than 6, these substances can be used to determine quickly the hardness of many common minerals. The best test is obtained from a smooth surface or crystal face. If an altered or dirty surface of the mineral is tested, erroneous results may be obtained.

To determine the hardness of the unknown mineral, see which of the materials of known hardness it will just scratch, or find which will scratch the mineral.

With a little practice, the hardness of many of the numerous minerals with a hardness of less than 5 can be determined quickly by the difficulty or ease with which they can be scratched with a pocket knife.

**Form:** The form is the characteristic shape assumed by the crystals of a mineral. Fluorite, when well crystallized, almost invariably occurs as six-sided forms called cubes. Quartz occurs as elongated crystals with a six-sided cross-section and steep pyramids at the ends. Some of the terms used in describing crystal shapes are:

- Micaceous.—In the form of very thin sheets or plates.
- Prismatic.—Elongated in one direction and of nearly equal dimensions in the other two. A pencil could be considered as prismatic.
- Tabular.—Short in one direction and of near equal dimensions in the other two. A table top is tabular.
- Pyramidal.—A form in which the crystal faces intersect such that they come to a point.

**Habit:** Habit means the way in which the mineral occurs, that is, as crystals, granular masses, crusts, or otherwise. Terms commonly used in describing habit include:

- Bladed.—Elongated and flattened, consisting of parts resembling knife blades.
- Botryoidal.—Having the form of a bunch of grapes.
- Columnar.—As long, thin prisms.
- Drusy.—Closely covered or lined with very small crystals.
- Foliated.—Capable of being separated into or occurring as, very thin sheets or plates.
- Lamellar.—Consisting of plates or leaves.
- Mammillary.—Resembling the botryoidal, but having larger curved surfaces.
- Reniform.—Kidney-shaped.

**Cleavage:** Many minerals have the capacity to split readily along one or more directions. This property is termed cleavage and is of assistance in the sight recognition of many minerals. In this paper only the number of directions of cleavage will be given. Galena has cubic or three-directional cleavage.

**Twinning:** Twinned crystals result from the intergrowth of two or more individual crystals in such a way that some of the crystallographic directions of one are common to those of its twin, while other crystal directions may appear as a mirror reflection from one twin to the other. Some minerals exhibit very characteristic twinned forms; staurolite and arsenopyrite twins form as crosses, rutile twins show doughnut-shaped forms, and albite twinning in the plagioclase feldspar is apparent as many fine, parallel lines or striations on one of the crystal faces.

**Fracture:** The character of the broken surface of a mineral, other than its cleavage or parting planes, is known as its fracture. The following terms designate common fracture surfaces:

- Conchoidal.—The surface is shell-like and smooth. Typical of obsidian.
- Hackly.—The mineral breaks with a jagged and irregular surface, having many sharp points. Example, native copper.
- Uneven.—The surfaces are rough. Example, chalcopyrite.
- Splintery or Fibrous.—Example, asbestos.
- Earthy.—The irregular fracture exhibited by substances such as clay and limonite.
Luster: The general appearance of the surface of a mineral in reflected light is its luster. Two main groups, metallic and nonmetallic, are recognized. Pyrite and galena are common minerals with metallic luster. The more important nonmetallic lusters are:

Vitreous.—Luster of quartz or glass.
Resinous.—The luster or appearance of resin. Sphalerite is a good example.
Pearly.—Having the iridescence of pearl. Commonly exhibited by minerals having platy or lamellar structure or pronounced cleavage planes. Example, talc.
Silky.—It is the result of fine, fibrous, parallel aggregates as in asbestos and fibrous gypsum.
Greasy.—As if the surface were covered with a thin oil film. Some massive quartz and some sphalerite have this luster.
Adamantine.—The hard, bright luster of the diamond. Example, cerussite.

Specific Gravity: The specific gravity of a mineral is a number expressing its weight compared with the weight of an equal volume of water. For example, if a mineral has a specific gravity of 2, a given specimen weighs twice as much as an equal volume of water. Specific gravity is represented by the abbreviation, "Sp. Gr." in this paper. For purposes of comparison, the following terms will be used for specific gravity:

low—less than 2.5 (gypsum)
average—2.5 to 3.5 (quartz)
high—3.5 to 4.5 (barite)
very high—4.5 to 6 (specularite)
exceptionally high—6 and greater (galena)

PART II. DESCRIPTIVE LIST OF MINERALS

An alphabetical list of the minerals described in the following pages is given in the index of this bulletin.

**ACTINOLITE-TREMOLITE**

*Calcium-magnesium iron silicate*

**Color:** White, gray, green. **Streak:** White. **Hardness:** 5-6. **Luster:** Vitreous, some varieties silky. Transparent to translucent. **Form:** Prismatic. Two directions of perfect cleavage. **Habit:** Bladed crystals, granular, massive, fibrous. **Sp. Gr.**: Average. **Occurrence:** Metamorphic rocks, such as gneiss, schist, and impure dolomitic marble.

**ALUNITE**

*Hydrous potassium-aluminum sulfate*

**Color:** White, gray, reddish. **Streak:** White. **Hardness:** 3.5-4, brittle. **Luster:** Vitreous, pearly. Transparent to translucent. **Form:** Six-sided crystals, nearly cubic. One direction of good cleavage. **Habit:** Crystal aggregates, fibrous, granular, massive. **Fracture:** Flat conchoidal, uneven. **Sp. Gr.:** Average. **Occurrence:** Altered light-colored volcanic rocks.

**ANDALUSITE**

*Aluminum silicate*

**Color:** Reddish brown, flesh-red, olive-green. **Fracture:** Uneven, subconchoidal. **Hardness:** 7.5. **Luster:** Vitreous. Transparent to opaque. **Form:** Prismatic, nearly square in cross-section, flat ends. One direction of good cleavage. **Habit:** Massive, columnar. **Sp. Gr.:** Average. **Occurrence:** Metamorphosed aluminous shale and slate and in contact metamorphic zones of aluminous rocks intruded by granitic rocks. **Varieties:** Chiastolite.—contains dark carbonaceous inclusions arranged in the form of a cross.

**ANGLESITE**

*Lead sulfate*

**Color:** Colorless, white, gray, yellow. **Streak:** White. **Hardness:** 3. **Luster:** Adamantine to dull. Transparent to translucent. **Form:** Prismatic, tabular. One direction of poor cleavage. **Habit:** Complex crystal growths, massive, granular, earthy. **Fracture:** Conchoidal. **Sp. Gr.:** Exceptionally high. **Occurrence:** In the upper, oxidized portions of lead deposits. Results from the oxidation of galena and cerussite. Associated with other lead minerals and minerals of zinc and iron.

**APATITE**

*Calcium fluo-chloro-phosphate*

**Color:** Colorless, green, blue, brown. **Streak:** White. **Hardness:** 5, brittle. **Luster:** Vitreous, subresinous. Transparent to translucent. **Form:** Long, six-sided prisms, rarely tabular. One direction of poor cleavage. **Habit:** Globular crystals, massive, granular to

### AURICHALCITE
**Calcium carbonate**
- **Color:** Colorless, white, pale shades of various colors. **Streak:** White. **Hardness:** 3.5-4, brittle. **Luster:** Vitreous. Transparent to translucent. **Form:** Long prismatic, tabular. Three directions of good cleavage. **Habit:** Stalactitic, columnar and reniform crusts and aggregates. **Fracture:** Subconchoidal. **Sp. Gr.** Average. **Occurrence:** As stalagmites and stalactites in limestone caverns, as incrustations around hot springs, and in beds of gypsum.

### AUGITE
**Calcium-magnesium-iron-aluminum silicate**
- **Color:** Green, brown, black. **Streak:** White, gray, grayish green. **Hardness:** 5-6, brittle. **Luster:** Vitreous, subresinous, dull. Transparent to opaque. **Form:** Short prismatic crystals, eight-sided in cross section. **Habit:** Individual crystals, granular, rarely fibrous. **Fracture:** Uneven to conchoidal. **Sp. Gr.** Average to high. **Occurrence:** Most commonly in volcanic rocks, and as an accessory mineral in dark-colored intrusive igneous rocks.

### ARAGONITE
**Calcium carbonate**
- **Color:** Colorless, white, pale shades of various colors. **Streak:** White. **Hardness:** 3.5-4, brittle. **Luster:** Vitreous, subresinous, dull. Transparent to translucent. **Form:** Long prismatic, tabular. Three directions of good cleavage. **Habit:** Stalactitic, columnar and reniform crusts and aggregates. **Fracture:** Subconchoidal. **Sp. Gr.** Average. **Occurrence:** As stalagmites and stalactites in limestone caverns, as incrustations around hot springs, and in beds of gypsum.
of perfect cleavage. **Habit:** Crystal aggregates, granular, earthy, fibrous, massive. Effervesces in hydrochloric acid. **Fracture:** Conchoidal, rarely observed because of the ease with which the mineral cleaves. **Sp. Gr.:** Average. **Occurrence:** Main constituent of limestone. Also common as veins in other rocks, as cementing material of many sandstones, and as a coating in the gas cavities in some basalts.

**CARNOTITE**
**HYDROUS POTASSIUM-URANIUM VANADATE**

**Color:** Bright yellow. **Streak:** Yellow. **Hardness:** 2-3. **Luster:** Dull. Pearly or silky when crystalline. **Form:** Tabular. One direction of good cleavage. **Habit:** Most abundant as an earthy to crystalline powder. **Sp. Gr.:** High. **Occurrence:** A secondary mineral. Deposits generally lens or pod shaped bodies in sandstone and associated with carbonaceous material. Sometimes found in petrified wood.

**CELESTITE**
**STRONTIUM SULFATE**

**Color:** White, pale, blue, pink. **Streak:** White. **Hardness:** 3-3.5. **Luster:** Vitreous, inclined to pearly. Transparent to opaque. **Form:** Tabular, prismatic. Three directions of perfect cleavage. **Habit:** Crystal aggregates, fibrous, granular. **Fracture:** Uneven. **Sp. Gr.:** High. **Occurrence:** In sedimentary rocks such as limestone, sandstone, and gypsum. As an accessory mineral in veins with galena, sphalerite, barite, and other sulfides and sulfates.

**CERARGYRITE-HORN SILVER**
**SILVER CHLORIDE**

**Color:** Gray, green, violet-brown. **Streak:** None. **Hardness:** 1-1.5, highly sectile. **Luster:** Resinous to adamantine. Transparent to translucent. **Form:** Cubic. **Habit:** Massive, waxy, commonly as crusts. **Fracture:** Subconchoidal. **Sp. Gr.:** Very High. **Occurrence:** An oxidation product of other silver minerals and therefore found in the upper or oxide portion of silver deposits. Commonly associated with other silver minerals and the oxidation products of lead, zinc, cobalt, and nickel.

**CHLORITE**
**HYDROUS MAGNESIUM-IRON-ALUMINUM SILICATE**

**Color:** Emerald to olive-green; rarely pink, yellow, white. **Streak:** Greenish to white. **Hardness:** 2-2.5, thin plates flexible. **Luster:** Somewhat pearly to brilliant. Transparent to translucent. **Form:** Tabular to prismatic. One direction of perfect cleavage. **Habit:** Crystal groups, massive scaly aggregates, compact. **Sp. Gr.:** Average. **Occurrence:** As an alteration mineral in granitic rocks, in schist, and in talcose rocks. Often found associated with serpentine.

**CHLOROCOLLA**
**HYDROUS COPPER SILICATE**

**Color:** Various shades of blue and green. **Streak:** White. **Hardness:** 2.4, some varieties somewhat sectile, translucent varieties brittle. **Luster:** Vitreous to earthy. Subtransparent to opaque. **Habit:** Very compact massive, earthy, botryoidal crusts. **Fracture:** Conchoidal. **Sp. Gr.:** Low. **Occurrence:** Upper or oxidized portions of copper deposits, associated with other secondary minerals of copper.
COPPER

CINNABAR

COPPER

CORUNDUM
Color: White, blue, red, yellow, brown, gray. Streak: None. Hardness: 9, brittle, very tough when compact. Luster: Adamantine to vitreous. Transparent to transluscent. Form: Prismatic. Habit: Rough and rounded crystals, massive, coarse to fine granular. Fracture: Uneven to conchoidal. Sp. Gr.: High. Occurrence: As an accessory mineral in crystalline metamorphic rocks such as gneiss, schist, slate, and marble. Associated minerals include chlorite, tourmaline, and kyanite. Varieties: Sapphire.—clear, transparent, blue variety prized as a gem stone. Ruby.—clear, transparent, red variety; also a gem stone.

COVELLITE

CROCOITE

ENARGITE
Copper-arsenic sulfide

EPIDOTE
Calcium-aluminum-iron silicate

EUXENITE
Complex oxide of calcium, columbium, tantalum, and rare-earths

FLUORITE
Calcium fluoride

GALENA
Lead sulfide

GARNET
Complex silicate of calcium, magnesium, aluminum, and iron

GLAUBERITE
Sodium-calcium sulfate

GOLD

GOSLARITE
Hydrous zinc sulfate
HALITE
SODIUM CHLORIDE


HEMIMORPHITE
BASIC ZINC SILICATE


HEMATITE
IRON OXIDE


HEMIPHILITE
BASIC ZINC SILICATE

**Limonite**

Hydrous iron oxide


**Magnetite**

Magnetic iron oxide


**Malachite**

Basic copper carbonate


**Manganese**

Hydrous manganese oxide


**Margarite**

Iron sulfide


**Metacinnabarite**

Mercury sulfide


**Mimetite**

Lead chloroarsenate


**Molybdenite**

Molybdenum sulfide


**Muscovite mica**

Potassium-aluminum silicate


**Olivine**

Magnetism-iron silicate


**Orthoclase feldspar**

Potassium-aluminum silicate

altered. Transparent to opaque. **Form:** Prismatic, tabular. Two directions of nearly perfect cleavage. Twinned crystals common. **Habit:** Individual crystals, granular to crystalline massive. **Fracture:** Conchoidal to uneven. **Sp. Gr.:** Average. **Occurrence:** As essential constituent of granite and granite pegmatites. Commonly present in gneisses. Also found as a constituent of some ore veins.

**PLAGIOCLASE FELDSPAR**

**SODIUM-CALCIUM-ALUMINUM SILICATE**

**Color:** White, pale shades of blue, red, green, gray. **Streak:** White. **Hardness:** 6-6.5, brittle. **Luster:** Vitreous, pearly. Transparent to translucent. **Form:** Tabular to long tabular. Two directions of nearly perfect cleavage. **Habit:** Granular to platy massive, individual and twinned crystals, striations generally present on one or two faces. **Fracture:** Uneven. **Sp. Gr.:** High. **Occurrence:** In veins associated with metallic ore minerals.

**POWELLITE**

**CALCIUM MOYBDATE-TUNGSTATE**

**Color:** Pale yellow. **Streak:** White. **Hardness:** 3.5, brittle. **Luster:** Vitreous to adamantine. Transparent to translucent. **Form:** Pyramidal. Four directions of cleavage. **Habit:** Massive, minute crystals. **Fracture:** Uneven. **Sp. Gr.:** High. **Occurrence:** Results from oxidation of molybdenite, in many places associated with scheelite.

**PSILOMELANE**

**HYDROUS MANGANESE OXIDE**

**Color:** Iron-black to steel-gray. **Streak:** Brownish black. **Hardness:** 5-7. **Luster:** Submetallic, dull. Opaque. **Habit:** Massive botryoidal, reniform. **Fracture:** Uneven. **Sp. Gr.:** High. **Occurrence:** As a secondary mineral associated with pyrolusite, barite, and calcite in bedded deposits.

**PYRITE**

**IRON SULFIDE**

**Color:** Pale brass-yellow. **Streak:** Brownish-black. **Hardness:** 6-6.5, brittle. **Luster:** Metallic, glistening. Opaque. **Form:** Cubic, generally striated on all faces. **Habit:** Individual crystals and crystal groups, massive, fine granular. **Fracture:** Conchoidal to uneven. **Sp. Gr.:** Very high. **Occurrence:** Very common in veins associated with other sulfides, also as small crystals, some microscopic in size, in shale and other metamorphic and sedimentary rocks.

**PYROMORPHITE**

**LEAD CHLORO-PHOSPHATE**

**Color:** Green, yellow, brown. **Streak:** White, pale yellow. **Hardness:** 3.5-4, brittle. **Luster:** Resinous. Transparent to translucent. **Form:** Prismatic, barrel-shaped. **Habit:** Crystal groups in parallel arrangement, globular, botryoidal, and reniform crusts. **Fracture:** Uneven to subconchoidal. **Sp. Gr.:** Exceptionally high. **Occurrence:** Secondary mineral in oxide zone of lead deposits, associated with galena and cerussite.

**PYROPHYLITE**

**HYDROUS ALUMINUM SILICATE**

**Color:** White, green, brownish green, yellow. **Streak:** White. **Hardness:** 1-2, laminae flexible. **Luster:** Pearly to dull. **Sp. Gr.:** High. **Occurrence:** In metallic sulfide veins with other arsenic minerals and sulfides of lead, zinc, and silver.

**QUARTZ**

**SILICON OXIDE**

**Color:** Colorless, white, yellow, blue, red, violet, black. **Streak:** White, paler than the color in colored varieties. **Hardness:** 7, brittle to tough. **Luster:** Vitreous to greasy, dull. Transparent to opaque. **Form:** Prismatic, commonly elongate. **Habit:** Individual crystals and crystal groups, coarse to fine granular, massive; drusy and mammillary inclusions, flint-like. **Fracture:** Conchoidal to uneven, splintery. **Sp. Gr.:** Average. **Occurrence:** The most common of minerals, important constituent of many igneous rocks, notably granite and rhyolite; major mineral in sandstone and quartzite; as river and beach sands; a major mineral in many ore veins. **Varieties:** Amethyst.—clear, purple, crystalline to massive. Chalcedony.—Crypto-crystalline, forms botryoidal crusts, color variable but usually white. Commonly found as "desert roses." Prase.—dull-green chalcedony. Agate.—variegated chalcedony, colors banded or irregular. Onyx.—Agate with colors banded in even layers. Jasper.—Impure, opaque colored quartz.

**REALGAR**

**ARSENIC SULFIDE**

**Color:** Red, orange. **Streak:** Same as the color. **Hardness:** 1.5-2, sectile. **Luster:** Resinous. Transparent to translucent. **Form:** Short prismatic, striated parallel to long direction. **Habit:** Crystal groups, fine to coarse granular, compact. **Fracture:** Small conchoidal. **Sp. Gr.:** High. **Occurrence:** In metallic sulfide veins with other arsenic minerals and sulfides of lead, zinc, and silver.
SERPENTINE
HYDROUS MAGNESIUM SILICATE

SHATTUCKITE
HYDROUS COPPER SILICATE

SIDERITE
IRON CARBONATE

SMITHSONITE
ZINC CARBONATE


RUTILE
TITANIUM OXIDE

SAMARSKITE
RARE-EARTH NIOBATE-TANTALATE

ROSASITE
BASIC COPPER-ZINC CARBONATE
TORBERNITIE
HYDROUS COPPER-URANIUM PHOSPHATE

THENARDITE
SODIUM SULFATE

TORBERNITIE
HYDROUS COPPER-URANIUM PHOSPHATE

WOLFRAMITE
IRON-MANGANESE TUNGSTATE

WOLFFENITE
LEAD MOYBYDATE

TETRAHEDRITE-TENNANTITE
COPPER-ANTIMONY SULFIDE, COPPER-ARSENIC SULFIDE

WOLLASTONITE
CALCIUM SILICATE

WILLEMITE
ZINC SILICATE

WILLEMITE
ZINC SILICATE

WOLFRAMITE
IRON-MANGANESE TUNGSTATE

WULLFENITE
LEAD MOYBYDATE

WOLLASTONITE
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WILLEMITE
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WOLLASTONITE
CALCIUM SILICATE

WILLEMITE
ZINC SILICATE
ZIRCON

ZIRCONIUM SILICATE


ZINNWALDITE

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SERVICES OFFERED BY THE ARIZONA BUREAU OF MINES

(Continued from inside front cover)

3. Geologic investigations of mining districts and counties and the making of topographic and geologic maps and reports. In cooperation with the United States Geological Survey a large-scale base map, a reconnaissance geologic map, and a topographic map (100-meter contours) of the entire State have been published. Geologic reports on various mineral resources of the State are prepared.

4. The Bureau provides an ore-testing service for ores originating within the State of Arizona. Full details will be furnished on request.

5. Semitechnical meetings with miners and prospectors are held throughout the state.

6. The collection and dissemination of statistics relating to the mineral industries of the State.

7. The collecting and filing of all items relating to Arizona mines and minerals that appear in Arizona newspapers and in many technical periodicals.

MAPS OF ARIZONA

The Arizona Bureau of Mines now has available for distribution the following maps of the State:

1. Base map of Arizona on a scale of about 17 miles to the inch, strictly geographic, indicating towns, railroads, rivers, surveyed lands, national forests, national parks and monuments, etc., revised to 1939. Printed in black on one sheet 22 x 26 inches. Price, 30 cents unmounted.

2. Base map of Arizona, 42 x 54 inches, similar to Map No. 1 but on a scale of about 8 miles per inch. This map sells for 50 cents.


5. Map of Arizona Mining Districts, 25 x 27 inches. A red overprint on Map No. 1 shows the principal mining districts or mining localities by means of numerals and index. Roads are also indicated. Price, 30 cents without tube. Cost if mailed, 45 cents.

6. Geologic map of Arizona in one sheet of many colors, 43 x 57 inches, on a scale of about 8 miles to the inch. It was issued in 1924, but is now out of print, and its lithographic plates are worn beyond repair. A new Geologic Map of Arizona is now in course of preparation and is expected to be available late in 1957 or early 1958.

Photo copies, consisting of 8 black-and-white prints covering the entire 1924 edition of the Geologic Map on a scale of about 8 miles to the inch, may be ordered from the Southwestern Technical Services, 234 E. Sixth St., Tucson, Arizona, for $10.00 plus mailing charges.

All communications should be addressed and remittances made payable to the Arizona Bureau of Mines, University of Arizona, Tucson, Arizona.