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Among the many lines of activity in which the Bureau engages, the following have proved especially important and valuable:

1. The preparation and publication of bulletins and circulars containing authoritative information on a wide range of topics of interest to prospectors, miners, and others concerned with the development of Arizona's mineral resources and industries. The bulletins are distributed free of charge to residents and at cost to non-residents of Arizona upon request.
2. The classification of mineral and rock specimens. Besides identifying rocks and giving the composition of minerals, the Bureau makes qualitative tests for important elements and answers inquiries concerning the probable market for and the economic value of material similar to samples submitted. This service is furnished free of charge providing the specimens originate within the State of Arizona; a charge of $1 per specimen is made for samples submitted from outside the State. When assays, quantitative chemical analysis, spectographic analyses, microscopic or thin sections are desired, they are furnished at rates established by law, a schedule of which will be submitted on request.

(Continued on inside back cover)

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ARIZONA BUREAU OF MINES

ONE HUNDRED ARIZONA MINERALS

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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, San Manuel, 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 homogenous 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 homogenous 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 can be almost pure calcite, and some very pure sandstones and quartzites are composed entirely of quartz. Other rocks are composed of a mixture of minerals, as 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.

Because certain minerals 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.

The 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 preexisting 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, mainly calcium and magnesium carbonates, is not necessarily very high. The precipitation is effected by living organisms which render the dissolved salts insoluble, either by extracting the salts from 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, samarskite, 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 characistic 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 cleaveage 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 transculent. **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

compact, fibrous. **Fracture:** Conchoidal. **Sp. Gr.:** Average. **Occurrence:** As an accessory mineral in all classes of rocks.

ARAGONITE

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.

AURICHALCITE

ZINC-COPPER CARBONATE-HYDROXIDE

Color: Pale green to sky-blue. **Streak:** White. **Hardness:** 2-3. **Luster:** Pearly. **Form:** Minute, thin blades. One direction of perfect cleavage. **Habit:** Drusy incrustations. **Sp. Gr.:** High. **Occurrence:** Oxidized zones of copper and zinc deposits, often associated with malachite.

AZURITE

HYDROUS COPPER CARBONATE

Color: Azure-blue. **Streak:** Pale blue. **Hardness:** 3.5-4. **Luster:** Vitreous, subadamantine. Transparent to translucent. **Form:** Highly modified crystals, either tabular or prismatic. **Habit:** Columnar crystal aggregates, earthy. **Fracture:** Conchoidal. **Sp. Gr.:** High. **Occurrence:** Oxidized portions of copper deposits, associated with other oxide zone minerals, particularly malachite.

BARITE

BARIUM SULFATE

Color: White, pale shades of yellow, red, blue and brown. **Streak:** White. **Hardness:** 2.5-3.5, brittle. **Luster:** Vitreous, subresinous, some varieties pearly on one face. Transparent to opaque. **Form:** Tabular, prismatic. Three directions of perfect cleavage. **Habit:** Crystal aggregates, globular masses, fibrous, granular, earthy. **Fracture:** Uneven. **Sp. Gr.** Very high. **Occurrence:** In veins commonly associated with minerals of lead, copper and silver.

BERYL

BERYLLIUM-ALUMINUM SILICATE

Color: Emerald-green, yellow, white, pale shades of green and blue. **Streak:** White. **Hardness:** 7.5-8, brittle. **Luster:** Vitreous, resinous. Transparent to translucent. **Form:** Long prismatic, striations parallel to long dimension. **Habit:** Individual crystals, granular to compact masses. **Fracture:** Conchoidal, uneven. **Sp. Gr.:** Average. **Occurrence:** In pegmatite veins and in druses in granitic rocks. **Varieties:** *Emerald.*—a clear, transparent, green beryl prized as a gem. *Aquamarine.*—clear, transparent, blue-green beryl, also prized as a gem stone.

BIOTITE

POTASSIUM-MAGNESIUM-IRON-ALUMINUM SILICATE

Color: Green, black. **Streak:** Uncolored. **Hardness:** 2.5-3, flexible in thin sheets. **Luster:** Splendent, somewhat pearly. Transparent to opaque. **Form:** Tabular, short prismatic. One direction of perfect cleavage. **Habit:** Thin, six-sided plates. **Sp. Gr.:** Average. **Occurrence:** Very common in granitic rocks and in gneiss and schist.

BISMUTITE

BASIC BISMUTH CARBONATE

Color: White, green, yellow, gray. **Streak:** White. **Hardness:** 4. **Luster:** Earthy. Opaque. **Habit:** Fibrous, earthy crusts. **Sp. Gr.:** Exceptionally high. **Occurrence:** Secondary mineral found in oxide zone of deposits containing other bismuth minerals.

BORNITE

COPPER-IRON SULFIDE

Color: Brownish red, iridescent when tarnished. **Streak:** Pale grayish black. **Hardness:** 3, brittle. **Luster:** Metallic. Opaque. **Form:** Cubic, rough or curved faces. **Habit:** Crystals rare. Generally massive, granular or compact. **Fracture:** Uneven, conchoidal. **Sp. Gr.:** Very high. **Occurrence:** In veins associated with other copper and iron sulfides such as covellite, chalcocite, chalcopyrite, and pyrite.

BROCHANTITE

BASIC COPPER SULFATE

Color: Emerald-green, blackish green. **Streak:** Pale green. **Hardness:** 3.5-4. **Luster:** Vitreous, pearly on cleavage face. Transparent to translucent. **Form:** Prismatic. One direction of perfect cleavage. **Habit:** Crystal groups, drusy crusts, massive, reniform. **Fracture:** Uneven. **Sp. Gr.:** High. **Occurrence:** Oxide zone of copper deposits associated with azurite and malachite.

CALCITE

CALCIUM CARBONATE

Color: Colorless, white, black, pale shades of all colors. **Streak:** White. **Hardness:** 3. **Luster:** Vitreous to earthy. **Form:** Six-sided crystals with diamond-shaped faces, prismatic. Three directions

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, and copper.

CERUSSITE

LEAD CARBONATE

Color: White, gray, dark gray, very pale blue. **Streak:** White. **Hardness:** 3-3.5, very brittle. **Luster:** Adamantine, vitreous, resinous, rarely submetallic. **Form:** Tabular, prismatic and as pyramids. Four directions of good cleavage. **Habit:** Crystal aggregates, granular or compact-massive, earthy. **Fracture:** Conchoidal. **Sp. Gr.:** Exceptionally high. **Occurrence:** Upper or oxidized portion of lead deposits associated with galena and anglesite.

CHALCANTHITE

HYDROUS COPPER SULFATE

Color: Various shades of blue, rarely greenish. **Streak:** White. **Hardness:** 2.5, brittle. **Luster:** Vitreous. Subtransparent to translucent. **Form:** Somewhat bladed. Several directions of imperfect cleavage. **Habit:** Massive, reniform, stalactitic, rarely fibrous. **Fracture:** Conchoidal. **Sp. Gr.:** Low. **Occurrence:** In copper mines deposited from mine waters. Highly soluble, therefore only found in arid regions.

CHALCOCITE

COPPER SULFIDE

Color: Lead-gray to blackish gray. **Streak:** Same as color. **Hardness:** 2.5-3, rather sectile. **Luster:** Metallic, tarnishes dull. Opaque. **Form:** Rarely crystalline. **Habit:** Granular to compact massive. **Fracture:** Conchoidal. **Sp. Gr.:** Very high. **Occurrence:** Very common in deposits of copper. Commonly associated with bornite, chalcopyrite, pyrite, galena and the oxidation products of these minerals.

CHALCOPYRITE

COPPER-IRON SULFIDE

Color: Brass-yellow, tarnishes iridescent. **Streak:** Greenish-black. **Hardness:** 3.5-4, brittle. **Luster:** Metallic. Opaque. **Form:** Four-sided crystals. **Habit:** Compact, massive. **Fracture:** Uneven. **Sp. Gr.:** High. **Occurrence:** Most common of the copper minerals. Found in veins, as an original constituent of igneous rocks, in gneisses and schists and as a replacement mineral in contact metamorphic deposits. Commonly associated minerals include pyrite, other sulfides of copper and the sulfides of lead, zinc, cobalt, and nickel.

CHLORITE

HYDROUS MAGNESIUM-IRON-ALUMINUM SILICATE

Color: Emerald to olive-green; rarely pink, yellow, white. **Streak:** Greenish white 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.

CHRYSOCOLLA

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.

CINNABAR

MERCURY SULFIDE

Color: Red, brownish red, lead-gray. **Streak:** Scarlet. **Hardness:** 2-2.5, somewhat sectile. **Luster:** Adamantine to submetallic. Transparent to opaque. **Form:** Thick tabular to long prismatic. Perfect cleavage in prism zone. **Habit:** Crystalline incrustations, granular, massive, earthy coatings. **Fracture:** Subconchoidal. **Sp. Gr.:** Exceptionally high. **Occurrence:** As replacement or vein deposits. Associated minerals may include pyrite, stibnite, realgar, gold, calcite and barite.

COPPER

Color: Copper-red. **Streak:** Copper-red. **Hardness:** 2.5-3, ductile, malleable. **Luster:** Metallic. Opaque. **Form:** Cubes, but distinct crystals rare. **Habit:** As sheets and twisted, wire-like forms. No cleavage. **Fracture:** Hackly. **Sp. Gr.:** Exceptionally high. **Occurrence:** In the oxide zone of copper deposits.

CORUNDUM

ALUMINUM OXIDE

Color: White, blue, red, yellow, brown, gray. **Streak:** None. **Hardness:** 9, brittle, very tough when compact. **Luster:** Adamantine to vitreous. Transparent to translucent. **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

COPPER SULFIDE

Color: Indigo-blue, tarnishes purple. **Streak:** Lead-gray to black. **Hardness:** 1.5-2, flexible in thin plates. **Luster:** Submetallic to resinous. Opaque. **Form:** Tabular, six-sided plates. One direction of perfect cleavage. **Habit:** As crystal plates, also commonly massive. **Sp. Gr.:** Very high. **Occurrence:** As a secondary mineral in the enriched portion of copper, deposits associated with chalcopyrite, pyrite, bornite, chalcocite, and enargite.

CROCOITE

LEAD CHROMATE

Color: Bright red. **Streak:** Orange-yellow. **Hardness:** 2.5-3, sectile. **Luster:** Adamantine to vitreous. Translucent. **Form:** Prismatic. Two directions of fair cleavage. **Habit:** As crystal groups, granular. **Fracture:** Small conchoidal to uneven. **Sp. Gr.:** Very high. **Occurrence:** A rare mineral of secondary origin. Occurs in a few lead deposits which have been acted upon by solutions containing chromic acid.

CUPRITE

COPPER OXIDE

Color: Various shades of red. **Streak:** Brownish red. **Hardness:** 3.5-4, brittle. **Luster:** Adamantine to submetallic. Translucent. **Form:** Cubes and octahedrons. **Habit:** Elongated crystals in tree-like growths, massive, granular, earthy. **Fracture:** Conchoidal, uneven. **Sp. Gr.:** Exceptionally high. **Occurrence:** Oxidized zone of copper deposits. **Varieties:** *Chalcotrichite.*—a variety crystallizing in tree-like growths.

DELAFOSSITE

COPPER-IRON OXIDE

Color: Velvet-black. **Streak:** Black. **Hardness:** 5.5, brittle. **Luster:** Metallic, dull to splendent. Opaque. **Form:** Thin to thick tabular. **Habit:** Individual crystals, crystal groups, botryoidal crusts. **Sp. Gr.:** High. **Occurrence:** Secondary mineral in copper deposits.

DESCLOIZITE

HYDROUS LEAD-ZINC VANADATE

Color: Cherry-red, brownish red, brown, black. **Streak:** Orange to brownish red. **Hardness:** 3.5. **Luster:** Resinous. Translucent to opaque. **Habit:** Groups of small crystals, massive, fibrous. **Fracture:** Uneven. **Sp. Gr.:** Very high. **Occurrence:** Upper or oxide zone of lead-zinc deposits. **Varieties:** *Cuprodescloizite.*—a variety in which copper replaces approximately half the zinc. *Mottramite.*—a variety in which almost all the zinc is replaced by copper.

DIOPTASE

COPPER SILICATE

Color: Emerald-green. **Streak:** Light green. **Hardness:** 5. **Luster:** Vitreous. Translucent. **Form:** Prismatic. Three directions of perfect cleavage. **Habit:** Individual crystals, crystalline aggregates, massive. **Fracture:** Conchoidal to uneven. **Sp. Gr.:** Average. **Occurrence:** A rare mineral found in only a few localities. Associated with other copper minerals.

DOLOMITE

CALCIUM-MAGNESIUM CARBONATE

Color: White, green, brown, gray, black. **Streak:** White. **Hardness:** 3.5-4, brittle. **Luster:** Vitreous, pearly. Transparent to translucent. **Form:** Six-sided crystals, like calcite. Three directions of perfect cleavage. **Habit:** Crystal groups, coarse to fine granular. **Fracture:** Subconchoidal. **Sp. Gr.:** Average. **Occurrence:** As extensive sedimentary deposits, similar to limestone and as a vein mineral associated with metallic ore minerals.

DUMORTIERITE

BASIC ALUMINUM-BORON SILICATE

Color: Bright blue to greenish blue. **Streak:** None. **Hardness:** 7, brittle. **Luster:** Vitreous. Transparent to translucent. **Form:** Pris-

matic. One direction of fair cleavage. **Habit:** Fibrous to columnar aggregates. **Fracture:** Uneven to subconchoidal. **Sp. Gr.:** Average. **Occurrence:** In crystalline metamorphic rocks such as gneiss and schist. Associated minerals include kyanite, tourmaline and sillimanite.

ENARGITE

COPPER-ARSENIC SULFIDE

Color: Grayish black to iron-black. **Streak:** Grayish black. **Hardness:** 3, brittle. **Luster:** Metallic. Opaque. **Form:** Prismatic, striated parallel to long direction. **Habit:** Small crystals, massive, granular. **Fracture:** Uneven. **Sp. Gr.:** High. **Occurrence:** In veins associated with other sulfides of copper and arsenic, and with sulfides of lead, zinc, silver, and iron.

EPIDOTE

CALCIUM-ALUMINUM-IRON SILICATE

Color: Pistachio-green to brownish green, black. **Streak:** Grayish white. **Hardness:** 6-7, brittle. **Luster:** Vitreous. Transparent to opaque. **Form:** Prismatic, deep striations parallel to long direction of crystal. One direction of perfect cleavage. **Habit:** Individual crystals and grains, granular massive. **Fracture:** Uneven. **Sp. Gr.:** Average to high. **Occurrence:** Formed by contact metamorphism. Occurs in gneiss, schist, marble, and quartzite. Commonly associated minerals include magnetite, quartz, garnet, and chlorite. **Varieties:** *Piedmontite.*—a reddish brown variety in which manganese is substituted for the iron.

EUXENITE

COMPLEX OXIDE OF
CALCIUM, COLUMBIUM, TANTALUM, AND RARE-EARTHS

Color: Black to brownish black. **Streak:** Yellowish brown to reddish brown. **Hardness:** 5.5-6.5, brittle. **Luster:** Submetallic to brilliant. **Form:** Prismatic. **Habit:** As crystals, massive. **Fracture:** Conchoidal. **Sp. Gr.:** Very high. **Occurrence:** In pegmatite veins associated with other columbium-tantalum minerals, biotite, beryl, magnetite, and lithium minerals.

FLUORITE

CALCIUM FLUORIDE

Color: Colorless, white, rose, blue, violet, green. **Streak:** White. **Hardness:** 4, brittle. **Luster:** Vitreous. Transparent to translucent. **Form:** Cubic. Four directions of perfect cleavage. **Habit:** Crystal groups in parallel growth, massive, granular. **Fracture:** Conchoidal, splintery. **Sp. Gr.:** Average. **Occurrence:** A vein mineral associated with metallic ore minerals, especially those of lead, silver, and zinc. Also found as replacement bodies in dolomite and limestone.

GALENA

LEAD SULFIDE

Color: Lead-gray. **Streak:** Lead-gray. **Hardness:** 2.5-2.75. **Luster:** Metallic. Opaque. **Form:** Cubic. Three directions of perfect cleavage at 90° to each other. **Habit:** Crystal groups, massive cleavable, coarse to fine granular. **Fracture:** Subconchoidal to even, rarely observed because of cleavage. **Sp. Gr.:** Exceptionally high. **Occurrence:** Widely distributed, found in veins and replacement bodies. Most commonly associated minerals are sphalerite, chalcopyrite, pyrite, tetrahedrite and other sulfides of copper, lead and silver.

GARNET

COMPLEX SILICATE OF
CALCIUM, MAGNESIUM, ALUMINUM, AND IRON

Color: Red, brown, yellow, white, green, black. **Streak:** White. **Hardness:** 6.5-7.5, brittle, tough when compact. **Luster:** Vitreous to resinous. Transparent to translucent. **Form:** Twelve-sided crystals. **Habit:** Rounded crystals and grains, fine to coarse granular, massive. **Fracture:** Uneven to subconchoidal. **Sp. Gr.:** High. **Occurrence:** Common accessory mineral in metamorphic rocks, including gneiss, schist, and marble.

GLAUBERITE

SODIUM-CALCIUM SULFATE

Color: Pale yellow, gray, brick-red. **Streak:** White. **Hardness:** 2.5-3, brittle. **Luster:** Vitreous. Translucent. **Form:** Tabular, prismatic. One direction of perfect cleavage. **Habit:** Individual crystals, crystal groups. **Fracture:** Conchoidal. **Sp. Gr.:** Average. **Occurrence:** In salt deposits associated with halite, calcite and other sulfates and carbonates.

GOLD

Color: Gold-yellow. **Streak:** Gold-yellow. **Hardness:** 2.5-3, malleable and ductile. **Luster:** Metallic. Opaque. **Form:** Eight-sided crystals. No cleavage. **Habit:** Skeleton crystals common; massive, wire, thin sheets, and grains. **Fracture:** Hackly. **Sp. Gr.:** Exceptionally high. **Occurrence:** In some quartz veins and replacement deposits, commonly associated with sulfides and oxides of copper, lead, zinc, and iron. Also in stream gravels as placer gold.

GOSLARITE

HYDROUS ZINC SULFATE

Color: White, pale red, pale yellow. **Streak:** White. **Hardness:** 2-2.5, brittle. **Luster:** Vitreous, silky. Transparent to translucent. **Form:** Long, hair-like prismatic crystals. **Habit:** Crystal masses, compact massive. **Sp. Gr.:** Low. **Occurrence:** Secondary mineral found coating walls and timbers in mine workings. Forms from decomposition of sphalerite.

GYPSUM

HYDROUS CALCIUM SULFATE

Color: White, gray, pink, yellow, blue. **Streak:** White. **Hardness:** 1.5-2. **Luster:** Subvitreous to pearly, earthy in compact varieties. Transparent to opaque. **Form:** Tabular, prismatic. One direction of perfect cleavage. **Habit:** Individual crystals with rounded faces, granular, massive, compact, fibrous. **Fracture:** Subconchoidal to flat. **Sp. Gr.:** Low. **Occurrence:** As extensive sedimentary beds, may be associated with potassium and sodium chlorides, in veins associated with the metal sulfides, and in hot spring deposits associated with native sulfur. **Varieties:** *Selenite.*—clear, colorless, well crystallized. *Satin spar.*—fine-fibrous with pearly luster. *Alabaster.*—fine-grained, compact variety, white or delicately shaded.

HALITE

SODIUM CHLORIDE

Color: Colorless, white, pale shades of yellow, red, blue, purple. **Streak:** White. **Hardness:** 2.5, brittle. **Luster:** Vitreous. Transparent to translucent. **Form:** Cubic. Three directions of perfect cleavage. **Habit:** Individual crystals and crystal groups, massive, granular. **Fracture:** Conchoidal. **Sp. Gr.:** Low. **Occurrence:** As beds in sedimentary series associated with gypsum, thenardite, calcite, and other sedimentary minerals.

HEMATITE

IRON OXIDE

Color: Red, dark gray to black. **Streak:** Cherry-red, reddish brown. **Hardness:** 5.5-6.5, brittle, earthy varieties appear softer. **Luster:** Metallic to dull. Translucent to opaque. **Form:** Thick to thin tabular. **Habit:** Individual crystals and crystal groups, botryoidal, lamellar, granular, earthy. **Fracture:** Subconchoidal to uneven. **Sp. Gr.:** Very high. **Occurrence:** Veins as both a primary and a secondary mineral, in beds and irregular masses resulting from weathering of iron-rich rocks, and as an original constituent of granitic igneous rock.

HEMIMORPHITE

BASIC ZINC SILICATE

Color: White, very pale shades of blue, green, yellow, brown. **Streak:** White. **Hardness:** 4.5-5, brittle. **Luster:** Vitreous, pearly, subadamantine. Transparent to translucent. **Form:** Tabular, prismatic. Two directions perfect cleavage. **Habit:** Crystal aggregates, massive granular, botryoidal, fibrous. **Fracture:** Uneven to subconchoidal. **Sp. Gr.:** Average. **Occurrence:** In veins in calcareous rocks associated with sulfides of zinc, iron and lead.

ILMENITE

IRON-TITANIUM OXIDE

Color: Iron-black. **Streak:** Submetallic, powder black to brownish red. **Hardness:** 5-6. **Luster:** Submetallic. Opaque. **Form:** Thick, tabular. **Habit:** Crystal groups, massive, compact, rounded grains. **Fracture:** Conchoidal. **Sp. Gr.:** Very high. **Occurrence:** Accessory mineral in many igneous rocks, forms veins and masses near intrusive rocks.

JAROSITE

BASIC POTASSIUM-IRON SULFATE

Color: Ocher-yellow to clove-brown. **Streak:** Yellow. **Hardness:** 2.5-3.5, brittle. **Luster:** Vitreous to subadamantine, silky. **Form:** Minute plates and tabular crystals. One direction of good cleavage. **Habit:** Minute crystals, massive, as incrustations. **Fracture:** Uneven. **Sp. Gr.:** High. **Occurrence:** In veins associated with metallic ore minerals.

KAOLIN-CLAY

HYDROUS ALUMINUM SILICATE

Color: White, gray, yellow, brown. **Streak:** White. **Hardness:** 2-2.5, flexible. **Luster:** Pearly to dull earthy. Transparent to opaque. **Form:** Minute scales. **Habit:** Clayey masses, either earthy or compact. **Sp. Gr.:** Average. **Occurrence:** Decomposition product of feldspar in igneous rocks, and in large deposits, mixed with quartz, resulting from extensive weathering of igneous rocks.

KASOLITE

LEAD-URANIUM SILICATE

Color: Yellow, brown. **Streak:** Yellow. **Hardness:** 4-5. **Luster:** Resinous, earthy. **Form:** Minute, prismatic. One direction perfect cleavage. **Habit:** Crystalline incrustations, massive, compact. **Sp. Gr.:** Exceptionally high. **Occurrence:** Secondary mineral, associated with torbernite, carnotite, and uranophane.

KYANITE

ALUMINUM SILICATE

Color: Blue, white. **Streak:** White. **Hardness:** 5-7.25. **Luster:** Vitreous to pearly. Transparent to translucent. **Form:** Flat, tabular. Three directions perfect cleavage. **Habit:** Long bladed crystals, columnar. **Fracture:** Uneven. **Sp. Gr.:** High. **Occurrence:** In gneiss and mica schist, accompanied by garnet, dumortierite, and corundum.

LEPIDOLITE

LITHIA MICA

Color: Rose-red, lilac, yellow, white. **Streak:** White. **Hardness:** 2.5-4, flexible in thin sheets. **Luster:** Pearly. Translucent. **Form:** Micaceous plates. One direction of perfect cleavage. **Habit:** Coarse to fine scaly, granular. **Sp. Gr.:** Average. **Occurrence:** Granitic pegmatites associated with other lithium minerals.

LIMONITE

HYDROUS IRON OXIDE

Color: Yellow to brown. **Streak:** Yellowish brown. **Hardness:** 5-5.5. **Luster:** Silky, dull earthy, submetallic. Opaque. **Habit:** Botryoidal, fibrous, massive, earthy. **Sp. Gr.:** High. **Occurrence:** In veins and beds, as a secondary mineral, resulting from the action of air, water, and organic acids on other minerals containing iron.

MAGNETITE

MAGNETIC IRON OXIDE

Color: Iron-black. **Streak:** Black. **Hardness:** 5.5-6.5, brittle. **Luster:** Metallic to submetallic. Opaque. **Form:** Eight-sided crystals. Poor cleavage. **Habit:** Individual crystals, crystal groups, massive, granular to compact. Highly magnetic. **Fracture:** Subconchoidal to uneven. **Sp. Gr.:** Very high. **Occurrence:** An accessory mineral in igneous rocks, gneiss and schist, and as large bodies near intrusive masses. A common constituent of black-sand deposits.

MALACHITE

BASIC COPPER CARBONATE

Color: Bright green. **Streak:** Pale green. **Hardness:** 3.5-4, brittle. **Luster:** Adamantine, silky, dull. Translucent to opaque. **Form:** Long prismatic. One direction perfect cleavage. **Habit:** Massive, botryoidal crusts, fibrous, radiating, earthy. **Fracture:** Subconchoidal, uneven. **Sp. Gr.:** High. **Occurrence:** Oxidized zone of copper deposits, associated with other copper minerals.

MANGANITE

HYDROUS MANGANESE OXIDE

Color: Steel-gray to black. **Streak:** Reddish brown, nearly black. **Hardness:** 4, brittle. **Luster:** Submetallic. Opaque. **Form:** Long prismatic, faces deeply striated. Three directions perfect cleavage. **Habit:** Crystal bundles, columnar. **Fracture:** Uneven. **Sp. Gr.:** High. **Occurrence:** Veins in granitic igneous rocks, associated with other manganese minerals, barite, and calcite.

MARCASITE

IRON SULFIDE

Color: Pale bronze-yellow. **Streak:** Gray to brownish black. **Hardness:** 6-6.5, brittle. **Luster:** Metallic. Opaque. **Form:** Tabular. Poor cleavage. Twinning produces "cockscomb" structure. **Habit:** Twinned crystal groups, reniform masses, radiating fibrous. **Fracture:** Uneven. **Sp. Gr.:** Very high. **Occurrence:** Deposited from low-temperature, hydrothermal and meteoric solutions in limestone replacement deposits, and associated with galena and sphalerite, and as a later mineral deposited on other minerals in veins.

METACINNABARITE

MERCURY SULFIDE

Color: Black. **Streak:** Black. **Hardness:** 3, brittle. **Luster:** Metallic. Opaque. **Form:** Four-sided crystals. Lamellar twinning. **Habit:** Individual crystals, crystal groups, massive. **Fracture:** Uneven to subconchoidal. **Sp. Gr.:** Exceptionally high. **Occurrence:** Secondary mineral found in upper portions of mercury deposits.

MIMETITE

LEAD CHLORO-ARSENATE

Color: Pale yellow, brown, white, colorless. **Streak:** White. **Hardness:** 3.5, brittle. **Luster:** Resinous. Translucent. **Form:** Prismatic, barrel-shaped. **Habit:** Crystal groups, globular, and mammillary crusts. **Fracture:** Uneven. **Sp. Gr.:** Exceptionally high. **Occurrence:** Secondary mineral found in the oxide portion of some lead deposits.

MOLYBDENITE

MOLYBDENUM SULFIDE

Color: Lead-gray. **Streak:** Greenish gray on porcelain, bluish gray on paper. **Hardness:** 1-1.5, sectile. Thin plates flexible. **Luster:** Metallic. **Form:** Tabular to short prismatic. One direction of perfect cleavage. **Habit:** Massive or scaly, foliated, fine granular. **Sp. Gr.:** Very high. **Occurrence:** Commonly in small amounts in copper deposits, in pegmatites, and in contact deposits, commonly associated with scheelite, fluorite, and wolframite. Also in some veins and replacement bodies.

MUSCOVITE MICA

POTASSIUM-ALUMINUM SILICATE

Color: White, gray, brown, yellow, green, violet. **Streak:** White. **Hardness:** 2-2.5, thin sheets flexible and elastic. **Luster:** Vitreous, pearly, silky. Transparent to translucent. **Form:** Thin tabular. One direction of perfect cleavage. **Habit:** Crystal "books," scaly massive, foliated, also compact-massive. **Sp. Gr.:** Average. **Occurrence:** Common in granite and granite pegmatites. Essential mineral in mica schist and phyllite. The variety sericite is commonly present as an alteration mineral in ore deposits.

OLIVINE

MAGNESIUM-IRON SILICATE

Color: Green, brown, yellow, red. **Streak:** White to pale yellow. **Hardness:** 6.5-7, brittle. **Luster:** Vitreous. Transparent to translucent. **Form:** Rudely tabular to elongate. One direction fair cleavage. **Habit:** Compact to granular, massive, embedded grains. **Fracture:** Conchoidal. **Sp. Gr.:** Average. **Occurrence:** An important constituent of some basalt and other igneous rocks high in iron and magnesium. As a product of metamorphism in some sedimentary rocks such as dolomite. **Varieties:** *Peridote.*—a clear, pale yellowish green variety used as a gem stone.

ORTHOCLASE FELDSPAR

POTASSIUM-ALUMINUM SILICATE
BUT COMMONLY CONTAINS SODIUM

Color: Colorless, white, flesh-red, gray, pale yellow. **Streak:** White. **Hardness:** 6, brittle. **Luster:** Vitreous, pearly, earthy when

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 to conchoidal. **Sp. Gr.:** Average. **Occurrence:** An essential constituent of most igneous rocks.

PLUMBOJAROSITE

Basic lead-iron sulfate

Color: Dark brown. **Streak:** Lighter than the color. **Hardness:** 2.5-3.5, brittle. **Luster:** Vitreous, silky. **Form:** Minute tabular crystals, micaceous. **Habit:** Fine crystalline masses to earthy. **Fracture:** Uneven. **Sp. Gr.:** High. **Occurrence:** In veins associated with metallic ore minerals.

POWELLITE

Calcium molybdate-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 renifom crusts. **Fracture:** Uneven to subconchoidal. **Sp. Gr.:** Exceptionally high. **Occurrence:** Secondary mineral in oxide zone of lead deposits, associated with galena and cerussite.

PYROPHYLLITE

Hydrous aluminum silicate

Color: White, green, brownish green, yellow. **Streak:** White. **Hardness:** 1-2, laminae flexible. **Luster:** Pearly to dull. Translucent to opaque. **Form:** Lamellar. One direction of perfect cleavage. **Habit:** Radiating fibrous, granular, compact, massive. **Fracture:** Uneven. **Sp. Gr.:** Average. **Occurrence:** Main constituent of some schist, commonly an accessory mineral in kyanite deposits.

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 incrustations, 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.

RHODOCHROSITE

MANGANESE CARBONATE

Color: Rose-red, yellowish gray, dark red, brown. **Streak:** White. **Hardness:** 3.5-4.5, brittle. **Luster:** Vitreous, pearly. Translucent. **Form:** Like calcite. **Habit:** Cleavable to granular massive, globular to botryoidal crusts. **Fracture:** Uneven. **Sp. Gr.:** High. **Occurrence:** As a constituent of sedimentary beds, also in veins commonly associated with siderite, calcite, and metallic sulfides.

ROSASITE

BASIC COPPER-ZINC CARBONATE

Color: Bright green to sky-blue. **Hardness:** 4-5, brittle. **Form:** Tabular. Two directions of cleavage. **Habit:** Botryoidal, fibrous crusts. **Sp. Gr.:** High. **Occurrence:** Secondary mineral in oxide zone of zinc-copper-lead deposits, associated with malachite, aurichalcite, and brochantite.

RUTILE

TITANIUM OXIDE

Color: Red, brown, yellow, black. **Streak:** Pale brown. **Hardness:** 6-6.5, brittle. **Luster:** Metallic to adamantine. Transparent to opaque. **Form:** Prismatic, striations parallel to long dimension, twins to form lattice-like shapes. **Habit:** Individual and twinned crystals, compact, massive. **Fracture:** Uneven to conchoidal. **Sp. Gr.:** High. **Occurrence:** Accessory mineral in igneous rocks and in placer sands resulting from such rocks.

SAMARSKITE

RARE-EARTH NIOBATE-TANTALATE

Color: Velvet-black. **Streak:** Dark reddish brown. **Hardness:** 5-6, brittle. **Luster:** Vitreous to resinous. **Form:** Prismatic. **Habit:** Massive, flattened grains. **Fracture:** Conchoidal. **Sp. Gr.:** Very high. **Occurrence:** Granite pegmatites, associated with columbite.

SCHEELITE

CALCIUM TUNGSTATE

Color: White, pale shades of green, brown, yellow, red. **Streak:** White. **Hardness:** 4.5-5, brittle. **Luster:** Vitreous to adamantine. **Form:** Tabular, pyramidal. Four directions of good cleavage. **Habit:** Massive, granular to cleavable, occasional individual crystals. **Fracture:** Uneven. **Sp. Gr.:** Very high. **Occurrence:** Pegmatite veins, contact-metamorphic zones, and metallic ore veins.

SERPENTINE

HYDROUS MAGNESIUM SILICATE

Color: Blackish green to brownish yellow. **Streak:** White. **Hardness:** 2.5-5.5, compact varieties usually harder than the fibrous varieties. **Luster:** Resinous, pearly, wax-like, silky, dull. Translucent to opaque. **Form:** Prismatic in fibrous varieties. **Habit:** Finely fibrous, foliated to compact massive, granular. **Fracture:** Conchoidal, splintery. **Sp. Gr.:** Average. **Occurrence:** Secondary mineral resulting from alteration of igneous rocks rich in magnesia, also from alteration of sedimentary and metamorphic rocks rich in magnesia. **Varieties:** *Chrysotile.*—Finely fibrous variety used for most asbestos. *Antigorite.*—Foliated to compact massive.

SHATTUCKITE

HYDROUS COPPER SILICATE

Color: Blue. **Streak:** Pale blue. **Luster:** Vitreous to earthy. **Habit:** Compact, granular, fibrous. **Fracture:** Uneven to subconchoidal. **Sp. Gr.:** High. **Occurrence:** An alteration product of other copper minerals.

SIDERITE

IRON CARBONATE

Color: Gray, brown, red, black, rarely white. **Streak:** White. **Hardness:** 3.5-4, brittle. **Luster:** Vitreous to pearly. Translucent. **Form:** Six-sided crystals. Form same as that of dolomite. Three directions of perfect cleavage. **Habit:** Cleavable and coarse to fine granular, massive; crystal faces commonly rounded. **Fracture:** Uneven. **Sp. Gr.:** High. **Occurrence:** As a vein mineral and, less commonly as sedimentary deposits.

SILVER

Color: Silver-white, black when tarnished. **Streak:** Silver-white. **Hardness:** 2.5-3, ductile and malleable. **Luster:** Metallic. Opaque. **Form:** Crystals rarely well formed. **Habit:** Massive, platy, wirey, flattened scales. **Fracture:** Hackly. **Sp. Gr.:** Exceptionally high. **Occurrence:** Upper portions of silver-bearing, metallic sulfide veins.

SMITHSONITE

ZINC CARBONATE

Color: White, pale shades of green, blue, brown. **Streak:** White. **Hardness:** 5.5, brittle. **Luster:** Vitreous to pearly. Translucent. **Form:** Same as that of calcite. **Habit:** Botryoidal and reniform crusts, granular, rarely crystalline. **Fracture:** Uneven, subconchoidal. **Sp. Gr.:** Very high. **Occurrence:** Veins and beds. When in veins, commonly associated with galena and sphalerite.

SPHALERITE

ZINC SULFIDE

Color: Yellow, brown, black, red, green, white. **Streak:** Brownish to light yellow, white. **Hardness:** 3.5-4, brittle. **Luster:** Resinous to adamantine. Transparent to translucent. **Form:** Four-sided crystals, as a rule highly modified. Four directions of perfect cleavage. **Habit:** Coarse to fine granular, compact, massive, cleavable. **Fracture:** Conchoidal. **Sp. Gr.:** High. **Occurrence:** In veins in all types of rocks and as replacements in limestone. Commonly associated with galena and often found with pyrite, chalcopyrite, silver ores, barite, and fluorite.

TETRAHEDRITE-TENNANTITE

COPPER-ANTIMONY SULFIDE, COPPER-ARSENIC SULFIDE

Color: Grayish black. **Streak:** Grayish black inclined to brown and red. **Hardness:** 3-4, somewhat brittle. **Luster:** Metallic to splendent. Opaque. **Form:** Four-sided crystals. No cleavage. **Habit:** Coarse to fine granular, massive; as crystal groups. **Fracture:** Subconchoidal to uneven. **Sp. Gr.:** Very high. **Occurrence:** Copper and silver veins associated with chalcopyrite, bornite, pyrite, galena, sphalerite, and other metallic sulfides.

THENARDITE

SODIUM SULFATE

Color: White to pale brown. **Streak:** White. **Hardness:** 2.7, brittle. **Luster:** Greasy. Translucent to opaque. **Form:** Short prismatic to tabular. One direction good cleavage. **Habit:** Individual crystals, crystal groups, massive. **Fracture:** Conchoidal to uneven. **Sp. Gr.:** Average. **Occurrence:** In salt deposits associated with halite, glauberite, and other chlorides and sulfates.

TORBERNITE

HYDROUS COPPER-URANIUM PHOSPHATE

Color: Green. **Streak:** Pale green. **Hardness:** 2-2.5, brittle. **Luster:** Pearly, subadamantine. Transparent to translucent. **Form:** Thin, square, tabular. Two directions good cleavage. **Habit:** Individual crystals and crystal groups, micaceous masses. **Fracture:** Uneven. **Sp. Gr.:** Average. **Occurrence:** In fractures, commonly associated with autunite and other uranium minerals.

TOURMALINE

COMPLEX SILICATE OF
BORON, ALUMINUM, MAGNESIUM, AND IRON

Color: Black, blue, green, red, rarely white or colorless. **Streak:** White. **Hardness:** 7-7.5, brittle. **Luster:** Vitreous, resinous. **Form:** Long prismatic, strong striations parallel to long crystal direction. **Habit:** Individual crystals and crystal groups, massive, granular. **Fracture:** Subconchoidal to uneven. **Sp. Gr.:** Average. **Occurrence:** Granitic rocks, particularly granite pegmatites. Gneiss, and sedimentary and metamorphic rocks near intrusives. Commonly associated minerals include quartz, feldspar, and muscovite.

TURQUOISE

HYDROUS COPPER-ALUMINUM PHOSPHATE

Color: Blue, bluish green, green, greenish gray. **Streak:** White, pale green. **Hardness:** 5-6, brittle. **Luster:** Slightly waxy. Opaque. **Form:** Minute crystals. Two directions of cleavage. **Habit:** Compact, massive, reniform and stalactitic crusts. **Fracture:** Conchoidal. **Sp. Gr.:** Average. **Occurrence:** Secondary mineral found as thin veins and small masses in highly altered rocks rich in alumina and containing copper mineralization.

VANADINITE

LEAD CHLORO-VANADATE

Color: Ruby-red to straw-yellow. **Streak:** White, pale yellow. **Hardness:** 2.7-3, brittle. **Luster:** Resinous. Translucent to opaque. **Form:** Six-sided prisms, often hollow. **Habit:** Groups of parallel prisms, globular crusts. **Fracture:** Uneven to subconchoidal. **Sp. Gr.:** Exceptionally high. **Occurrence:** Rare secondary mineral found in some areas of lead mineralization. **Variety:** *Endlichite.*—A brownish yellow variety in which arsenic replaces about one-half the vanadium.

WILLEMITE

ZINC SILICATE

Color: White, green, yellow, flesh-red, brown. **Streak:** White. **Hardness:** 5.5, brittle. **Luster:** Glassy, resinous. Transparent to opaque. **Form:** Short to long prismatic. One direction of good cleavage. **Habit:** Crystal groups, massive, disseminated grains. **Fracture:** Conchoidal to uneven. **Sp. Gr.:** High. **Occurrence:** In veins and replacement deposits, commonly associated with other zinc minerals.

WOLFRAMITE

IRON-MANGANESE TUNGSTATE

Color: Grayish to brownish black. **Streak:** Black. Hardness: 5-5.5, brittle. **Luster:** Submetallic. Opaque. **Form:** Tabular, prismatic. One direction of perfect cleavage. **Habit:** Bladed, columnar, granular. **Fracture:** Uneven. **Sp. Gr.:** Exceptionally high. **Occurrence:** Pegmatites and metal sulfide veins. **Varieties:** *Ferberite.*—iron tungstate. *Hubnernite.*—manganese tungstate:

WOLLASTONITE

CALCIUM SILICATE

Color: White, gray, yellow, red, brown. **Streak:** White. **Hardness:** 4.5-5, brittle. **Luster:** Vitreous, pearly. Transparent. **Form:** Tabular, short prismatic. Two directions of perfect cleavage. **Habit:** Cleavable-massive, fibrous, compact. **Fracture:** Uneven. **Sp. Gr.:** Average. **Occurrence:** Contact-metamorphic mineral in crystalline limestones. Commonly associated minerals include garnet, other calcium silicates, and scheelite.

WULFENITE

LEAD MOLYBDATE

Color: Orange, yellow, green, brown, red, white, colorless. **Streak:** White. **Hardness:** 2.75-3, brittle. **Luster:** Resinous to adamantine. Translucent. **Form:** Square-tabular. Four directions of good cleavage. **Habit:** Crystal clusters, coarse to fine granular, massive. **Fracture:** Subconchoidal. **Sp. Gr.:** Exceptionally high. **Occurrence:** Secondary mineral in oxide zone of lead-zinc deposits.

ZIRCON

ZIRCONIUM SILICATE

Color: Colorless, pale shades of yellow, gray, green, red. **Streak:** Uncolored. **Hardness:** 7.5, brittle. **Luster:** Adamantine. Transparent to opaque. **Form:** Square prisms. **Habit:** Individual crystals and grains. **Fracture:** Conchoidal. **Sp. Gr.:** Very high. **Occurrence:** Common accessory mineral in granitic rocks and concentrated as placer deposits in sands derived from such rocks.

ZINNWALDITE

IRON-LITHIA MICA

Color: Pale violet, yellow, brown. **Streak:** White. **Hardness:** 2.5-4. **Luster:** Pearly. Transparent to opaque. **Form:** Micaceous. One direction of perfect cleavage. **Habit:** Scaly-granular, massive. **Sp. Gr.:** Average. **Occurrence:** Pegmatite veins and less commonly in granite.

ZOISITE

HYDROUS CALCIUM-ALUMINUM SILICATE

Color: White, gray, yellow, brown, red, rose-red. **Streak:** White. **Hardness:** 6-6.5, brittle. **Luster:** Vitreous, pearly. Transparent to translucent. **Form:** Prismatic, striated parallel to long dimension. **Habit:** Crystal groups, massive, compact. **Fracture:** Uneven, subconchoidal. **Sp. Gr.:** Average. **Occurrence:** Schist resulting from metamorphism of dark igneous rocks.

SUGGESTED REFERENCES

The following books may be ordered directly from the publishers listed after the title of each book, or they may be purchased from local book stores.

GENERAL GEOLOGY

Gilluly, J., Waters, A. C. and Woodford, A. O.
Principles of Geology. 631 pp. W. H. Freeman and Company, San Francisco (1951).

Longwell, C. R. and Flint, R. F.
Introduction to Physical Geology. 432 pp. John Wiley and Sons, Inc., New York (1955).

MINERALS

Dana, E. S. and Ford, W. E.
A Textbook of Mineralogy (Fourth Edition). 851 pp. John Wiley and Sons, Inc., New York (1949).

Dana, E. S. and Hurlbut, C. S., Jr.
Minerals and How to Study Them. 323 pp. John Wiley and Sons, Inc., New York (1949).

Hurlbut, C. S., Jr.
Dana's Manual of Mineralogy (Sixteenth Edition). 539 pp. John Wiley and Sons, Inc., New York (1952).

MINERALS AND ROCKS

Pough, F. H.
A Field Guide to Rocks and Minerals. 333 pp. Houghton Mifflin Company, Boston (1953).

ROCKS

Grout, F. F.
Kemp's Handbook of Rocks. 300 pp. D. Van Nostrand Co., Inc., New York (1940).

Pirsson, L.V. and Knopf, A.
Rocks and Rock Minerals. 349 pp. John Wiley and Sons, Inc., New York (1947).

Spock, L. E.
Guide to the Study of Rocks. 256 pp. Harper and Brothers, Publishers, New York (1953).

INDEX TO MINERALS AND SOME OF THEIR LOCALITIES

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 throughouth 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.

3. Metallic Mineral Map of Arizona, 25 x 27 inches. A red overprint on Map No. 1 shows the principal known localities of metallic minerals by means of representative symbols. Roads are indicated. Revised in May, 1953. Price 30 cents without tube. Cost if mailed, 45 cents.

4. Nonmetallic Mineral Map of Arizona, 25 x 27 inches, similar to Map No. 3 but devoted to nonmetallic minerals. Price, 30 cents without tube. Cost if mailed, 45 cents.

5. Map of Arizona Mining Districts, 25 x 27 inches. A red overprint made 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.